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RESEARCH ARTICLE

EVALUATION OF MUNGBEAN (*VIGNARADIATA* L.) AS GREEN MANURE ON SOME SOIL CHARACTERISTICS UNDER PERLIS CONDITION

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ABSTRACT

Adding plant residue with or without mineral fertilizers to soils is seen as an excellent approach in agriculture due to the fact that it enhances the quality of the plant and the fertility of the soil. The study intends to elucidate the influence of green manure on the properties of soil and enumerate suitable amounts of green manure that would be optimum for the soil. A field experiment was conducted at the experimental farm of Institute of Sustainable Agro technology, University Malaysia Perlis, Padang Besar, Perlis, Malaysia. The results confirmed that mungbean as green manure significantly increased all of the properties of the soil except for total N and pH. Level 15% (150g kg^{-1} soil) factor had the highest magnesium, phosphorus, soil organic carbon, organic matter and C:N, whereas control treatment gave highest value in pH and total N. There was no significant different among the treatments in calcium and potassium content. The three levels of mungbean residue had impact on soil properties but level 15% led to improve the soil chemical properties more than did 5% (50 gkg^{-1} soil) and 10% (100 gkg^{-1} soil).

INTRODUCTION

The low fertility level of soils around the world results in general low crop yields. Chemical fertilizers have been used to circumvent this problem and increase yields. However, its repeated use will inevitably result in the buildup of toxicity in the soil, involving elements such as cadmium (Cd), arsenic (Ar) and lead (Pb). These buildups will be transferred into plants and subsequently, its fruits and vegetables. Prolonged utilization of chemical fertilizers will also alter the pH of the soil, increase the presence of pests and decrease the presence of good microbes in the soil. The detrimental side effects of these fertilizers have shifted the current focus to biological management systems. Green manure crops are plants that act as protective cover for soil in order to improve its physical, chemical and biological characteristics. Green manure could in theory be planted independently or alongside other crops. Green manuring is defined as a practice of alternating green manure with the primary agricultural crop in a field.

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Subsequently, the green manure crop will remain in the soil and not harvested in order to improve the health of the soil and recycle its nutrients (Rhodes *et al*., 2012). Mungbean is an important leguminous crop and is commonly used as green manure. It is advantageous in the context of certain crops as it increases the productivity of the soil (Buresh and De Datta, 1991). The improved soil physical conditions as the result of accumulated organic matter from the incorporation of green manure or crop residue, are mostly due to decreased bulk density, increase in total pore space, and hydraulic conductivity of the soil (Tirlok *et al*., 1980). Furthermore, synthetic fertilizers are quite expensive, and in order for them to be effective, the crops will require significant amounts. It is therefore prudent that better green manure crop be used. The current work involves the determination of the efficacy of the utilization of mungbean as green manure on the physical and chemical properties of the soil in Perlis, Malaysia.

MATERIALS AND METHODS

Field work was conducted in 2016 at the experimental farm of Institute of Sustainable Agro technology, University Malaysia Perlis, Padang Besar, Perlis, Malaysia (Lat. 76° 28° 30 N, Long. 254° 46° 00 E). The climate in the region is tropical, reporting average annual rainfall of 1,700-2,200 mm. Its mean annual temperature is 27 °C. The treatment process was arranged in RCBD and replicated five times. The green manure treatments encompassed multiple levels: 50, 100 and 150 g per kg of soil, with a control treatment, equivalent to 5%, 10% and 15% per kg soil. In order to determine the physic o-chemical properties of the soil prior to the addition of green manure, the samples were taken from a depth of 0-30 cm(Table 1). The mungbean was planted on 17-11- 2015and harvested on 18-12- 2015.The chemical characteristics of the green manure are tabulated in Table 2.Each plot was represented by five pots. The mungbean plants were incorporated into the soil during the vegetative phase. Samples from the soils were taken four weeks after the incorporation of mungbean, air-dried, and sieved through a 20-mesh screen. Some of the properties that were measured include pH, organic carbon (O.C), organic matter (O.M), total N, available P, C:N ratio, potassium (K) equivalent, magnesium (Mg) equivalent, and calcium (Ca) equivalent.

The pH was determined using a method reported by Blakemore *et al*., (1987). The organic carbon content was determined by a method reported by Walkley and Black (1934). The total N and available P were determined using method reported by Van Reeuwijk (2002), while the presence of K, Mg, and Cawere determined using a method reported by Holmgren *et al*., (1977).The soil pH was determined using apH meter, while the amount of total nitrogen (N) was determined by kjeldahl digestion and semi-micro distillation. The exchange cations (Ca, Mg, and K) were determined using an Atomic absorption spectrophotometer (Varian, Australia, model spectra AA), while the total organic C was determined using Wakley and Black titrimetry. The actual content of organic matter was determined using Muffle furnace (Barnstead (USA) model F62730-33), while phosphorus (P) content was determined using a UV-Visible Spectrophotometer (Thuramed (USA) model T 60).

Statistical Analysis

The statistical significance of the data was tested using the analysis of variance package that is included in Microsoft Excel 2013, while SAS 9.0 mean comparisons were performed using Duncan's multiple range test. A probability level of $p \leq 0.05$ was regarded as significant.

RESULTS AND DISCUSSION

Characteristics of soil

Initial soil properties of the experimental site are presented in Table 1. The mechanical analysis indicated that the soil was loamy sand. Organic carbon value of 0.14% for the experimental site was low while total nitrogen and available phosphorus values of 0.13% and 44 mg kg^{-1}, respectively, were moderate. The soil was extremely acidic, with a pH value of 4.2. Generally, the soil was low in exchangeable bases, with potassium, magnesium, and calcium values of 0.24, 0.8 and 4.2 mol kg^{-1}, respectively.

Characteristics of the mungbean plant

Some chemical properties of the mungbean residue analyzed were pH, organic carbon (OC.), organic matter (OM.), nitrogen (N), phosphorous (P), C: N ratio, potassium (K), magnesium (Mg) and calcium (Ca)) at the vegetative phase of growth (Table 2).

Effects ofdifferent amount of mungbean residue onsoil nutrients

The effect of the application of mungbean residue on soil nutrients is shown in Figures 1, 2, and 3. The concentration of K of the applied mungbean residue was low (Figure 1), rendering its impact on the soil's parameters almost negligible.

Table1.Soil characteristics of the experimental site

pH	O.C (%)	O.M (%)	N(%)	P (ppm)	C:N	K(%)	Mg (%)	Ca (%)	Sand(%)	Silt(%)	Clay(%)	Textural class
5.1	0.14	3.7	0.13	44	1.07	0.24	0.8	4.2	79.1	11.1	6.1	Loamy sand

Table 2. Chemical characteristics of the mungbean residue used in the experiment.

pH	O.C (%)	O.M (%)	N(%)	P (ppm)	C:N	K(%)	Mg(%)	Ca(%)
5.2	27	79	3.6	2440	6.75	29.6	11	36

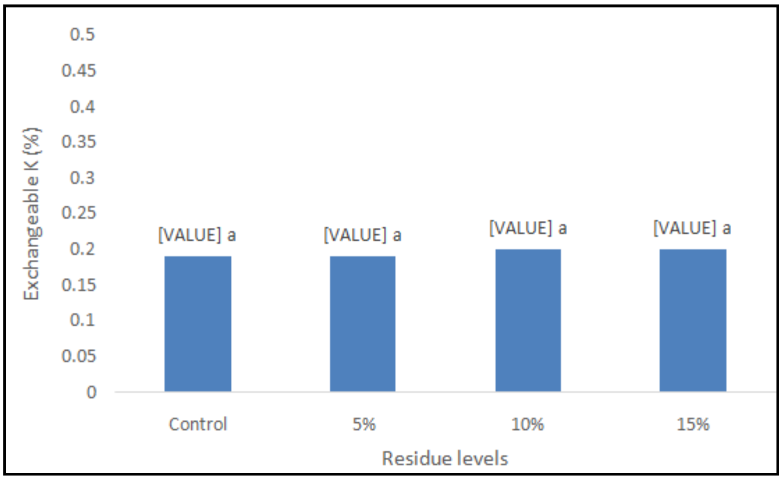

Figure 1. Effects of mungbean residue levels onpotassium content in the soil

The application of mungbean residue to the soil resulted in a slight increase in the concentration of Ca in the soil, but this increase was not significant (Figure 2). However, the influence on Mg in the soil via the application of mungbean residue was significant (Figure 3). Mungbean residue contains amounts of Mg, which, in part, contribute to increase exchangeable Mg in the soil (Table 2).The addition of mungbean residue to the soil might have provided supplemental nutrients, such as K, Ca and Mg to the soil. Where they postulated that the introduction of organic manure increases the concentration of organic matter, which will subsequently increase the levels of K, Ca and Mg. Nutrients are released over time via chemical, physical, and biological processes.

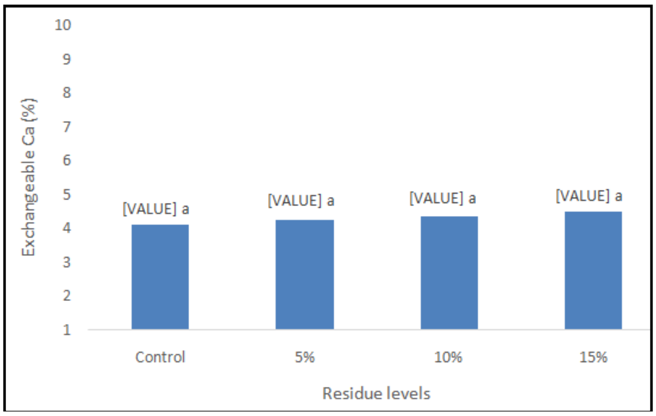

Figure 2. Effects of mungbean residue levels on calcium content in the soil

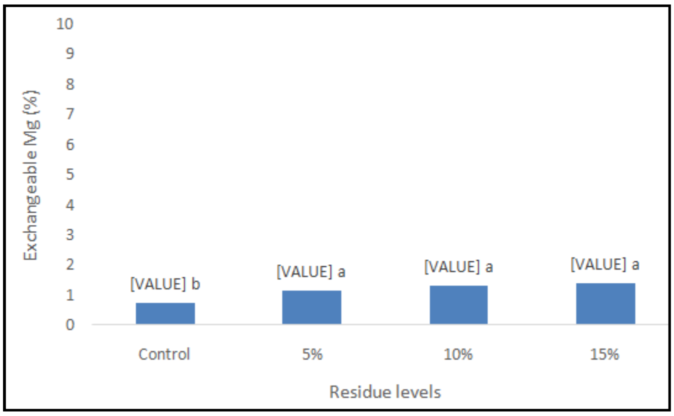

Figure 3. Effects of mungbean residue levels on magnesium content in the soil

Considerable quantities were released within a short period of time, depending on residual quality (Luna-Orea *et al*., 1996) and the kind of nutrients (Lefroy *et al*., 1995). Increases in exchangeable cations (K, Ca and Mg) and base saturation were reported by Kretzschmar *et al*., (1991) and Geiger *et al*., (1992).The changes in the properties of the soil were mainly attributed to the management of activities, such as the application of fertilizers (Zhang *et al*., 2012). Therefore, it can be speculated that changes to the chemical properties observed our study were due to the usage of mungbean residue. Ogbodo, (2011) reported that soil treated with rice straw, burnt rice husk, and legume led to increased levels of Ca, K and Mg in the soil. Zeynep and Gülser (2015) noticed that the exchanged Mg and K values of the soil significantly increased, but the level of exchanged Ca decreased compared to the control treatment via the application of rice husk compost.

Effects of different amount of mungbean residue on soil pH

Figure 4 indicated that 5% and 10% levels of application of mungbean residue resulted in a corresponding decrease in the soil pH compared to the control treatment. However, at 15% mungbean residue, soil pH was similar to the control. This might be due to the role of organic ligands released post-degradation of crop residue. Higher microbial activity and CO_2 release into the soil in the presence of crop residue could also reduce pH. Increased soil pH could be due to the contribution from base elements, such as Ca, Mg and K in plant residue, as postulated by Somado *et al*., (2007). Legume residue often induced greater increases in soil pH compared to grasses or other crop residue (Hue and Amien, 1989; Bessho and Bell, 1992; Miyazawa *et al*., 1993).However, plants are made up of large amounts of organic N, encompassing proteins and amino acids, which can be mineralized to nitrate in soils, producing protons during nitrification, which in turn acidifies the soil (Yan *et al*., 1996). Shahrzad *et al*. (2014) reported that sorghum, safflower, sunflower, and trifolium residue showed decreased pH when compared to its control treatment. Deanna (2013) noted that corn residue treatments did not affect the soil pH at 0-5 cm or 5-20 cm soil depths. This was in contrast with Ogbodo (2011), who reported that pH was significantly higher than the entire soil's chemical properties with treated soil (rice straw, burnt rice husk and legume residue).

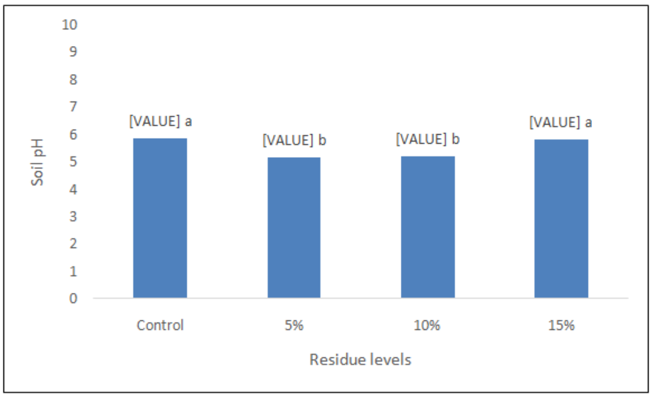

Figure 4. Effects of mungbean residue levels on pH of the soil

Effects of different amount of mungbean residue on soil nitrogen

As shown in Figure 5 all residue treatments tended to reduce the concentration of Nas opposed to the control treatment. Due to N being a key nutrient for microbial growth, hence having tremendous influence on residual breakdown (Mohammed *et al*., 2014). This agrees with Kaleeem *et al*., (2015) that control treatment after 28 days results in the highest total N in the soil, at 30.9 mg.kg-1, from *Glycine max* root, *Zea mays* shoot, *Zea mays* root, and *Populuseuramericana* leaves (Kaleeem *et al*. 2015). However, Singh *et al*., (2008), Ogbodo (2011) and Behnam *et al*., (2014) disagreed and reported that the available N in the soil increased with the incorporation of rice, mungbean, cotton, maize, wheat, and alfalfa.

Effects of different amount of mungbean residue on soil phosphorus

The application of green manure significantly increased the concentration of P in the soil (Figure 6), where the greatest increase was recorded at 15% level of residue application. However, this increase fluctuated, which was mostly due to the different amounts of mungbean residue.

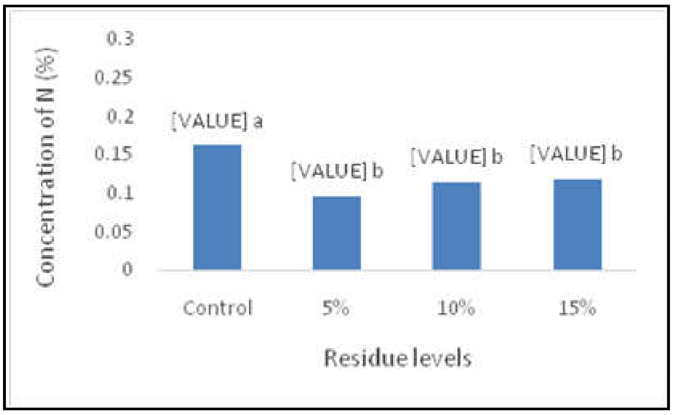

Figure 5. Effects of mungbean residue levels on nitrogen content in the soil

Due to mungbean residue in this study had relatively high P (2440 ppm) , which led to higher available P in the soil (Table 2).Organic acids, which are mostly regarded as a decomposition product of organic matters, is a source of nutrient for plants, especially P (and other micro elements). Vavoulidou *et al*. (2004) pointed out that due to organic treatment, the productivity levels of the soils are directly correlated with the concentration of P. The tendency of P to accumulate in the soil from intensive cropping systems due to the addition of crop residue has been observed in different cropping systems. The overall conclusions drawn from these data postulated that mungbean residue contributed towards increasing the concentration of P in the soil. The amount of mungbean residue is directly correlated to the concentration of P.

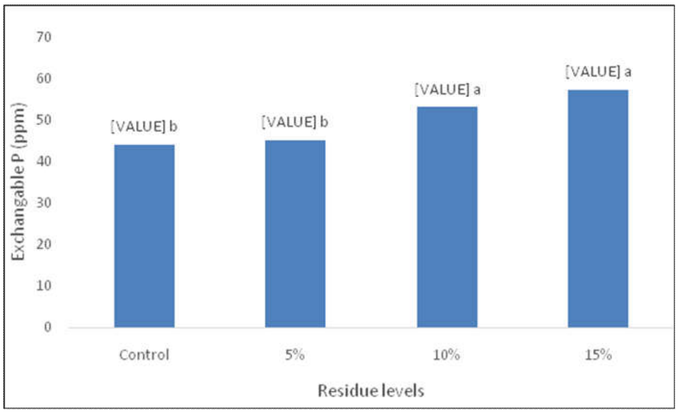

Figure 6.Effects of mungbean residue levels on phosphorus content in the soil

Effects of different amount of mungbean residue on organic carbon

Figure 7 shows the soil organic carbon content. The residue treatments greatly increased the amount of carbon in the soil compared to the control. This was expected, as reported by Singh *et al*. (2008). The decomposition of mungbean residue resulted in products that serve as a binding agent, which holds the soil particles together via the formation of aggregates, culminating in increased C storage (Jastrow *et al*., 1997). The increased doses of mungbean residue resulted in increased carbon content in the soil. Ogbodo (2011) pointed out that residue that is treated with rice straw and legume increased the levels of organic carbon, while Goyal *et al*. (1992, 1999) found that application of inorganic fertilizer and organic amendments (wheat straw, animal manure, or sesbania) increased the levels of organic carbon at amounts higher than inorganic fertilizer in the top 15 cm of the soil (plow layer).

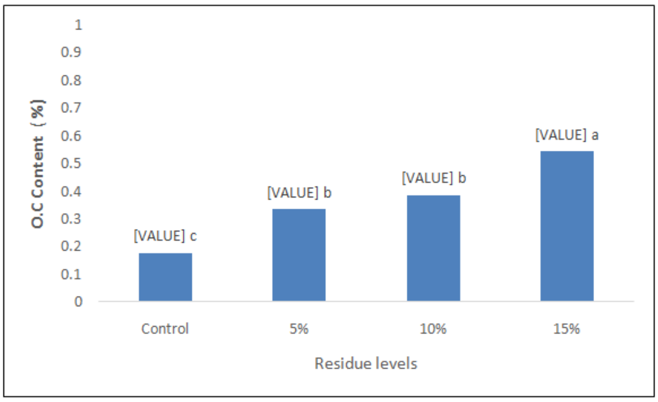

Figure 7. Effects of mungbean residue levels on organic carbon content in the soil

Effects of different amount of mungbean residue on organic matter

The highest organic matter content was reached at all residue treatments, whereas the lowest in the control treatment (Figure 8), due to the decomposition of mungbean residue producing more organic matter in the soil. The introduction of the residue resulted in the overall increase in the level of organic matter in the soil, where both are directly correlated. Increased application of biomass of different treatments also contributed towards the improvement of the status of organic matter in the soil (Sarwar *et al*., 2008), mostly from decomposition. These increases in the levels of organic matter is associated with treating soils with crops residue. This observation agrees with those made by Ogbodo (2011) and Zeynep and Gülser (2015), but disagreed with Deanna (2013).

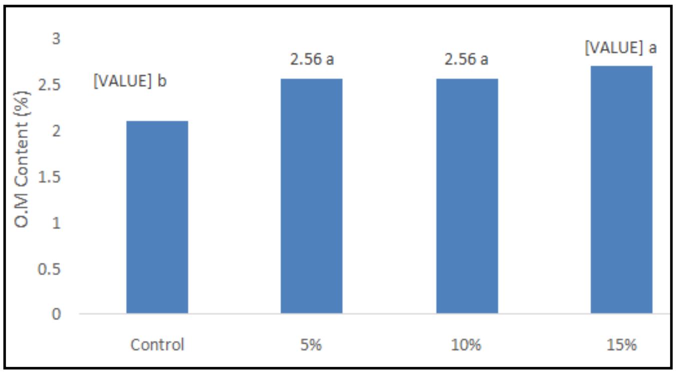

Figure 8. Effects of mungbean residue levels onorganic matter content in the soil

Effects ofdifferent amount of mungbean residue on C:N ratio

The result showed that green manure application provided a significant increase in C:N ratio in the soil (Figure 9).

However, there was no differences among residue treatments. The mineralization of N is inversely related to the C:N ratio of incorporated crop residue (Norman *et al*., 1990; Aulakh *et al*., 1991).

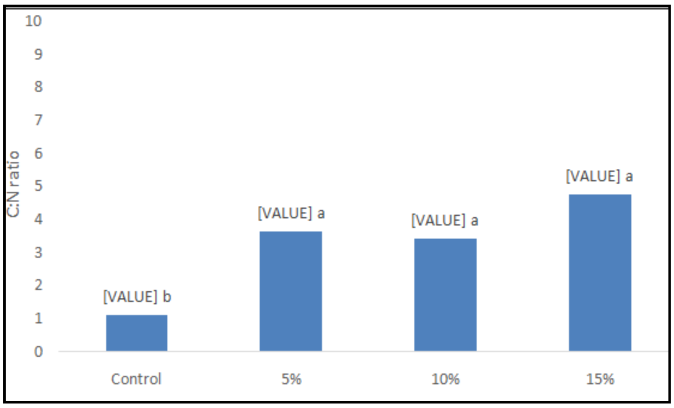

Figure 9. Effects of mungbean residue levels on C:N in the soil

The lower C:N ratio of the green manure material is commonly related with higher rates and total quantities of the mineralization of N. Higher C:N ratios may suggest that microbial populations use nitrogen with wide C:N ratios, possibly led that to reducing N and C conservation in the long term (Franzluebbers and Arshad, 1996). Therefore, our results showed that addition of mungbean resulted in a higher C:N ratio than in control treatment.

Conclusion

The improvement of soil by legume green manure is particularly important in tropical soils, which have low natural fertility and high organic matter decomposition rates. The application of green manure constituted by mungbean plants had a positive effect on soil chemical properties, and therefore this organic waste may be considered a good strategy for application to agricultural areas under Perlis condition. Green manure cultivation is a promising technology forth reduction of chemical fertilizers and herbicides in soils. The results showed that green manure treatments led to an increase in magnesium, phosphorus, soil organic carbon, organic matter and C:N ratio. Based on these results, the application of mungbean as green manure can lead to an important reduction in chemical fertilizers use. Overall, these results indicated that mungbean residue applied to the soil has the potential for use as a green manure crop.

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