

Effect of Palm Oil Mill Sludge Cake on Yield and Yield Components 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 yield and yield components 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 Bris soil enriched with POMSC showed better performance in number buds/plant, flower and calyces and yield parameters such as calyces weight/plant, calyx weight, capsule weight, calyx size.
Keywords: Palm oil mill sludge cake, bris soil, roselle, yield and yield components.

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. 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 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 the yield and yield components of roselle var. UKMR-2 grown on 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 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^{-1} 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^{-1} 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.

Yield parameters were observed and measured. The yield parameter measured were number of buds, number of flowers and number of calyces. The data were collected on the field at week 6 after planting until week 18 after planting at 2 week intervals. The number of buds, flowers and calyces were counted manually. Harvesting was done at 10 week after planting at maturity stage three. Records on the fruit weight per plant (kg), calyx weight (g), capsule weight weight (g), calyx diameter and length of three samples were taken at harvest. The fresh calyces weight were immediately weight using digital balance and recorded to indicate the fresh calyces roselle production per plant. Three roselle fruits were taken and de-cored and weighed separately using digital balance for fruit calyx weight (g) and fruit capsule weight (g). Then, another three calyces were used to measure the diameter and the length using venier caliper. The diameter was measured at the largest rounded portion of the calyx.

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 Number of Buds Per Plant

The number of buds per plant for roselle was demonstrated in Table 3.1. Only at week 8 after planting, the number of buds per plant was significantly for all POMSC rates.

However significant different was observed for treatment 20, 30 and 40 t/ha POMSC at week 6. While for week 10, only 20 and 40 t/ha POMSC had significant number of buds per plant and for week 12, only 10, 20 and 40 t/ha POMSC had significant number of buds per plant. At week 14 after planting only 10, 20 and 30 t/ha POMSC had significant effect.

The results showed that at 10, 20 and 30 t/ha POMSC had significant difference at week 16. While for week 18 after planting at 10 and 20 t/ha POMSC give significant result.

With respect to the rates of application, based on week 18 after planting, only POMSC at 20 t/ha had produced significant number of buds which was also the highest with 97.63. The obtained results showed that BRIS soil ameliorated with POMSC promoted the plant growth of roselle. Thus, the suitable application of POMSC onto BRIS soil was application of POMSC at the rate 20 t/ha POMSC.

Table 3.1: Number of Buds of Roselle as Affected at Different Rates of POMSC

Treatment	Week After Planting						
	6	8	10	12	14	16	18
CONTROL	35.75 ± 2.60^{Ec}	60.75 ± 2.92^{Dc}	74.63 ± 14.47^{ABCcd}	83.88 ± 9.14^{Ac}	81.50 ± 3.74^{ABc}	68.88 ± 10.40^{BCDc}	67.13 ± 6.77^{CDc}
10t/ha POMSC	40.25 ± 3.58^{Cbc}	79.88 ± 4.22^{Bb}	80.50 ± 3.07^{Bc}	93.88 ± 3.94^{Ab}	94.88 ± 4.64^{Ab}	80.13 ± 5.64^{Bb}	80.13 ± 3.87^{Bb}
20t/ha POMSC	47.13 ± 5.14^{Ca}	98.13 ± 1.25^{Ba}	104.88 ± 2.03^{Aa}	109.63 ± 4.21^{Aa}	105.38 ± 3.34^{Aa}	94.88 ± 2.17^{Ba}	97.63 ± 4.24^{Ba}
30t/ha POMSC	43.38 ± 2.07^{Dab}	78.88 ± 3.60^{Bb}	70.25 ± 4.30^{Cd}	92.13 ± 4.12^{Abc}	93.88 ± 2.36^{Ab}	78.13 ± 1.13^{Bb}	63.88 ± 10.55^{Cc}
40t/ha POMSC	44.88 ± 4.52^{Eab}	94.38 ± 5.60^{Aa}	92.75 ± 3.06^{ABb}	99.75 ± 6.63^{Ab}	84.38 ± 3.07^{Bc}	74.63 ± 7.73^{Cbc}	65.13 ± 9.55^{Dc}

A-E – 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)

3.2 Number of Flowers Per Plant

Data presented in Table 3.2 represent the average of number of flowers per plant as affected by different rates of POMSC. With respect to POMSC rates, only at week 10 after planting had significant difference in number of flowers per plant.

At week 12 after planting, only at 20 t/ha POMSC had significant difference in the number of flowers per plant in comparison with control.

At week 18 after planting, the number of flowers per plant at 20 and 40 t/ha POMSC showed significant effect.

Concerning the effects of POMSC as soil ameliorant, based on week 18 after planting, the obtained results indicated that the highest number of flowers per plant was found at BRIS soil with 20 t/ha POMSC treatment for roselle variety UKMR-2 Thus the suilable application of POMSC to obtain high flowers number per plant was at 20 t/ha

Table 3.2: Number of flowers of Roselle as Affected at Different Rates of POMSC

Treatment	Week After Planting					
	8	10	12	14	16	18
CONTROL	$0.38±0.52^{Dc}$	$2.50±1.07^{Cd}$	$4.38±1.30^{Bb}$	$6.38±1.41^{Ab}$	$5.50±0.76^{ABa}$	$1.00±0.00^{Dab}$
10 t/ha POMSC	$1.00±0.00^{Cab}$	$6.25±1.04^{ABab}$	$5.38±1.19^{Bb}$	$6.63±0.92^{Ab}$	$5.88±0.64^{ABa}$	$0.63±0.52^{Cb}$
20 t/ha POMSC	$1.25±0.46^{Da}$	$6.75±1.91^{BCa}$	$8.63±1.92^{Aa}$	$8.25±0.71^{ABa}$	$5.38±0.74^{Ca}$	$1.38±0.52^{Da}$
30 t/ha POMSC	$1.13±0.35^{Ca}$	$4.75±0.89^{Bbc}$	$5.75±1.98^{ABb}$	$7.38±0.92^{Aab}$	$6.13±2.03^{ABa}$	$0.88±0.35^{Cab}$
40 t/ha POMSC	$0.50±0.53^{Cbc}$	$4.25±0.46^{Bc}$	$5.38±2.07^{Bb}$	$7.50±1.07^{Aab}$	$5.13±0.64^{Ba}$	$1.25±0.46^{Ca}$

A-D – 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 ($p>0.05$)

3.3 Number of Calyces Per Plant

Data recorded in Table 3.3 showed the number of calyces per plant as affected by different rates of POMSC. The roselle started to produce the calyx at week 8 after planting for all POMSC rates. The number of calyces per plant was significantly affected in application of 10, 20 and 30 t/ha POMSC.

With respect to POMSC rates, only at week 10 and 16 after planting had significant different in number of calyces per plant. At week 12 and 18 after planting, only POMSC at 20 t/ha had significant number of calyces per plant in comparison with control. At week 14 after planting only at 20 t/ha POMSC give significant difference in number of calyces compared with control.

The data revealed that an application of POMSC at all rates produced the highest number of calyces per plant in comparison with control. With respect to the rates of application based on week 18 after planting only at 20 t/ha POMSC produced significance number of calyces which was also the highest calyces number per plant. The significance number of calyces was observed at 20 and 30 t/ha POMSC, but the high calyces number per plant was at 20 t/ha POMSC with 110.25.

Concerning the effects of POMSC as soil ameliorant on BRIS soil, the obtained results indicated that POMSC increase the number of calyces per plant. But the highest number of calyces per plant was found at BRIS soil with 20 t/ha POMSC for roselle variety UKMR-2.

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

Treatment	Week After Planting					
	8	10	12	14	16	18
CONTROL	$0.00±0.00^{Db}$	$17.88±3.00^{Cb}$	$70.88±12.99^{Bb}$	$82.75±8.86^{ABbc}$	$73.13±12.72^{Bc}$	$89.25±10.35^{Ab}$
10 t/ha POMSC	$1.00±0.00^{Db}$	$45.63±7.27^{Ca}$	$72.75±4.77^{Bb}$	$81.75±10.75^{ABc}$	$82.25±7.70^{ABb}$	$91.50±12.13^{Ab}$
20 t/ha POMSC	$3.00±1.60^{Ea}$	$48.63±6.72^{Da}$	$86.25±4.27^{Ca}$	$99.63±1.30^{Ba}$	$103.63±4.27^{Ba}$	$110.25±1.91^{Aa}$
30 t/ha POMSC	$2.13±0.35^{Da}$	$47.38±7.11^{Ca}$	$75.63±7.41^{Bab}$	$93.50±5.50^{Aab}$	$101.50±8.35^{Aa}$	$98.88±9.19^{Aab}$
40 t/ha POMSC	$0.25±0.46^{Cb}$	$46.13±8.49^{Ba}$	$81.38±5.45^{Aab}$	$82.00±8.23^{Ac}$	$87.75±7.98^{Ab}$	$90.00±5.93^{Ab}$

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

a-c – Means bearing the same superscript within the same column were not significantly different at 5%

level (p>0.05)

3.4 Yield and Yield Components

Data recorded in Table 3.4 showed the yield and yield components with respect to POMSC treatments. With respect to the calyx weight (g), there was significant difference at all POMSC rates. With respect to the POMSC rates, 20 t/ha POMSC produced significance highest calyx weight which was 10.62 g. Similar result was reported by Mohamed et al., (2009) who studied on development of new varieties of roselle through mutation breeding.

With respect to calyces weight per plant (kg/plant), there was significant responses to applied POMSC treatments when compared with control. The data revealed that the application of POMSC as soil ameliorant produced the highest values of calyces weight (kg/plant) in comparison with control. The average calyces weight per plant was significantly higher at 20 t/ha POMSC which was 3.82 kg.

The roselle cultivated on BRIS soil ameliorated with POMSC showed higher calyces weight/plant if compared to previous studies by Mohamed et al., (2009) that had been cultivated on soil without treatment with 2.3 kg/plant. The result was also in agreement with Mehdi (2012) who studied effect of mineral and organic fertilizers on the calyx yield of roselle which the highest calyx yield was observed at the combination of 20 t/ha of hen manure and 20 t/ha ostrich manure.

Meanwhile, the capsule weight of roselle was significantly influenced by the application of POMSC as soil compared to roselle from control (untreated BRIS soil). Considering the capsule weight (g) significant responses were observed at 20 t/ha POMSC. The results showed that capsule weight of roselle was slightly higher compared to the capsule weight of the same variety as reported by Mohamed et al., (2009).

In addition, the calyx diameter (cm) of roselle also had significant differences at all POMSC rates. With respect to the rates of application, POMSC at 20 t/ha produced significance highest calyx diameter which was 9.22 cm.

With respect to the rates of application, the highest calyx length was observed at 20 /ha POMSC with 10.52 cm as the highest calyx length that was recorded.

Table 3.4: Yield and Yield Components of Roselle as Affected at Different Rates of POMSC Ameliorant

TREATMENT	Calyx weight (g)	Calyces/plant (kg)	Capsule weight (g)	Calyx diameter (cm)	Calyx length (cm)
CONTROL	6.22±0.13^{d}	1.68±0.03^{e}	4.54±0.15^{c}	7.01±0.03^{d}	9.34±0.16^{c}
10 t/ha POMSC	9.06±0.32^{c}	2.85±0.06^{b}	4.33±0.110^{d}	7.89±0.34^{c}	9.52±0.38^{c}
20 t/ha POMSC	10.62±0.17^{a}	3.82±0.05^{a}	5.29±0.25^{a}	9.22±0.11^{a}	10.52±0.04^{a}
30 t/ha POMSC	9..78±0.33^{b}	2.74±0.06^{c}	5.09±0.11^{b}	8.27±0.13^{b}	10.01±0.43^{b}
40 t/ha POMSC	9.22±0.21^{c}	2.51±0.04^{d}	4.78±0.36^{c}	7.91±0.28^{c}	9.72±0.48^{bc}

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

4.0 Discussion

4.1 Yield Parameters

The fruit consists two major parts namely the calyx and the seed portion. Each fruit consist five calyces. The yield parameters in terms of roselle calyx weight per calyx, calyx weight per plant, capsule weight per calyx, roselle diameter and length were significantly affected by POMSC rates. The highest values for the yield parameters of calyx were obtained from 20 t/ha POMSC. The values for these parameters were reduced with further increased in POMSC rates. It is suggested that the POMSC might increase BRIS soil health; therefore the roselle yield parameters in terms of quantity and quality were increased.

The positive response of yield parameters to POMSC application confirmed the findings of Tindall (1983) who reported that economic yield of roselle were only obtained on soils which were well supplied with organic materials and essential nutrients and those of Mehdi (2012) who observed increased in yield parameters as a result of mineral and organic manure fertilization and those of Hassan (2009) and Abo-Baker and Mostafa (2011) who observed increased in yield components of roselle as a results of application of bio-fertilization rates.

A large amount of sand (>90%) and very low physical and chemical characteristics of BRIS soil affect roselle yield parameters. Therefore, the yield was significantly lower under BRIS soil condition for roselle. The findings of the current study are consistent with those of Zebarth et al., (1999) who found that the effect soil amendment is generally attributes to enhancement physical criteria of the soil including better aeration, better nutrient availability and good balance between nutrients in the soil solution and improvement of nutrient exchange between the soils.

5.0 Conclusion

The results demonstrated that POMSC rates enhanced yield of roselle until a certain levels, as indicated by the enhanced number of buds, number of flowers and at 20 t/ha POMSC rate and yield productions 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 and yield of roselle. Thus, the optimum rate of POMSC that provide roselle with better yield parameters 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 yield production on BRIS soils.

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References

Abo-Baker, A.A. and Mostafa, G.G. 2011. Effect of bio and chemical fertilizers on growth, sepals yield and chemical composition of *Hibiscus sabdariffa* at new reclaimed soil of South Valley area. Asian Journal Crop Science, 3(1): 16-25.

Department of Agriculture (DOA). 2010. Ministry of Agriculture and Agro-Based Industry, Putrajaya, Malaysia.

Hassan, F. 2009. Response of *Hibiscus sabdariffa* plant to some bio-fertilization treatments. Annals Agriculture Science Ain Shams University Cairo, 54(2): 437-446.

Lim, K.H., Wood, B.J., Lai, A.C., Wan Sulaiman, W.H. and Mohamed, S. 1983. Land application of digested POME supernatant on oil palm using a flatbed system. Proceedings Seminar on Land Application of Oil Palm and rubber facrtory effluents (Eds.). Lim, K.H., Bachik, A.T. and Poon, Y.C. KL: Malaysian Society of Soil Science. 163-169.

Mehdi, D. 2012. Effect of mineral and organic fertilization the growth and calyx of roselle (*Hibiscus sabdariffa*). African Journal of Biotechnology, 11 (48): 10899-10902.

Mohamad, O., Ramadan, G., Halimaton Saadiah, O., Noor Baiti, A.A., Marlina, M.M., Nurul Rahainah, C.M., Aulia Rani, A., Elfi, K., NurSyakireen, I., Salwa, A.S., NurSamahah, M.Z., Zainal, M., Mamot, S., Jalifah, L., Aminah, A., Golam, F., Ahmad Bachtiar, B., Mohd Nazir, B., Mohd Zulkifli, M.Z., Abd. Rahman, M., and Zainal, A.A. 2009. Development of three new varieties of roselle mutation breeding. Oral papers: Genetic Resources and Breeding. Proceeding of the 8th Malaysia Congress on Genetics. p. 65-70.

Othman, A.B., Aminuddin, Y., Abdul Rashid, A., Abdul Aziz, B. Lee, C.S. and Lim, S.P.1990. Recent approach to fruit tree cultivation on sand tailing. Seminar Kebangsaan Ex-mining land and Bris soil- prospect and perspective, 15-16 Oct. 1990. Kuala Lumpur.

Radziah, O. 1996. The phytotoxicity of palm oil mill effluent, its degradation and effect on plant growth. Ph.D Thesis, Universiti Putra Malaysia, Malaysia.

SAS Institute. (1999). SAS User's Guide: Statistics. SAS Inst., Cary, NC.

Tindall, H.D. 1983. Vegetables in the Tropics English language book society. Macmillan Company. London. Pp 32-41.

Wan Zaki, W.M. 2008. Palm oil mill sludge cake (POMSC) is effective in improving the performance of flue-cured tobacco grown on bris soil. Buletin Teknologi Tanaman. Bil. *5*: 47-53.

Zahari, A.B.M., Wahab, N.A., Chaang, T.C. and Rahim, M.A. 1992. Distribution, characterization and utilization of problem soils in Malaysia-a country report. Tropical Agriculture Resources Series, 15: 41–61

Zebarth, B.J., Neilsen, G.H., Hogue, E., and Neilsen, D. 1999. Influence of organic waste amendments on selected soil physical and chemical properties. Can. Journal Soil Science, 79: 501-504