Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol., No.6, 2015

Effect of Palm Oil Mill Sludge Cake on Growth of Roselle (Hibiscus sabdariffa) Grown on Bris Soil

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Abstract
The roselle variety UKMR-2 was used in this study to determine the effect of palm oil mill sludge cake on growth of roselle (*Hibiscus sabdariffa)* grown on Bris Soil. The roselle was planted in the field into polyethylene bags filled with Bris soil and POMSC at different rates as treatment. The palm oil mill sludge cake (POMSC) was applied at the following rates of 0 (treated as control), 10, 20, 30 and 40 t/ha rates and chicken manure at 20 t/ha was given as the standard treatment and then left for two weeks to allow for mineralization before sowing. Two-week-old seedlings were used as the planting materials. The commercial fertilizers were used at the rate of 350 kg/ha for NPK Green (15:15:15) were applied at week 2, 4 and 6 after planting and NPK Blue (12:12:17 + TE) at the rate 1120 kg/ha applied at week 8, 10, 12, 14, 16 and 18 after planting. Drip irrigation system was used to irrigate the crop. Pesticides were applied when necessary. The results showed that the optimum rate of POMSC that provide roselle with better growth performance was at 20 t/ha of POMSC. The results also showed 20 t/ha POMSC can be used effectively as potential soil ameliorant for commercial roselle planting on Bris soils.
Keywords: Palm oil mill sludge cake, bris soil, roselle, growth.

1. Introduction

BRIS (Beach Ridges Interspersed with Swales) is a problematic soil in Malaysia. This soil is distributed generously along east coast of Peninsular Malaysia from Kelantan, Terengganu, Pahang and right down along the east coast of Johore (Figure 1). Bris soils are the sandy marine deposits which mainly developed along with a narrow belt ranging from 3 to 12 km fringing the east coast of Peninsular Malaysia. The estimated total area of Bris soils in Peninsular Malaysia is 162,000 hectares and accounts for 1.23% of the total land area (Zahari et. al. (1992). The physical characteristics of Bris soil are too sandy, weakly structured, nutrient deficient and low water retention capacity, limited ability to support plant growth and having a relatively high soil temperature. These characterizations have caused Bris soil unsuitable for agricultural purposes. Attempt had been made to utilize this soil for crops production. However Bris soil has a bright potential to be used by agriculture sectors through enriching it with suitable soil treatments, after which the land can then be cultivated with varieties of crops

The presence of abundant agricultural residues in Malaysia prompted the need to utilize these wastes to overcome environmental pollution. A large portion of these wastes comes from the oil palm effluent. Previously, empty fruit bunches (EFB) and palm oil mill effluent (POME) or recently known as palm oil mill effluent sludge cake (POMSC) had been used as soil treatments to increase growth and yield of tomato and spinach (Radziah, 1996), oil palm and other crops (Lim et al., 1983) and fruit trees such as star fruit and sapodilla (Wan Zaki, 2008). The mix of Bris soils with EFB or POME in a small underground planting hole or upper surface of the soil were proven successful in supporting the plant growth. However, inorganic fertilizers still need to be given with suitable amount for plant nutrient supports. The benefits of POMSC were it can enhance the ability of cation exchange capacity, organic carbon and nutrient in soils and reduce the leaching of nutrients underground. It also can reduce the high fertilizer usage and costs. The POMSC has the ability to hold 0.5% N, 0.4% P, 0.5%K, 0.8%Ca and 0.3%Mg (Othman et al., 1990; Wan Zaki, 2008).

Roselle is a new commercial crop of Malaysia, where it was reported to have been brought in from India. Roselle was first introduced in Terengganu in 1993 by the Department of Agriculture, Terengganu, Malaysia. Roselle was introduced into Malaysia only recently as new cash crop and classified as potential crop in National Agriculture Policy 3 (1998-2010) and hence, information about its agronomics practice for sustainable production is not available or at best, scarce. The new variety (mutant) namely UKMR-2 was released by UKM in 2009. The new roselle variety has special characteristics but in general, it has overall features of having shorter maturity, medium plant size, reduced plant height, high yield production and better calyx features compared to their parent variety Arab and Terengganu (Mohamad et al., 2009). There is a need to establish the research data on the respond of crop to palm oil mill effluent sludge cake as soil treatments on Bris soil. The objective of this study was to determine the effect of palm oil mill sludge cake on growth of roselle var. UKMR-2 grown on Bris soil.

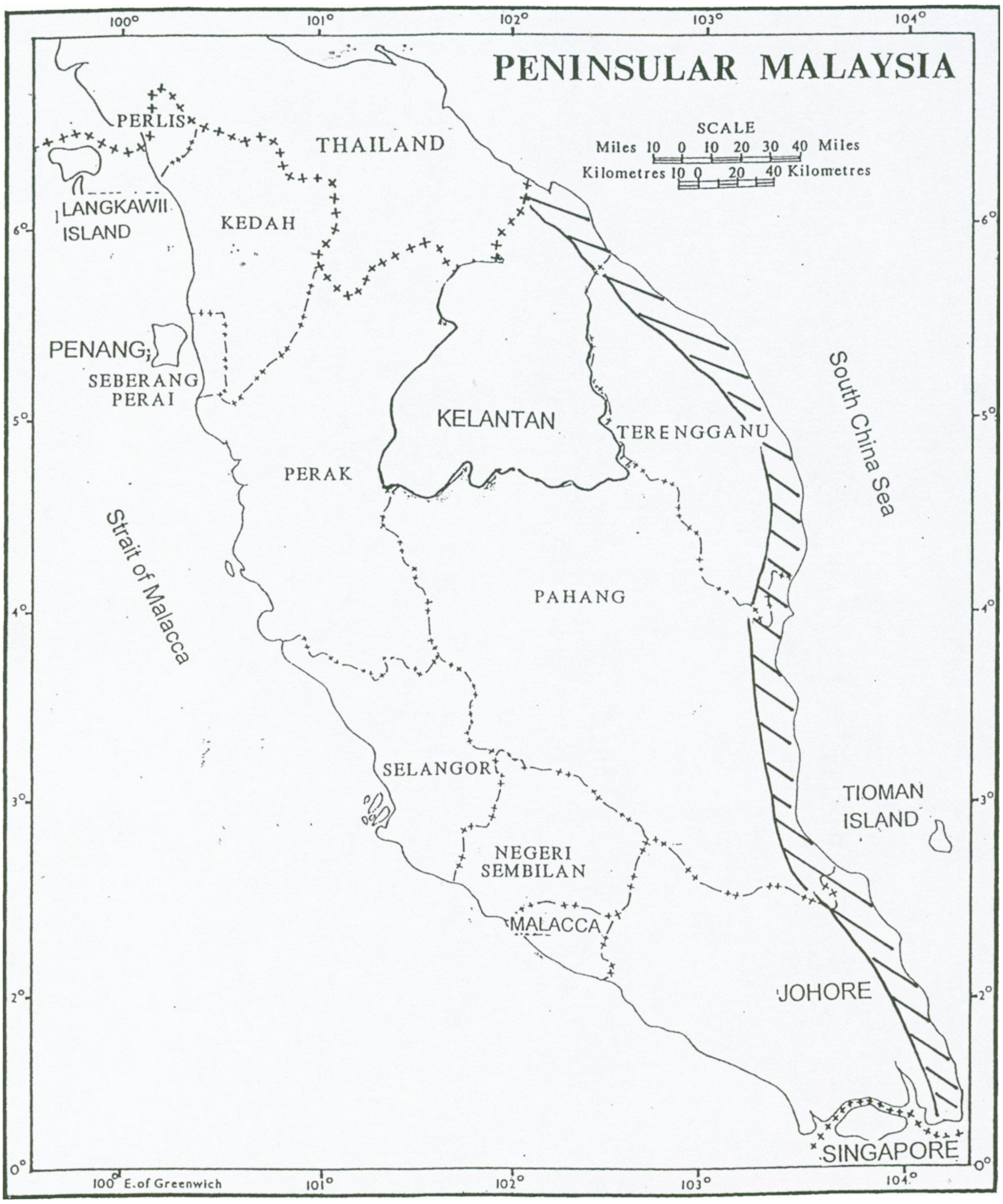

Figure 1: Map of Peninsular Malaysia showing BRIS soil.

2. Materials and Methods

The study area was located at Commodity Development Centre, Department of Agriculture, Rhu Tapai, Setiu, Terengganu, Malaysia (5.65˚ to 6.23˚ North latitudes and between 101.95˚ and 102.53˚ East longitudes). The mean annual rainfall was high with a total 2784 mm/year in Terengganu (DOA, 2010).

Roselle variety UKMR-2 was used in this study. Roselle was planted in the field into polyethylene bags filled with Bris soil and POMSC at different rates as treatment. The palm oil mill sludge cake (POMSC) was applied at the following rates of 0 (treated as control), 10, 20, 30 and 40 t/ha rates and organic manure (chicken dung) at 20 t/ha was given as the standard treatment and then left for two weeks to allow for mineralization before sowing. Two-week-old seedlings were used as the planting materials. The commercial fertilizers were used at the rate of 350 kg/ha for NPK Green (15:15:15) applied at week 2, 4 and 6 after planting and NPK Blue (12:12:17 + TE) at the rate 1120 kg/ha applied at week 8, 10, 12, 14, 16 and 18 after planting. Drip irrigation system was used to irrigate the crop. Pesticides were applied when necessary.

Growth parameters were observed and measured. The growth parameter measured were plant height, canopy diameter and number of leaves. The data were collected on the field at week 0 after planting until week

18 after planting at 2 week intervals. Plant height was measured from the soil line to the shoot tip using measuring tape. For plant canopy, each tree was viewed from all sides to determine the side where the canopy was widest. Two range poles were erected to mark the extreme edges of the canopy. The distance between the two poles was measured with a measuring tape and recorded as the canopy width (cm). Leaf number was counted when the main veins were first visible.

The experimental design at field was arranged as a completely randomized block design (CRBD). Each block had three replicates per treatment. All data collected were analyzed using SAS statistical program (SAS Inst, 1999). Analysis of variance (ANOVA) was conducted and significant differences among the treatments were determined using Duncan New Multiple Range Test (DNMRT) at $P \leq 0.05$.

3. Results

3.1 Plant Height

The average plant height for respective POMSC treatments was tabulated in Table 3.1. Only at week 0 after planting the plant height was not significantly different for all treatments. At week 2 after planting, the plant height was significantly different at 10, 20 and 40 t/ha POMSC.

At week 4 after planting significant responses was observed for treatment 10, 20 and 30 t/ha POMSC. At week 6 after planting there was no significant difference for all POMSC treatments. Significant effect was observed for treatment 10, 20 and 40 t/ha POMSC. At week 8 after planting the plant height was significantly affected at 20, 30 and 40 t/ha POMSC.

Differential growth in plant height was observed at 10, 12 and 14 weeks after planting. The results showed significant growth in plant height at all POMSC rate at week 10 after planting. But at week 12 no significant different in growth and at week 14 had significant increased in plant height at the same level of POMSC treatment.

The plant growth at 16 and 18 weeks after planting had no significant difference at 20 t/ha POMSC. With respect to the rates of application, 20 t/ha POMSC the tallest plant height compared with other treatments which was 123.6 cm. This roselle variety cultivated on Bris soil ameliorated with POMSC showed highest plant height compared with roselle of the same variety grown by Mohamed et al., (2009) without soil treatment which was 108.7 cm.

Table 3.1: Plant height of Roselle as Affected by Different Rates of POMSC

Treatment	Week After Planting									
	0	2	4	6	8	10	12	14	16	18
CONTROL	10.0 ± 0.0^{Ha}	13.0 ± 3.1^{Hb}	22.4 ± 4.4^{Gc}	41.3 ± 8.2^{Fc}	60.0 ± 10.4^{Ec}	75.6 ± 12.8^{Dc}	87.6 ± 11.1^{Cc}	94.3 ± 4.2^{Bc}	104.5 ± 3.5^{Aa}	108.9 ± 3.5^{Ab}
10 t/ha POMSC	9.8 ± 0.4^{Ia}	14.6 ± 3.3^{Ha}	27.5 ± 6.7^{Ga}	46.8 ± 6.9^{Fb}	65.0 ± 9.9^{Ebc}	80.5 ± 12.4^{Db}	87.8 ± 8.7^{Cc}	99.9 ± 0.6^{Bb}	105.4 ± 0.9^{Aa}	108.9 ± 3.6^{Ab}
20 t/ha POMSC	10.1 ± 0.5^{Ha}	15.1 ± 1.4^{Ga}	27.5 ± 3.6^{Fa}	52.4 ± 9.8^{Ea}	71.1 ± 12.5^{Da}	93.5 ± 16.9^{Ca}	97.4 ± 17.5^{Ca}	107.1 ± 3.4^{Ba}	109.9 ± 2.6^{Ba}	123.6 ± 5.9^{Aa}
30 t/ha POMSC	9.9 ± 0.1^{Ia}	13.8 ± 2.9^{Iab}	25.6 ± 5.0^{Hab}	45.6 ± 5.9^{Gbc}	68.5 ± 15.1^{Fab}	82.4 ± 12.2^{Eb}	91.0 ± 13.6^{Dbc}	99.3 ± 1.0^{Cb}	106.4 ± 5.1^{Ba}	113.0 ± 1.8^{Ab}
40 t/ha POMSC	9.9 ± 0.3^{Ha}	14.9 ± 2.5^{Ha}	24.3 ± 5.6^{Gbc}	50.0 ± 5.5^{Fab}	66.3 ± 8.5^{Eab}	80.5 ± 11.6^{Db}	92.6 ± 17.9^{Cb}	99.5 ± 2.6^{Bb}	108.1 ± 6.1^{Aa}	113.0 ± 4.1^{Ab}

A-I – means bearing the same superscript within the same row are not significantly different at 5% level (p>0.05)
a-c – Means bearing the same superscript within the same column are not significantly different at 5% level (p>0.05)

3.2 Plant Canopy Diameter

Table 3.2 shows the canopy diameter of roselle cultivated on Bris soil with POMSC at different rates. However, the significant result was observed at 10, 20 and 40 t/ha POMSC for week 2 after planting and at 10 and 20 t/ha POMSC for week 4 after planting. In addition, at week 6 after planting, only 10 t/ha POMSC had no significant difference in canopy diameter.

At week 8 after planting showed significant responses at all POMSC treatments. At week 10 after planting, plant canopy diameter was significantly affected at 20 t/ha POMSC.

At week 12 and 14 after planting, plant canopy diameter at 20 and 40 t/ha POMSC had significant different at week 12, while at week 14, only at 20 and 30 t/ha POMSC had significant difference. While, at week 16 after planting, plant canopy diameter was significantly different at all POMSC treatments.

At all stages (week after planting), there was significant response to canopy diameter in application of all POMSC treatments but 20 t/ha POMSC showed the highest responses in this variety. With respect to the rates of application, based on week 18 after planting, 20 t/ha POMSC give the biggest canopy diameter which was 74.5 cm.

Table 3.2: Canopy Diameter of Roselle as Affected by Different Rates of POMSC

Treatment	Week After Planting									
	0	2	4	6	8	10	12	14	16	18
CONTROL	4.0 ± 0.0^{Ia}	14.1 ± 5.5^{Ib}	14.5 ± 5.2^{Hc}	29.4 ± 10.5^{Gc}	37.4 ± 7.6^{Fc}	41.1 ± 6.2^{Eb}	48.9 ± 4.9^{Db}	53.3 ± 1.5^{Cc}	58.0 ± 2.9^{Bc}	62.6 ± 1.8^{Ab}
10 t/ha POMSC	4.0 ± 0.0^{Ha}	16.6 ± 5.3^{Ga}	16.6 ± 3.7^{Gb}	29.6 ± 7.1^{Fc}	41.1 ± 8.5^{Eb}	42.1 ± 6.8^{Eb}	48.1 ± 14.7^{Db}	55.5 ± 3.1^{Cbc}	63.6 ± 1.8^{Bb}	73.6 ± 2.2^{Aa}
20 t/ha POMSC	4.0 ± 0.0^{Ia}	17.1 ± 3.9^{Ha}	20.5 ± 4.3^{Ga}	35.5 ± 3.8^{Fa}	45.4 ± 4.8^{Ea}	45.4 ± 5.1^{Ea}	52.9 ± 5.3^{Da}	61.0 ± 1.6^{Ca}	68.0 ± 3.7^{Ba}	74.5 ± 2.7^{Aa}
30 t/ha POMSC	4.0 ± 0.0^{Ha}	13.0 ± 6.6^{Gb}	16.0 ± 5.6^{Gbc}	32.8 ± 8.1^{Fb}	40.5 ± 7.8^{Eb}	43.0 ± 6.3^{Eb}	50.5 ± 12.7^{Dab}	58.9 ± 3.8^{Cab}	64.1 ± 2.0^{Bb}	72.6 ± 4.8^{Aa}
40 t/ha POMSC	4.0 ± 0.0^{Ha}	16.5 ± 4.0^{Ga}	15.0 ± 4.6^{Gbc}	32.8 ± 7.7^{Fb}	41.5 ± 5.2^{Eb}	41.1 ± 5.6^{Eb}	51.5 ± 3.9^{Da}	56.9 ± 3.0^{Cbc}	67.3 ± 2.5^{Bab}	73.3 ± 2.8^{Aa}

A-I – means bearing the same superscript within the same row are not significantly different at 5% level (p>0.05)

a-c – Means bearing the same superscript within the same column are not significantly different at 5% level (p>0.05)

3.3 Number of Leaves Per Plant

The number of leaves per plant for respective POMSC treatments was as shown in Table 3.3. The number of leaves per plant was significantly different at all POMSC rate at week 4, while at week 2, only POMSC at 30 t/ha showed no significant difference.

The number of leaves per plant on POMSC treatments performed better than control. With respect to the rates of application, based on week 4 after planting, the highest number of leaves per plant was recorded from 20 t/ha POMSC which was 32.50. The results showed that Bris soil ameliorated with POMSC treatments promoted the plant growth of roselle varieties in terms of leaves number. This result indicates that the condition of POMSC to Bris soil increase Bris soil health which increase the leaves number per plant. Thus, the best application of POMSC onto Bris soil was application of POMSC at the rate 20 t/ha POMSC.

Table 3.3: Number of Leaves of Roselle as Affected at Different Rates of POMSC

Treatment	Week After Planting		
	0	2	4
CONTROL	4.00 ± 0.00^{Ba}	8.75 ± 0.46^{Bd}	26.38 ± 1.69^{Ab}
10 t/ha POMSC	4.00 ± 0.00^{Ba}	11.63 ± 1.06^{Bc}	30.00 ± 0.93^{Aa}
20 t/ha POMSC	4.00 ± 0.00^{Ca}	19.13 ± 1.13^{Ba}	32.50 ± 2.67^{Aa}
30 t/ha POMSC	4.00 ± 0.00^{Ba}	9.50 ± 0.53^{Bd}	32.00 ± 2.00^{Aa}
40 t/ha POMSC	4.00 ± 0.00^{Ca}	14.50 ± 1.51^{Bb}	30.75 ± 0.71^{Aa}

A-C – means bearing the same superscript within the same row were not significantly different at 5% level (p>0.05)

a-d – Means bearing the same superscript within the same column were not significantly different at 5% level (p>0.05)

4.0 Discussion

4.1 Plant Growth Performance

Generally, plant growth performance in terms of plant height, canopy diameter, number of leaves were influenced by the application of POMSC as soil ameliorant. The plant growth performance of roselle was significantly different at all POMSC rates. These results indicated that the condition of POMSC in Bris soil increased Bris soil health and thus increased the plant growth performance. Plant growth performance fairly increased in POMSC rates from control to 20 t/ha and higher POMSC rates adversely affected these important plant growth performance.

Meanwhile, the plant growth performance of roselle cultivated on Bris soil without POMSC (control) was statistically lower because Bris soil is poor in cation exchange capacity and water holding capacity. Thus, the nutrients and other chemicals may be leach or move downward with water more rapidly (Roslan et al., 2010). Thus, the application of POMSC might improves the formation of water stable aggregate and thus will improve soil permeability and aeration (Wortmann and Shapiro, 2008), increase nutrient and water holding capacity (McConnell et al., 1993; Gallaher and McSorley, 1994; Karlen and Stott, 1994), and affects the infiltration rates and total quantity of water in the soil as well as evaporation from the soil surface (McConnel et al., 1993). According to Radziah (1996), the improvement in soil structure subsequently stimulates root growth for better absorption of nutrients and water.

The degrees to which these additional benefits occur were determined by the quantity of POMSC applied and its decomposition rate. Amelioration of BRIS soil with 20 t/ha POMSC treatment gave highest plant growth performance compared to control and other rates for roselle. The ameliorated Bris soil becomes more productive and for plants to grow better. Thus, the best application of POMSC onto BRIS soil was application of POMSC at the rate 20 t/ha.

According to Abo-Baker and Mostaffa (2011) the sufficient nutrients supplemented proved to be significant which showed its importance in vegetative growth of roselle. The lack of significance at the initial growth stage may be due to time lag for the roselle root system to develop sufficiently to take up the available nutrients in soil solution, urea being a highly soluble fertilizer is well known that the chemical fertilizers promote plant growth through the role of nitrogen in protein synthesis and increasing merismatic activity (Abo-Baker and Mostaffa 2011).

Previous study by Radziah (1996) reported that application of 1 to 21% decomposed palm oil mill (POMeal) increase the plant growth of tomato and spinach grown on sandy soil. Besides, soil NPK contents, pH, electrical conductivity also increase with increase in POMeal levels. According to Chan et al., (1981), the use of POME has been shown to improve soil productivity and increase the yield of crops as well as contribute to better root health by improving the soil structure. Application of POME to soil has been shown to increase the growth of oil palms and other crops (Lim et al., 1983). An increase in crop yield on the order of 10 to 24% has been reported (Lim et al., 1983). Land application of POME has also been shown to improve soil physical, chemical and biological properties (Radziah, 1996). Teoh and Chew (1983) have further shown that mixtures of soil and POME in a ratio of 1:5 resulted in more vigorous growth of cocoa seedlings and decreased nursery rotation without the addition of supplementary fertilizers.

With the help of organic matter consisting of peat and sludge from POME, Shamshuddin et al., (2004) confirmed that aluminium toxicity towards the growth of cocoa seedlings on acid sulfate soil could be reduced to a certain extent. Agamuthu (1994) stated that the application of POME alone as fertilizer provided the highest yield of Napier grass (*Pennisetum purpureum*), up to 3276 kg/ha as a result of POME containing almost all the major and minor elements required for its growth (Agamuthu et al., 1992).

Meanwhile, the current study shows that the addition of high rates of POMSC of 40 t/ha POMSC has decreased the plant growth of roselle. Application of high rates of POME has been proven to inhibit the growth of several plant species. This effect could be due to the unfavorable physical, chemical and biological properties of POME or the unfavorable soil properties that arise as a result of POME application. Previous studies with oil palm seedlings indicated that the presence of high lipid and volatile substances in POME could cause clogging of soil, which subsequently will inhibit growth of plant roots.

This also could be due to soil compaction which reduces to circulate the air in the root zone. It also increases water runoff. Furthermore, the filling pores with water with restrict the movement of gases even further, and it is the reason that waterlogged soils often become anaerobic (Anon, 2012). This is in agreement with Mohd Nazeeb et al., (1994) who reported that the addition of high rates of POME has been proven to inhibit the growth of several plant species. This effect could probably be due to the unfavorable physical, chemical or biological properties of POME or the unfavorable soil that arise as a result of POME application. Earlier studies with oil palm seedlings indicated that the presence of high lipid and volatile substances in POME could cause clogging of soil, which subsequently will inhibit growth of plant roots.

5.0 Conclusion

The results demonstrated that POMSC rates enhanced plant growth until a certain levels, as indicated by the enhanced plant height, canopy diameter and number of leaves at 20 t/ha POMSC rate, plant growth were maximum and at control (0 t/ha POMSC), the value of these parameters were minimum, indicating the potential beneficial application of POMSC to the Bris oil for better growth of roselle. Thus, the optimum rate of POMSC that provide roselle with better growth performance was at 20 t/ha. The above advantages imply that 20 t/ha POMSC can be used effectively as potential soil ameliorant for commercial roselle planting on Bris soils.

Acknowledgements
The authors would like to thank Universiti Malaysia Terengganu for giving permission to publish this paper.

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