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Use of *Panicum maximum* as a Source of Bio-fertilizer and Biochar on Crop Response of *Raphanus sativus* L. in Organic Cultivation

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Abstract

Panicum maximum is an invasive perennial weed become a threat to environment and agriculture in Sri Lanka. Its control is extremely difficult and expensive due to its heavy dispersion ability. *Azospirillum* associated with *Panicum maximum* roots is a free living, nitrogen fixing, plant growth promoting proteobacteria having ability to produce various phytohormones that improve root growth, adsorption of water and minerals that eventually support plant growth. If there is a possibility of using *Azospirillum* associated roots of *Panicum maximum* as a bio-fertilizer and making biochar from whole *Panicum maximum* plant it could be helpful in controlling *Panicum maximum* and also promote organic agriculture in Sri Lanka. This study was focused on introduction of low cost, easily prepared and freely available bio-fertilizer and biochar to enhance the vegetative growth, yield and quality of crops using *Raphanus sativus* L. (Radish) grown in an organic system. Six treatment combinations of biochar and bio-fertilizer were tested as a pot trial in a polytunnel. A significant highest number of leaves and highest yield parameters were observed in radish grown with root pieces of *Panicum maximum* (bio-fertilizer A) without biochar. Further it exhibited a significantly better sensory properties for quality of the radish compared to other treatments. Root pieces of *Panicum maximum* can be used as the source of bio-fertilizer to enhance the vegetative growth, yield and quality of radish in organic agriculture. Further, it will help to control *Panicum maximum*.

Keywords: Biochar, Bio-fertilizer, *Panicum maximum*, Radish, Roots

Introduction

Panicum maximum (Guinea grass) is a ubiquitous perennial weed that classified as an invasive species in Sri Lanka. It spreads in most parts of the country making a major problem for agriculture in Sri Lanka. When the growth is uncontrolled, it can grow up to about 2 m in height. It has faster spreading ability by seeds and underground stem parts. So its control is extremely difficult and expensive (Weerawardane and Dissanayake, 2005).

Azospirillum is a free living, gram positive, nitrogen fixing, and plant growth promoting proteobacteria associated with *Panicum maximum* roots. Dobbelaere *et al*. (2001) reported that growth promotion capacity of *Azospirillum* lies on its ability to produce various phytohormones that improve root growth, water and minerals adsorption that eventually yield larger, and in many cases more productive plants. They can fix nitrogen and induce dense growth of root hairs which increase the surface area for absorption of soil nitrogen. Thus, *Panicum maximum* often grow better. *Azospirillum* in association with *Panicum maximum* fix approximately 40 Kg of nitrogen per hectare per year (Alexander and Blooms, 2000). There is a possibility of using *Azospirillum* associated roots of *Panicum maximum* as a bio-fertilizer which could be helpful in controlling *Pannicum maximum* and in turn promoting organic agriculture in Sri Lanka. Making biochar from *Panicum maximum* will also be helpful to control the weed in Sri Lanka.

The aim of this study was to introduce the *Panicum maximum* root associated microorganisms as a bio-fertilizer and whole plant as biochar to enhance the vegetative growth, yield and quality performance using *Raphanus sativus* L. (Radish) grown in an organic system.

Material and Methods

The experiment was carried out at Wayamba University of Sri Lanka, Makandura, Gonawila (NWP), Sri Lanka which is situated in IL1a Agro Ecological Zone from July to September 2017. The experiment was carried in a poly-tunnel as a pot trial. Radish (variety; *Beeralu rabu*), a short term crop that can be grown in low country, Sri Lanka was chosen for this experiment.

Preparation of Biochar

Well established flowering *P. maximum* plants were uprooted and dried. They were cut in to (about 15 cm) pieces. These materials were used to produce biochar in a unit described by Pushpakumara *et al*. (2016).

Preparation of Bio-fertilizer

Two different methods were used to prepare the bio-fertilizer using roots of *P. maximum*.

Bio-fertilizer A – Root Pieces

Hundred grams of fresh roots of well-established flowering *P. maximum* were cut into about 1 cm pieces and mixed with soil potting mixture (per plant) 24 h before sowing seeds.

Bio-fertilizer B – Root Solution

Hundred grams of fresh roots of well-established flowering *P. maximum* were shaken in 200 ml water for 5 minutes (per plant). It was applied on the soil surface 24 h before seed sowing and continued weekly.

This study was laid-out using a Randomized Complete Block Design (RCBD) with six treatments and three replicates. Pots were filled with a mixture of Municipal Solid Waste compost, biochar and soil, two days before seed sowing. Soil mixture was filled up to a height of 12.5 cm from the bottom of the poly bag. Bio-fertilizers were mixed with soil about 5 cm soil depth from the surface. After placing bags in the design, four seeds were sown per pot at a space of 2.5 cm and thinning was done as soon as seedlings were bearing at least three leaves. One well grown, vigorous, healthy and uniform seedling was maintained per polybag throughout the study. Irrigation was done manually and irrigation intervals were adjusted according to field capacity. When root solution (Bio-fertilizer B) was applying to respective plants, similar amount of water was added to the other plants of different treatments at the same time. Soil mixture was filled up further time to time with the growth of plants. Treatment combinations are given in Table 1.

Table 1. Tested treatment combinations

Code	Treatment Combinations
T_0	Control
T_1	Bio-fertilizer A (Root Pieces)
T_2	Bio-fertilizer B (Root Solution)
T_3	Biochar
T_4	Biochar + Bio-fertilizer A (Root Pieces)
T_5	Biochar + Bio-fertilizer B (Root Solution)

Number of leaves was measured as vegetative parameter. Harvesting was carried out 46 days after seed sowing. Yield parameters such as, fresh weight of the total yield, fresh weight of the tuber and fresh weight of the leaves were measured at the time of harvesting. Sensory evaluation was carried out immediately after harvesting. It included six samples from six treatments. The samples of radish were reviewed by 30 respondents. Tuber colour, tuber shape, size of the tuber, skin smoothness/texture of the tuber, hardness/firmness of the tuber, colour of the leaves, shape of the leaves, overall acceptance and willingness to buy or consume were rated according to the

9-point hedonic scale. ANOVA was used to analyse all data using SAS Statistical software (version 9.4) and presented as mean±SD with 95% confidence level.

Results and Discussion

Number of Leaves

Mean values of number of leaves at 20, 30 and 40 days after germination are given in Table 2. Number of leaves were significantly different among the treatments recorded in 30 days after germination (p value=0.0081) and 40 days after germination (p value=0.0231). A significant highest number of leaves were observed in T_1 radish (Bio-fertilizer A without biochar).

Table 2. Mean value of Number of Leaves

T	**Number of Leaves**		
	20 DAG	**30 DAG**	**40 DAG**
T_0	4.50^a	7.17^b	10.17^b
T_1	5.33^a	9.08^a	12.17^a
T_2	4.17^a	7.08^c	8.75^d
T_3	4.42^a	7.58^b	10.92^b
T_4	4.91^a	7.83^{bc}	10.58^b
T_5	4.58^a	8.08^b	11.50^c
P	0.1621	0.0081	0.0231

T_0- Control; T_1- Bio-fertilize A (Root Pieces); T_2- Bio-fertilizer B (Root Solution); T_3- Biochar; T_4- Biochar +Bio-fertilizer A(Root Pieces); T_5- Biochar + Bio-fertilizer B(Root Solution); p- significant probability value; DAG= Days After Germination; T= Treatment combinations.

Fresh Weight of Total Yield, Tuber and Leaves

Mean values of yield parameters are given in Table 3. Fresh weight of total yield, tuber and leaves were significantly different among treatments ($p<0.05$). T_1 (Bio-fertilizer A; Root pieces of *P. maximum* without biochar) treated radish recorded the highest fresh weight of total yield (745.0±7.50 g), highest fresh weight of tuber (490.5±2.02 g) and highest fresh weight of leaves (254.5±9.52 g) whereas the T_2 (Bio-fertilizer B; Root solution of *P. maximum* without biochar) recorded the lowest total fresh weight (521.0±9.81 g), fresh weight of tuber (340.5±16.45 g) and fresh weight of leaves (180.5±6.63 g). Therefore, Bio-fertilizer A (root pieces of *P. maximum*) may lead to enhance the yield of radish when incorporating them into the soil.

Table 3. Mean values of yield parameters

Treatment	**Yield Parameters**		
	Fresh weight of total yield (g)	**Fresh weight of Tuber (g)**	**Fresh weight of Leaves (g)**
T_0	$630.5±25.11^b$	$386.0±25.40^b$	$244.5±0.28^{ab}$
T_1	$745.0±7.50^a$	$490.5±2.02^a$	$254.5±9.52^a$
T_2	$521.0±9.81^d$	$340.5±16.45^b$	$180.5±6.63^c$
T_3	$576.0±31.75^{ce}$	$354.5±16.45^b$	$221.5±15.29^{ab}$
T_4	$587.3±9.20^{bc}$	$373.0±24.98^b$	$214.3±22.69^{bc}$
T_5	$591.0±15.01^{be}$	$363.5±8.94^b$	$227.5±6.06^{ab}$
cv	4.88	8.58	8.88
p	0.0002	0.0067	0.0204

Means in column followed by the same letters are not significantly different at 0.05 probability level; T0- Control; T1- Bio-fertilize A (Root Pieces); T2- Bio-fertilizer B (Root Solution); T3- Biochar; T4- Biochar +Bio-fertilizer A (Root Pieces); T5- Biochar + Bio-fertilizer B(Root Solution); cv- coefficient of variance; p- significant probability value.

Sensory Evaluation

The results of sensory evaluation of 30 respondents for radish are given in Figure1. The results revealed that T1 radish grown with Bio-fertilizer A (Root Pieces) gave the best tuber color, tuber size, texture of the tuber, firmness of the tuber, color of the leaves, shape of the leaves, highest overall acceptance and willingness to buy with compared to other treatment combinations. Tuber shape was evaluated as the best in T5 radish (Biochar + Bio-fertilizer B (Root Solution)).

The results indicated the significant treatment effect mainly in yield parameters and quality parameters. Bio-fertilizer A (Root pieces of *P. maximum*) without biochar indicated a better performance among all other treatments.

Department of Agriculture (DOA), Sri Lanka recommends the yield of 20 to 30 t/ha for *Beeralu rabu* with inorganic fertilizer. In the present study, it ranges from 27.3 to 27.9 t/ha with the treatment of bio-fertilizer A (Root pieces) without biochar incorporation that lies within the DOA recommendation. Under the same condition, the control (No bio-fertilizer and no biochar) yielded only 22.4 to 24.3 t/ha. However, incorporation of Bio-fertilizer A (Root pieces) into growth media, could increase the yield by 12.9 percent suggesting that organically grown crops with bio-fertilizer could also increase the yield similar to DOA recommendation for inorganic cultivations.

Majority of the agriculture sector of Sri Lanka currently rely on agro-chemicals. Fertilizers, pesticides and growth regulators are widely used to meet the increasing demand for the quantity of food rather than quality due to limited land area and increasing population. Organic farming is considered negligible in the agricultural sector, since productivity is somewhat less than the intensive agricultural farming units which use agro chemicals (Sangakkara and Katupitiya, 1989).

This study confirmed that *Azospirillum* based bio-fertilizer produced using *P. maximum* can increase the yield under organic cultivation. When compared with other commercial bio-fertilizers, *P. maximum* root based bio-fertilizer is a simple, island wide available, easy to prepare in the field and low cost solution for rural farmers.

Conclusions and Outlook

This study revealed that the root pieces of *P. maximum* can be used as a source of bio-fertilizer to enhance the vegetative growth, yield and quality of radish in organic agriculture with which dispersion of *P. maximum* can be controlled. This low cost, easily prepared and island-wide available bio-fertilizer is advantageous in promoting organic agriculture in Sri Lanka. Adding biochar produced by barrel method did not make any significant improvement for the crop growth probably due to the failure of providing expected temperature range for biochar making process in simple barrel method.

Further studies are necessary to evaluate the bio-fertilizer produced by *P. maximum* in the field conditions with different weather conditions and soil types before recommending for farmers. More upstream oriented research would be needed to develop low cost microbial growth promoting soil additives to activate the microbial population associated with *P. maximum* root pieces used as the bio-fertilizer.

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