The use of a by-product of paper industry in reclamation of berry-cultivated soils

Mohammadi Torkashvand, A.[1]*, Bizhannia, A.[2], Mavajpour, M.[2] and Haghighat, N.[1]

[1]Rasht Branch, Islamic Azad University, Rasht, Iran
[2]Iran Silkworm Research Center, Rasht, Iran
*Corresponding E-mail: m.torkashvand54@yahoo.com;Torkashvand@iaurasht.ac.ir,
Tel. 0098-131-4247058; Fax: 0098-131-422362.

Abstract: Using conventional lime in amending acidic soils reform is expensive. Therefore, the importance of using cheaper resources is seems more necessary. A variety of materials including industries by-products are used in reclamation of acidic soil. By-products with the character of lime not only increase the pH and improvement of soils have special priority, but also increase the fertility with create consistency with the aggregate building sustainable soil, air conditioning, increases porosity and cation exchange capacity and soil reactivity. In this study, the possibility of using paper sludge lime had been investigated in berry orchard improvement under cultivation of sericulture in a field experiment. The results indicating the potential of paper lime sludge as acidic soil modifiers in the replacement of conventional calcite sources such as calcite which can reduce the disposal costs and possible environmental contamination of this by-product.
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1. Introduction

Amelioration of acid soils with liming materials is a common management (Haby et al, 1995; Quoggio et al, 1995), but from other materials are also used as acid soil amendment, such as gypsum and phosphate rocks (Hea et al, 1996) and some industrial by-products (Edward et al, 1985; Vityakon et al, 1995; Oguntoinbo, 1996; Stuczynski et al, 1998; Curnoe et al, 2006; Alves et al, 2006; Mohammadi Torkashvand, 2010). The main aim of soil liming is to neutralize acidic inputs and recovering the buffering capacity to the soil (Ulrich, 1983).

Paper mill sludge (PMS) is produced as a by-product of paper industry that disposal of this material presents a problem for the mill (Battaglia et al., 2007; Mahmood and Elliot, 2006). Disposal by land filling, the most common disposal method, is costly and faces increasingly stringent environmental regulations (Feldkinchner et al., 2003). Lime sludge is the solid waste produced as part of the process that turns wood chips into pulp for paper. The major component of lime mud is calcium carbonate ($CaCO_3$) and it is estimated that about 0.47 m^3 of lime mud is generated to produce 1 ton of pulp (Wirojanagud et al., 2004).

A 4-year field study in Alberta (Macyk, 1996) recommended an agronomically sound decomposed pulp mill sludge application rate of 40–80 dry ton ha^{-1} for brome grass. Kannan and Oblisami (1990) also concluded in a same research that paper alkaline waste along pulp with paper in irrigating sugar can fields is leading to reduced growth. High consumption of sludge (10 ton/ha) also caused to reduced plant yield. Leon et al. (2006) during a research concluded that the use of paper sludge as soil modifiers significantly caused to decreased rot in bean in sludge treatments compared with control. They knew the reducing disease result from a change in properties of soil biology. Curnoe et al. (2006) identified the positive effects of lime sludge paper factory on maize yield. Gaskin and Morris (2004) indicated that lime mud has potential to be used as an agricultural liming material because of its capability to neutralize soil acidity (increase soil pH) and add calcium and magnesium to the soil. Although high moisture content of lime mud creates more shipping and handling difficulties than typical dry agricultural liming materials (Mahmoudkhani et al., 2004), this obstacle can be overcome as sludge dewatering technology improves (Chen et al., 2002 and Yin et al., 2004).

2. Materials and Methods

In this study, the effect of a by-product of paper industry called Paper Mill Sludge (PMS) was investigated as a liming factor to correct soil acidity of berry fields. The chemical composition of the paper mill sludge (was collected from Pars and Chocka factories, Khoozestan and Guilan provinces, Iran) showed that this compound contained about 58.4% calcium carbonates equivalent and a pH about

13.2 (pH of 1:2.5 dry paper mill sludge/water suspension), and small amounts of Zn, Cu, Cr, Cd and Pb respectively 4.12, 2.35, 7.54, 3.25 and 28.6 mg.kg^{-1}. A field experiment was conducted in a berry orchard of silk worm research center by a randomized completely block design with three replicates pay attention to incubation experiment results. In addition to a control treatment, the amounts of 2.5, 5 and 10 ton.ha^{-1} of PMS and a treatment of used common lime i.e. calcite amounted 2.5 ton.ha^{-1} were used. The dimension of every plot was 1×7m including 5 berry plants. All plots received N-P-K fertilizers, uniformly.

The soil analysis of berry field showed a pH=6.3. The ECe, nitrogen and organic matter, phosphorus and potassium (mg/kg) were 0.32 dS/m, 0.105%, 1.12% and 17.2 and 168.2 mg/kg, repectively. Total concentrations of some elements in the paper mill sludge were determined in the extract after digestion of samples with HNO_3 and HCl (Hossner, 1996) for elemental analysis. The amounts in the digests were determined using inductively coupled plasma atomic emission spectrometry (ICP-AES, LEEMAN LABs, Inc.). The sludge pH and EC (Rhoads, 1996) were determined in a 1:2.5 paper mill sludge/water suspension.

After 90 days, leaf dry matter yield was determined after drying of the harvested shoots at $70°C$ for 48 h. Total kjeldahl nitrogen (TKN) of samples were estimated by using a micro-kjeldahl method (Singh and Pradhan, 1981). Subsamples of dry leaf were ground and then dry-ashed in a furnace at $550°C$ and then extracted with 2N HCl. Concentration of K by flame photometry and P by spectrophotometry. Data were analyzed by standard ANOVA procedures using MSTATC and SAS softwares and significance were based on $\rho < 0.05$ level for LSD Test.

3. Results and Discussion

Many studies have shown that the liming improved the growth of many crops cultivated on acid soils such as red clover (Steiner and Alderman, 2003), wheat and barley (Tang et al., 2003), peanut (Chang and Sung, 2004) and cotton (Pearson et al., 1973). Results of this study showed that the berry leaf dry matter yield increased significantly (P≤0.05) in 2.5 and 5 ton/ha of PMS treatments than in the control (Figure 1). This increase in leaf dry matter yield was 1.36 and 1.55 times higher than in the control (L_0). Increase in yield can be due to the correction of soil acidity lead to improved soil conditions for growth berries. Hea et al. (2009) during the research had been used from paper industry lime sludge as soil acidic modifiers and concluded that the amount between L_2 and L_3 treatments, i.e. between 4.51 and 9.01 tons per hectare cause to a better response of ryegrass yield to application of lime sludge. Pantasiz et al (2009) in a greenhouse experiment in the use of paper alkaline waste concluded that use of it, caused to increase plant growth.

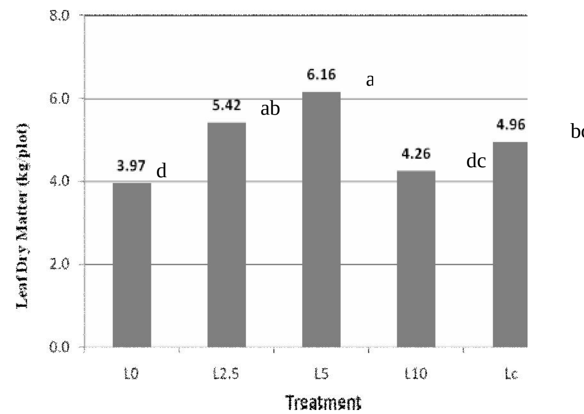

Figure 1. The effect of treatments on leaf dry matter

PMS and calcite lime treatments increased leaf protein, significantly (Figure 2). Sericulture production is depending to the amount of leaves percent of proteins, therefore sludge had been caused to increase the percent of protein and yield of leaf. Increase of leaf protein in sludge treatments is because the increase of leaf N concentration in this treatment (Figure 2). Because leaf nitrogen concentration is more in calcite lime treatment than sludge treatment, so the percentage of protein in the leaves in calcite lime treatments even higher in sludge treatment, so according to leave yield, in the treated soils with 2.5 and 5 ton sludge, is more important in comparison with calcite lime.

Uptake more phosphorus in 2.5 ton/ha treatment due to more concentration of phosphorus in leave dry matter and higher plant yield (dry leaves) is undergoing this treatment. Reducing the treatments of P concentrations in leaves and other paper sludge and lime calcite is considered the result of lower uptake of phosphorus. It is likely that the increases of calcium lead to phosphorus precipitation as calcium phosphates and phosphorus availability it had been restricted for plants. Increasing the potassium uptake in treatments 2.5 and 5 tons per hectare is due to increased leave potassium concentration and increase dry matter of leaf yield. Nunes et al (2008) during a greenhouse study to evaluate potential of paper lime sludge as a cause of calcareous on the growth of wheat in two soil of Cambisols and Arenosol concluded that the use of it cause to significantly increase of soil PH, total nitrogen, available phosphorus and potassium. They introduced this by-product as a calcareous factor in amending acidic soils which are better for growth of grain crops along with magnesium fertilizers.

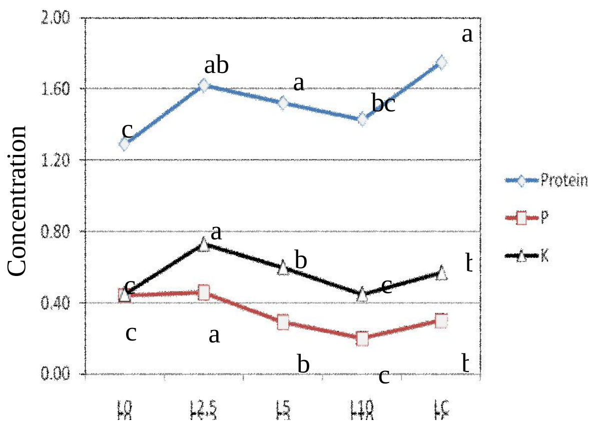

Figure 2. The effect of treatments on phosphorus, potassium and protein concentrations (%) of berry leaves and nutrients uptake of soil (g/plot)

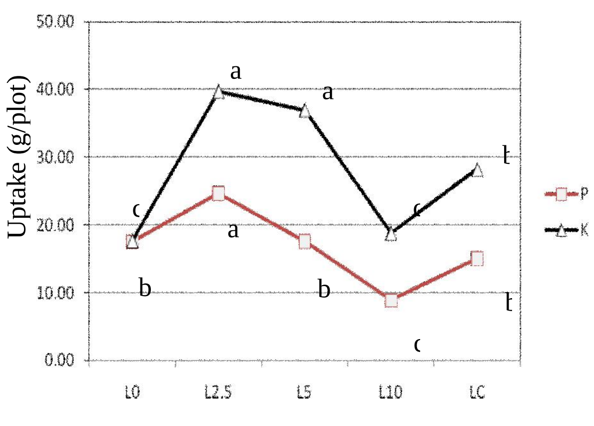

Figure 3. The effect of treatments on phosphorus and potassium uptake by berry leaves

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Corresponding Author:
Dr Ali Mohammadi Torkashvand
Agriculture Faculty,
Rasht Branch, Islamic Azad University,
Rasht, Iran.
Torkashvand@iaurasht.ac.ir,
m.torkashvand54@yahoo.com

4. Conclusion

Taking into consideration dry matter yield, protein and nutrient uptake jointly, treatments 2.5 and 5 ha of PMS had better effects in comparison with calcite lime. The results indicated the potential of PMS as acidic soil modifiers in the replacement of conventional calcite sources such as calcite which can reduce the disposal costs and possible environmental contamination of this by-product.

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