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Effects of Peat in Reducing the Salinity of Spent Mushroom Waste as Growing Medium

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ABSTRACT

Spent mushroom waste (SMW) is a mushroom-growing material that is left over from the harvest of various mushroom flushes. Normally SMW are left abandoned or discarded at the end of the development cycle. The handling and disposal of SMW remains one of the major environmental problems in mushroom producing countries. SMW can be used as growing medium however it is high of salinity where it will affect plant growth performance. Peat soil are capable to minimize the salinity due to acidic condition of peat. Therefore, peat soil was mixed with SMW in order to reduce the salinity of SMW. The treatments were constructed based on different ratio of SMW and peat soil which consist of 1:0 (T0), 1:1 (T1), 1:2 (T2), 2:1 (T3) and 1:3 (T4) and these treatments were arranged in Randomised Complete Block Design (RCBD), along with four replications. The medium were analysed for chemical properties such as salinity, pH, extractable phosphorus and exchangeable K, Ca, Mg content. The parameters of plant growth performance were measured such as plant height, leaves number, leaves width, branches number, roots length and plant biomass. Peat soil proved significantly able to reduce the salinity of spent mushroom waste and subsequently increased the growth parameter of spinach. However, the high ratio of SMW (T3) and high ratio of peat (T4) were reducing the plant biomass. The ratio of 1:1 (T1) and ratio 1:2 (T2) shows optimum chemical properties as well as shows good plant growth performance which these ratios can be suggested for growing medium.

Keyword: spent mushroom waste, salinity, peat soil, spinach

INTRODUCTION

Mushrooms are grown using organic materials sourced from agriculture, forestry, animal husbandry, and the manufacturing industry (Danny, 2002). Saw dust, banana leaves, peanut hulls, corn leaves and husks, sugarcane leaves, rice and wheat straw, cotton wastes, paper wastes, cocoa shells, wheat, bedded horse dung, and other wastes are examples of these wastes (Jonathan, 2002). In Asia, rice straw base is the most commonly utilized substrate for mushroom production, but sawdust is more commonly used in South East Asian countries presently. Fasidi *et al.* (2008) defined spent mushroom waste (SMW) or spent mushroom compost (SMC) as the residual material remaining after several cycles of mushroom harvesting. Due to a decline in quality and an increase in maintenance costs, mushroom composts are typically not reused. This situation is particularly pronounced in countries with a significant mushroom production industry, where the processing and proper disposal of SMW emerges as pressing environmental challenges (Medina et al., 2009). Approximately 5 kg of SMW is generated for every kilogram of mushroom produced (Ma et al., 2014), resulting in a significant volume of waste. Improper disposal of SMW, which has high salt and organic content, can lead to environmental pollution, including contamination of soil and water (Ribas *et al*., 2009). However, SMW is a rich source of valuable organic materials and can be conveniently recycled in various forms.

SMW offers versatile applications, serving as a valuable tool in vermiculture, a means to enhance soil in agriculture and landscaping, and a matrix for bioremediating polluted soils (Danny, 2002). Its effectiveness as a growth substrate has been widely demonstrated, leading to enhanced production and quality of various vegetables and horticultural crops, resulting in impressive yields across multiple studies (Kavitha *et al*., 2013). Despite its potential as a growth medium, SMW presents a challenge due to its high electrical conductivity (EC), indicative of its salt content. It has known that SMC with high salt content has negatively affected on plant growing (Lemaire et al.,1985). The EC in SMW often surpasses that of natural soils, frequently exceeding 4 dS/m. Salt stress, associated with elevated EC levels, is a known cause of various plant disease. This stress triggers imbalances in nutritional ions, reduced stomatal conductance, diminished photosynthetic activity (Ivanova *et al*., 2015), and alterations in plant morphology that lead to decreased leaf count, reduced plant size, shortened root length, and compromised fruit production (Ivanova *et al*., 2015).

One approach for mitigating the negative effects of salinity is to add organic materials to soil (Luedeling *et al*., 2005; Wichern *et al*., 2006), since they can enhance soil physical, chemical, and biological properties (Wichern *et al*., 2006; Iqbal *et al*., 2016; Chahal *et al*., 2017; Leogrande and Vitti, 2019). The positive biological effects may be attributed to the availability of carbon (C) from the added organic matter, which enables microbial cells to adapt to osmotic stress by producing osmolytes that counteract it (Wichern *et al*., 2006). Peat, an organic substrate commonly used as a growing medium due to its physical and chemical properties, can help reduce salinity levels in SMW. Hence, this study aims to explore how the incorporation of peat influences salinity reduction in SMW. It also seeks to evaluate the growth performance of plants cultivated in a mixture of SMW and peat and examine the altered chemical properties of SMW when treated with peat as a growth medium.

MATERIALS AND METHODS

The experiment was conducted at the UiTM Jasin, and the spent mushroom waste used in the study was obtained from *Pertubuhan Perladang Kawasan* (PPK), Jasin. The SMW planting used in the experiment was *Pleurotus ostreatus* mushroom, while peat was collected from an oil palm plot at UiTM Jasin. The treatments are formulated by employing varying ratios of growth mediums using SMW and peat, as outlined in Table 1. Brazilian spinach (*Alternanthera sissoo*) was selected as the test plant for the experiment, and it was germinated following the standard procedures recommended by the Department of Agriculture (DOA) in Malaysia. After 14 days of germination, the plants were transplanted, and the standard procedures for growing plants was followed. This encompassed the application of 4 grams of NPK 15:15:15 fertilizer per plant, alongside regular weeding. In the field, the polybags were arranged in a Random Complete Block Design (RCBD), spaced at 60 cm intervals between each polybag. The entire experiment was replicated five times.

Table 1: Treatments

Treatment	Ratio
T0: Spent Mushroom	1:0
T1: Spent Mushroom and Peat	1:1
T2: Spent Mushroom and Peat	1:2
T3: Spent Mushroom and Peat	2:1
T4: Spent Mushroom and Peat	1:3

The parameters of plant growth performance such as plant height, leaf width, and leaf number were recorded every two weeks. At the end of the experiment, Brazillian spinach were harvested, and the parameters of plant biomass and root length were measured. The chemical properties of SMW and the combination of SMW and peat were analysed for pH (soil water ratio method 1:10), electrical conductivity (EC), extractable phosphorus (P), as well as exchangeable of K, Ca, and Mg. The determination of extractable P involved employing the Bray II solution, while the exchangeable levels of macronutrients K, Ca, and Mg were ascertained through the modified shaking method utilizing 1 M ammonium acetate (NH_4OAc) solution. The quantification of phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) was conducted using an Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES). Subsequently, the acquired data was subjected to simple analysis of variance (ANOVA) using the SPSS program. Significant differences between means were compared using Tukey's test.

RESULT AND DISCUSSION

Plant growth performance

Figure 1 displays the growth performance data of Brazillian spinach, including leaf number, leaf width, plant height, branch number, root length, and plant biomass, under different ratios of SMW and peat. The results of the analysis of variance indicate that there were significant differences in all growth parameters SMW (T0) and the other treatments that included peat. Among the treatments that included peat, the ratio of 1:1 (T1) resulted in better growth performance than the other ratios. However, as the ratio of peat increased, the growth parameters of Brazillian spinach decreased. Nevertheless, there were no significant differences among the treatments that included peat, except for plant biomass. The plant biomass of Brazillian spinach decreased significantly as the ratio of SMW and peat increased. Overall, these results suggest that a mixture of SMW and peat at a ratio of 1:1 (T1) is optimal for the growth performance of Brazillian spinach, while a higher ratio of peat may negatively affect plant growth, particularly in terms of plant biomass.

Incorporating peat into the growing medium can reduce the negative effects of high salinity in SMW. Besides that the application of peat also reduce the alkalinity of medium thereby increase nutrient uptake and subsequently support the plant growth (Medina *et al*., 2009). However, a high ratio of peat (T4) can also result in acidic growing conditions, which can limit plant growth performance. Peat soil is naturally acidic due to the presence of large amounts of organic matter, which can release organic acids such as humic and fulvic acids (Jordon *et al*., 2018).

Selected chemical properties

Electrical conductivity (EC) shows varied significantly among different media. The 100% of SMW (T0) had the highest electrical conductivity (EC) value (1.35mS/cm), while T4 had the lowest (0.32 mS/cm). However the salinity of T0 is not considered high salinity since the value is less than 4 dS/m. The media of SMW was high salinity due to higher in pH value (Maher et al., 2000; Jordan *et al*., 2008). The mean salinity of SMW (T0) was recorded at 1.35 mS/cm, while the mixture of SMW with peat shows significant reduction in salinity. As illustrated in Figure 2 (a), the incorporation of peat into the growing media resulted in a reduction in salinity levels. An increase in the ratio of peat to soilless media led to a decrease in pH [Figure 2 (b)], but the pH remained within the optimum range for nutrient uptake. The highest rate of peat application resulted in the lowest pH and salinity levels in the growing media. This can be attributed to the acidic nature of peat, which lowers the salinity of the media.

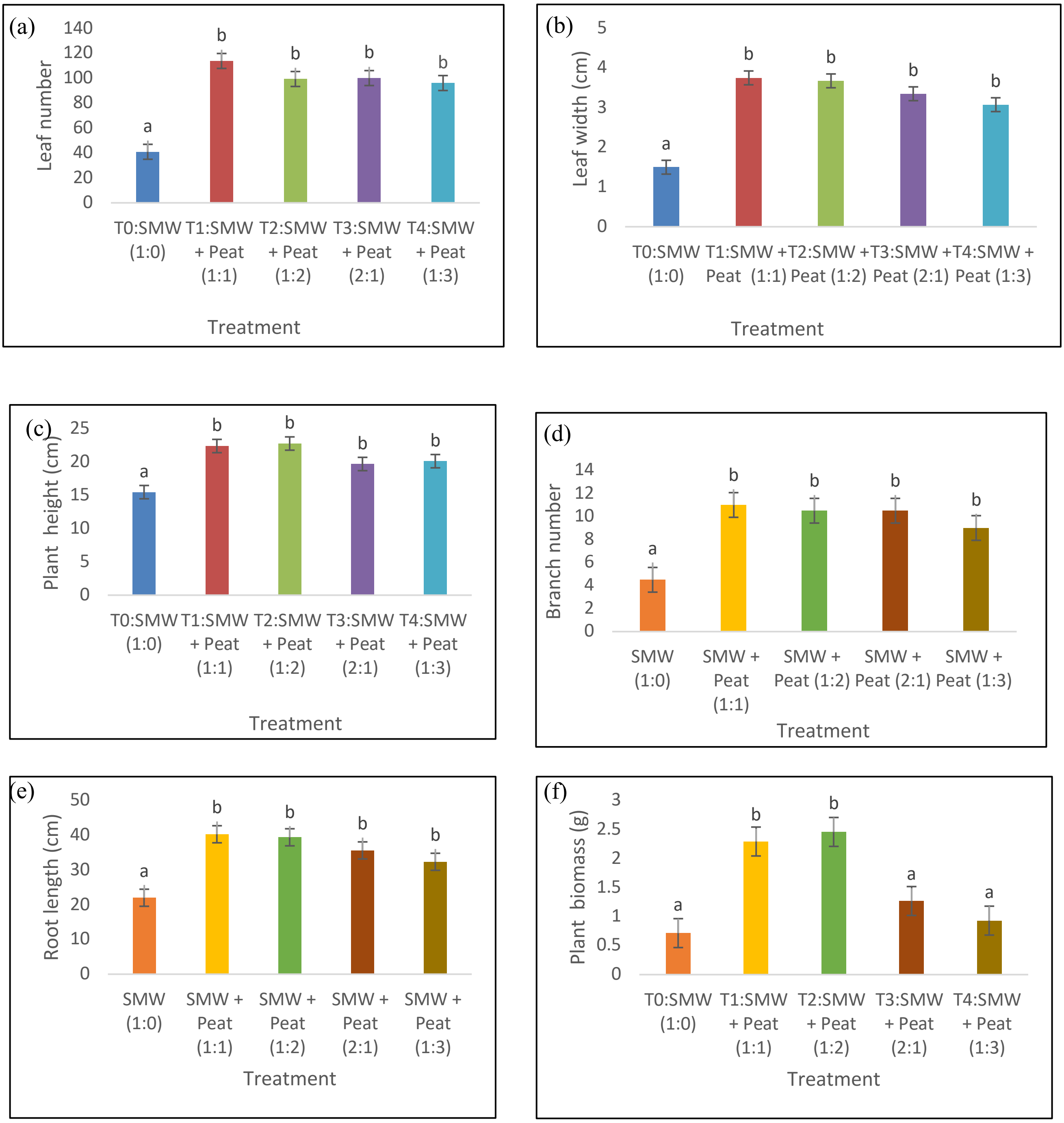

Figure 1. *(a) Leaf number, (b) leaf width, (c) plant height (d) branch number (e) root length and (f) plant biomass of Brazillian spinach after two months planting*

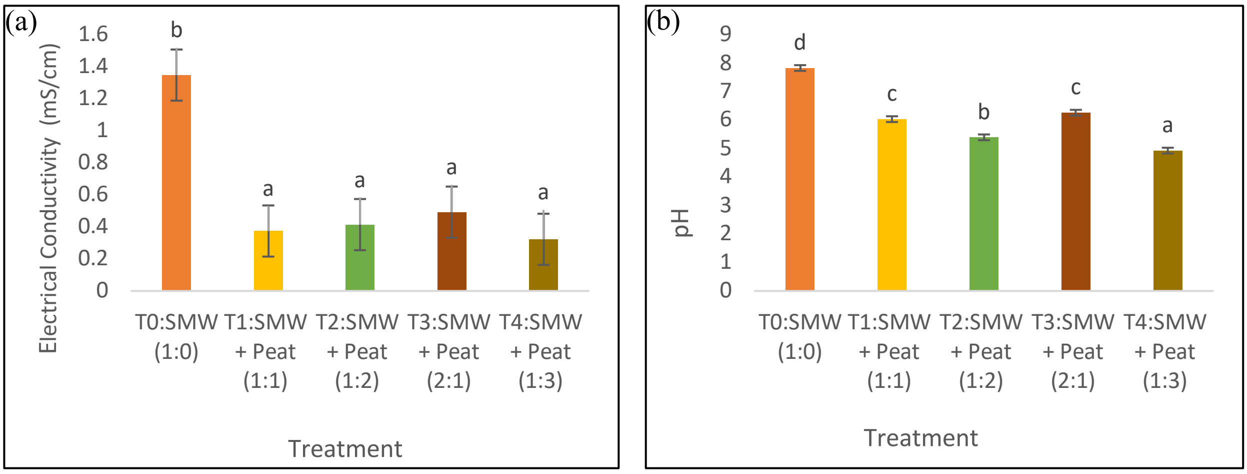

Figure 2. *(a) electrical conductivity and (b) pH of different ratio of SMW and peat*

Macronutrient content

All the nutrients shows varied significantly among different growth media. Table 2 clearly sho ws the SMW (T0) contain high macronutrients that can support plant growth. Dallon's (1988) findings reveal that the SMC's NO_3-N, K, and Mg contents are significantly elevated, while so luble salts and Ca are also abundant. Despite the high macronutrient content of T0, the treatm ent exhibited poor growth performance in spinach. This can be attributed to the high salinity l evels in the SMW, which can negatively impact crop biomass and productivity through variou s physiological, morphological, and biochemical processes (Khan et al., 2021). Research sugg ests that high salinity levels can interfere with plant water uptake and lead to excessive accum ulation of ions, ultimately reducing plant growth and productivity.

Interestingly, adding peat to the SMW can further enhance the macronutrient content of the growing medium, particularly at a 1:1 ratio (T1). Peat has long been an essential component of growing media due to its unique properties that facilitate plant growth. However, overreliance on peat can have negative consequences, such as reduced P, K, Ca, and Mg levels in the growing medium as shown in Table 2. This trend is evident in the growth performance of Brazilian spinach, where a high peat rate (T4) is associated with diminished plant growth. The treatment of T4 stands out as having the lowest extractable P, likely due to the high peat soil content compared to SMW. Peat soil is known for its acidic properties, which can contribute to low extractable P levels, particularly in T4 where much of the P is strongly bound by Al and Fe oxide. According to Havlin *et al.* (2013), soils with high levels of Fe and Al tend to adsorb P in large amounts, which could explain the low extractable P levels in T4.

Table 2. Mean comparison of macronutrient content

Treatment	Extractable P (mg/kg)	Exchangeable K (mg/kg)	Exchangeable Ca (mg/kg)	Exchangeable Mg (mg/kg)
T0: SMW (1:0)	6198.66b	12610c	35423.33b	5202b
T1: SMW + Peat (1:1)	1430.6a	6511b	6210.333a	1066.533a
T2: SMW + Peat (1:2)	1025.13a	5120.667ab	3370.33a	679.5a
T3: SMW + Peat (2:1)	2014.66a	5605.66ab	7975a	1383.667a
T4: SMW + Peat (1:3)	874.03a	3918a	2434.66a	500.63a
P value	0.000	0.000	0.000	0.000

Note:[a,b] Different letters indicate significant difference of plant growth mean at $p< 0.05$ level (Tukey multiple comparison test)

CONCLUSION

To summarize, this study effectively demonstrates that peat soil has the capacity to mitigate the salinity levels in spent mushroom waste, leading to notable improvements in the growth parameters of spinach. Nonetheless, it's worth noting that the excessive utilization of SMW (T3) and peat (T4) ratios resulted in a reduction of plant biomass. Consequently, the ratios of 1:1 (T1) and 1:2 (T2) emerge as recommended ratios for the growth medium. These ratios have been proven to enhance plant growth while effectively diminishing salinity, rendering both mediums ideally suited for cultivation.

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