Application of organic residues for yield improvement of *Orthosiphon stamineus* on contrasting soils

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ABSTRACT

Most of residues generated by the agriculture and forest industries have good attributes for land application, to improve soil fertility and quality. We carried out a study to evaluate the effect of applying organic mulch from the residues to cultivate *Orthosiphon stamineus* (misai kucing) on five different soils with contrasting properties. The residues used for mulching were oil palm empty fruit bunches (EFB) fibres, chipped acacia bark, chipped kenaf bark and chipped wood debris from construction site. Each mulch types was spread on top of five different soils ranging from mineral, peat, alluvial, tin tailing and sandy BRIS (Beach Ridges Interspersed with Swales) planted with *O. stamineus* seedling. Treatment without mulch application was established as a control. Once the plants reached three-month-old, the aboveground plant biomass was harvested for dry matter yield measurement, and the plants were left to coppice for the next harvest. The medicinal plant raised on these five soils responded differently to the different mulches application. The highest dry matter yield of *O. stamineus* was obtained with mineral soil regardless of the type of mulch used. The yields were far higher than on other soils, reflecting the preferred soil for planting *O. stamineus*. EFB and kenaf bark mulches work well with the three sandy soils with significantly higher harvested yield of *O. stamineus*. EFB works better than other mulches on peat soil.

Keywords: medicinal plant, mulching, mineral soil, peat soil, sandy soil

INTRODUCTION

Agriculture and forest industries produced a number of organic residues which can be reutilized to improve soil quality for planting. Rice straw, rice husks, sawdust, wood off-cuts, sludge from paper mills are among the residues generated by these industries. Oil palm industry alone, with millions of hectares plantations, produces 22% EFB, 12% mesocarp fibres, 7% palm kernel shells and 3% palm kernel cake as byproducts out of every ton of fresh fruit bunches processed for oil extraction [1]. At present, some of the residues are used back for specific purposes such as re-processing to produce animal feed, pyrolized into biochar for crop cultivation and as feedstock for energy generation, while some are disposed at landfill. Reutilizing these residues as mulches can be another option whereby these materials provide many benefits to the soils. At present, only EFB is used back in the oil palm plantation as mulch. Among useful attributes of organic mulches are improved soil structure and aeration for plant root to expand, reduced water loss through evaporation, buffer soil temperature and suppress weed growth by inhibiting its germination. Nutrients which are being released from biodegradation of these organic materials add as soil supplement thus improve fertility for plant growth [2]. Apart from these, the inimitable feature obtained from colored and different textured mulches resulted in colorful and decorative landscape upon spreading over in garden planting.

Orthosiphon stamineus, locally known as misai kucing, has been commercially used in health food industry to produce beverage product as well as capsules. For many centuries, the plant leaves have been used as diuretic, treatment of rheumatism, abdominal pain, kidney and bladder inflammation, edema, gout and hypertension [3,4]. *O. stamenius* extract lowers uric acid concentration by blocking its production, and inhibits calcium oxalate crystal aggregation by reducing crystal size then altering its surface [5,6].

Being one of the most marketed medicinal plants, *O. stamineus* is needed in perpetuity and in large quantity. With limited good agriculture land available for planting, it is important to focus on idle lands which mostly sit on problematic and degraded soils. This paper reports output of a study on planting of *O. stamineus* on five different soils of good and poor fertility. The soil selected were mineral, peat, BRIS, alluvial and tin tailings. The objectives of the study were to assess other suitable soils for cultivating *O. stamineus*, and to evaluate the contribution of mulches in improving dry matter yield of the plant. Organic mulches used in this study were EFB, acacia bark, kenaf bark and wood chips. These materials were transformed into appropriate forms to be used as mulch.

MATERIALS AND METHODS

Collection and processing of organic mulches

Four types of organic mulches were tested in this study i.e. oil palm empty fruit bunches (EFB), kenaf bark, acacia bark and colored wood chips. Raw EFB obtained from the nearest palm oil mill was shredded into loose fibres and converted into mulch mat as described by Wan Asma *et al*. [7]. Briefly, biodegradable glue was sprayed evenly onto the partially dried shredded fibres and then packed into a mould before subjected to cold pressing to form a mat. Both kenaf and acacia barks were obtained from the research processing mills, which were discarded as by-products. These organic wastes were shredded and air dried for one day. Wood chip mulch was processed from partially decayed woods collected from construction sites. After segregation, these woods were cleaned from rusty nail, other metals and concrete cement deposits. These materials were then chipped into even-size wood chips and boiled with dye of various colors for aesthetic appearance upon application onto the soil surface.

Soil samples collection

The five different soils tested in this study were obtained from five different sites in Peninsular Malaysia. Peat soil, which was already subsided due to land use change, was collected from Kuala Selangor. It was fully decomposed organic material mixed with bed soil. Mineral soil was taken from an area in Muar, Johor, which was under perennial fruit orchard. Alluvial soil was collected at the bank along the stream in FRIM main campus in Kepong, Selangor, while the respective BRIS and tin tailing soils were taken from FRIM Research Stations in Setiu, Terengganu and Bidor, Perak. All soils were taken within the rooting depth of 0-30 cm from the surface.

Establishing experimental plot

The study was setup at Bukit Hari experimental site in FRIM campus, Kepong. The seedlings of *O. stamineus* were first raised in small pots at FRIM’s nursery and approximately after two weeks they were transplanted into the polybag containing 40 kg soil. Organic mulch was then placed on top of the soil. Seedlings were layout in a complete randomized design with four replications. The treatments established consisted of four different types of mulches applied on five different soils. Control plots were treatments without mulch addition on each of the soil types. Watering was carried out daily except on rainy days. The aboveground plant parts were harvested at three months after repotting for biomass analysis and the stump were left to coppice for second crop harvesting. The samples were separated into stem, leaves and flower for total dry matter yield measurements.

Laboratory analysis of mulch and soil samples

Representative subsamples of all mulches and soils used in this study were brought to the laboratory for analysis. Both materials were dried and ground before analysis using standard procedures for soil and plant preparation. The mulches were checked for N concentration on nitrogen determinator (LECO FP-528). Other elements i.e. P, K, Ca and Mg were extracted using microwave digester. Exchangeable K, Ca, and Mg in soils were extracted through leaching column with neutral ammonium acetate solution. The extracted elements in both soils and mulches were determined their elements concentration on Inductive Couple Plasma (ICP) spectrometer. The organic carbon in mulches and soils were analyzed using the Walkley and Black rapid titration method. Available P in soil was determined by Bray and Kutz no. 2 method. The soil textural classes were separated using pipette method and pH was measured on 1:2.5 soil to water ratio.

RESULTS AND DISCUSSION

Properties of mulches and soils

Table 1 summarizes nutrient properties of the four organic mulches used in this study. In general, mulches from EFB, kenaf bark and acacia bark have better plant nutrient values than the colored wood chips. However, acacia bark was lacking in P and K nutrients. Both of these nutrients were available in higher quantity in EFB and kenaf bark due to fertilization in the course of their planting. EFB mulch also contained the highest N and the lowest organic carbon, having C/N ratio value within a good range for nutrient mineralization. The most challenging mulch could be wood chip, having the highest organic carbon and overall low nutrient reserve. Nevertheless, it still has the ability to retain moisture.

The chemical parameters analyzed for all the five soils used are given in Table 2. Mineral and peat soils have better nutrient content compared with the other three sandy soils. Peat soil has the highest C/N ratio of 51, caused by the high organic carbon and this has potential for N immobilization [8]. Of the three sandy soils, BRIS soil has the poorest nutrient value. All soils are acidic, with peat soil having strongly acidic while pH for mineral soil is typical for the highly weathered Malaysian soils. pH values for sandy soils are within a good range for plant growth.

Table 3 shows that all the three sandy soils have more than 90% sand which has high tendency for mobile nutrients to be leached out easily resulting in low content in exchangeable K, Ca and Mg [9]. Mineral soil has good texture properties with proportional mixture of silt, clay and sand. Even though peat soil has the highest clay content of more than 70%, its high organic content helps to reduce soil bulk density thus eases root penetration.

Effect of soil on plant dry matter yield

The most preferred soil for planting *O. stamineus* is clearly portrayed in Figure 1. Similar to majority of other plant species, the more balance texture of mineral soil is preferable. The yields produced regardless of mulches used were far higher than those planted on sandy or peaty soils.

Table 1. Nutrient levels in organic mulches used based on average value of three replicates analysis.

Mulch Type	Total N	Organic C	C:N	P	K	Ca	Mg
	%			%			
EFB	1.49	33.93	22.77	0.15	10.83	0.30	0.20
Kenaf bark	1.07	36.97	34.55	0.10	10.34	0.21	0.07
Acacia bark	1.08	36.15	33.47	0.05	0.56	0.71	0.03
Wood chip	0.28	46.77	167.0	0.004	0.04	0.12	0.05

Table 2. Fertility indicators of the soils used based on average value of three replicates analysis.

Soil Type	Total N	Org. C	C:N	Av. P	Exc. Ca	Exc. Mg	Exc. K	Dry pH
	%			µg/g	cmol/kg			
Mineral	0.23	3.03	13.17	10.51	2.35	3.68	0.09	4.57
Peat	0.65	33.07	50.88	19.44	1.60	0.92	0.09	3.43
Alluvial	0.01	0.11	11.00	6.10	0.12	0.07	0.04	6.68
TinTailing	0.07	1.79	25.57	0.73	0.07	0.04	0.02	6.15
BRIS	0.02	0.86	43.00	0.78	0.06	0.02	0.04	6.18

Org. – organic; Av. – available; Exc. – exchangeable.

Table 3. Texture properties of the five soils used in the study.

Soil Type	Coarse sand %	Fine sand %	Silt %	Clay %
Mineral	5	16	32	48
Peat	3	3	20	73
Alluvial	98	1	1	8
TinTailing	92	6	0	7
BRIS	93	5	0	7

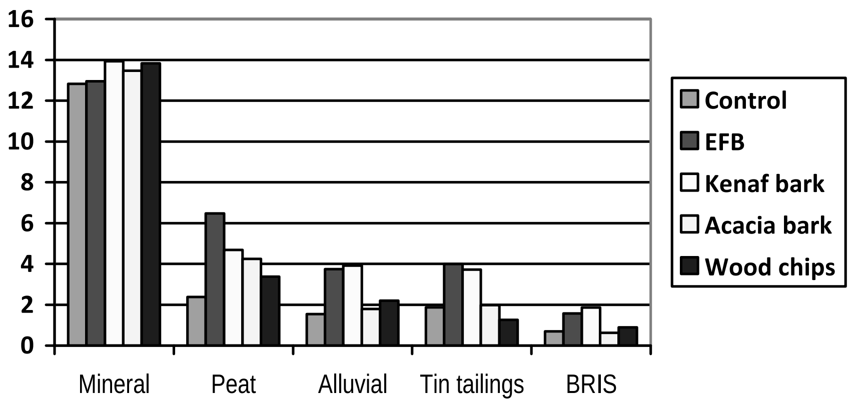

Figure 1. Dry matter yield production (g/plant) of *O. stamineus* recorded on different soils.

Table 4 shows the statistical differences in plant biomass production between different soils and within similar mulch type used. With or without mulching, mineral soil produced significantly higher biomass exceeding 12 g, compared with the nearest yield on peat soil applied with EFB mulch at one magnitude lower. Even though nutrient levels in peat soil are the highest among the five soils used, factors such as high C/N ratio may contribute to the nutrient availability at root microsites. The value of C/N ratio is 50.88, high enough to immobilize N in the soil to support microbial growth thus restricted its availability for plants [10]. Other limiting factors could be heavy clay and very acidic soil with pH at 3.43. Too low pH can lead to conversion of elements in soil into forms that are not easily accessible to the plants [9]. The three sandy soils have significantly lower yields, with BRIS soil as the most problematic. Low nutrient content and poor soil texture due to very high proportion of sand could be the main reasons for these low yields.

Table 4. Performance of *O. stamineus* planted on five different soils within the same mulch type.

Soil Type	Without mulch	EFB	Kenaf	Acacia bark	Wood chip
Peat	2.38 b	6.47 b	4.69 b	4.25 b	3.37 b
Mineral	12.82 a	12.95 a	13.93 a	13.46 a	13.82 a
Alluvial	1.54 b	3.74 c	3.91 b	1.79 c	2.20 bc
Tin tailing	1.87 b	3.99 bc	3.73 b	1.98 c	1.26 c
BRIS	0.70 b	1.57 c	1.86 b	0.63 c	0.82 c

Values having the same alphabet in the same column are not significantly different at $p<0.05$ according to the Duncan New Multiple Range Test (DMRT).

Effect of mulch application on plant dry matter yield

Aboveground biomass production of *O. stamineus* planted on five different soils and received different mulch treatments are presented in Figure 2. The results show that *O. stamineus* grown on these five soils responded differently to the mulch application. On mineral soil, all of the mulches applied did not give any significant increase in plant dry matter yield. Whereas on peat soil, EFB mulch yielded the highest plant biomass, significantly outdo wood chips and the control. The considerably higher biomass yield could be due to higher macronutrients uptake, released by EFB which enhanced the growth of plant on peat soil. On the other hand, kenaf bark and EFB mulches was equally good when applied on sandy soils. Both mulches gave significantly higher yield than the Acacia bark and wood chips mulches, also higher than the control. Nevertheless, we would expect better performance with the latter two mulches when applied in combination with fertilizer. Treating soil with mulch and fertilizer was reported to enhance the growth performance of medicinal plant on sandy soils [11,12]. The experiment used the unfertilized as well as non-mulch soils as controls.

This study reveals that mulch having inherently higher nutrient concentration produces higher plant biomass yield, as shown by the use of EFB and kenaf bark mulches. Utilization of organic mulches stimulates microbial activities in soil, subsequently improves soil fertility and nutrient availability through bio-degradation process which is beneficial for plant growth [13,14]. However, the use of mulch on peat soil could induce higher soil acidity due to formation of organic acids at initial stage of organic material degradation. This could affect productivity, as demonstrated by the performance of kenaf bark on peat soil in this study (Figure 2). For soils with limited nutrient availability, combining mulch and fertilizer could result in better plant growth yield [12].

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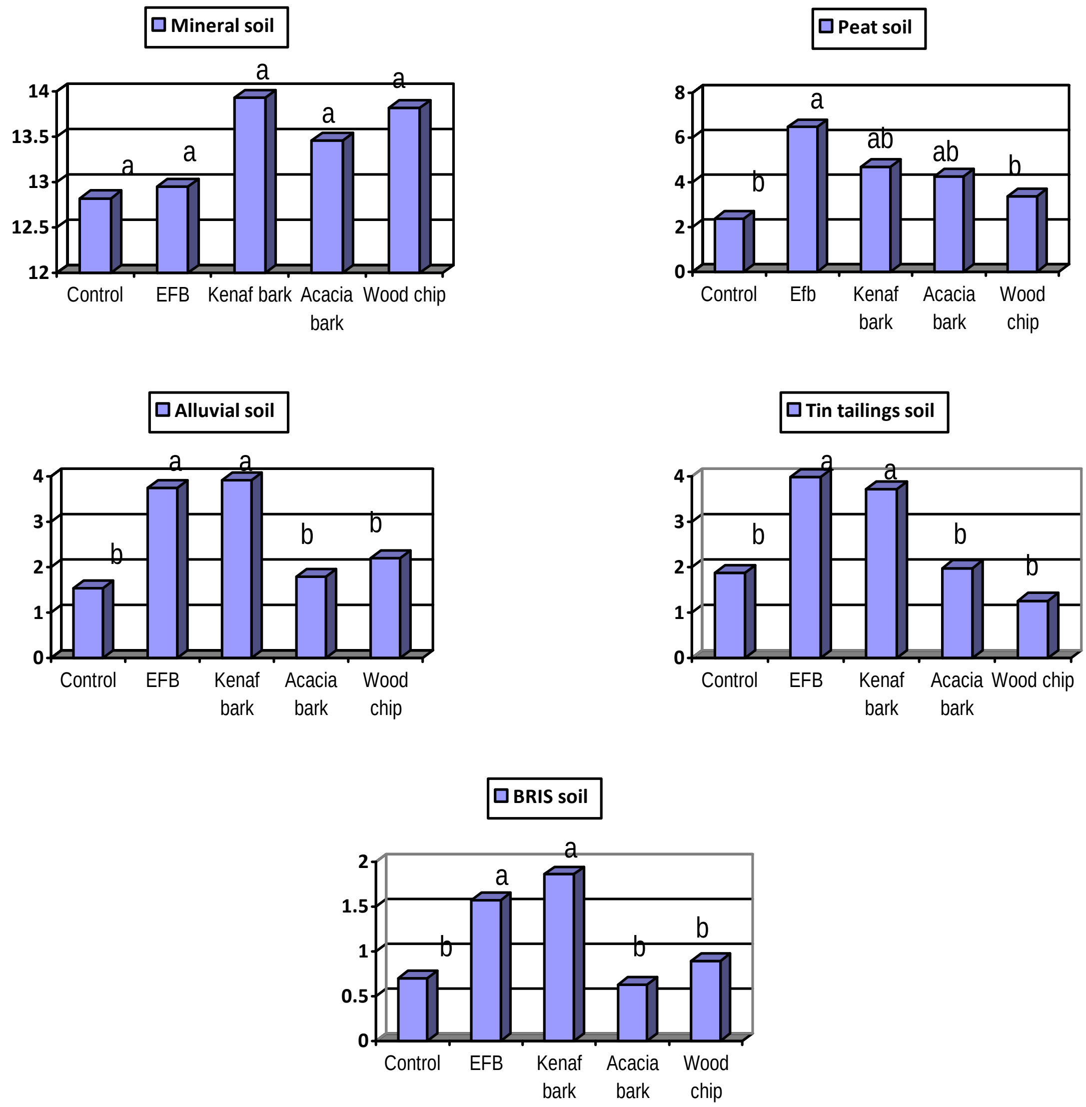

Figure 2. Performance of four different mulches on five different soils in improving dry matter yield (g/plant) of *O. stamineus*; Means with the same alphabet are not significantly different at 5% probability level based on Duncan Multiple Range Test.

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