EVALUATION OF IRON CONTENT IN A POTENTIAL FODDER CROP OAT (Avena sativa L.) GROWN ON SOIL TREATED WITH SUGARCANE FILTER CAKE

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Abstract

The effects of different doses of sugarcane filter cake (SFC) on iron concentrations in the leaves of varying age of a potential fodder crop oat (Avena sativa L.) are reported in this study. Nine different treatments of SFC used were: 0 (control), 600, 900, 1200 and 1500 kg/ha applied to soil as full doses before sowing, and 600, 900, 1200, and 1500 applied as two equal splits, 1st before sowing and the 2nd before flower initiation. Samples of soil were taken just after mixing the appropriate dose of SFC, whereas those of leaves were taken at the vegetative stage (45 days after sowing; hereafter they are referred as early leaves) and at the grain filling stage (hereafter referred to as late leaves). Iron (Fe) concentrations in soil and leaf samples (early and late) were determined unconnectedly. Soil Fe content increased significantly due to soil amendment with filter cake and it was well above the known critical level (2.5 mg/kg). In contrast, although soil amended with SFC improved the Fe content of both early and late leaves, their Fe content was well below the normal requirement of grazing animals. Thus, the ruminants feeding on this fodder species growing on soils amended with SFC are prone to experience Fe deficiency. Mineral suppletions containing reasonable amount of Fe sources are recommended to prevent complications caused by Fe deficiency as well as to achieve an optimal animal production of ruminants being reared on the pasture.

Introduction

The arable area under cultivation of different fodder crops in Pakistan is about 3.35 million ha producing over 60 million tons of fodder, which has been reported to be significantly insufficient even to meet the maintenance requirement of the livestock (Anon., 2007). One of the chief barriers to expand the arable area is that most of the land is severely hit with high amounts of soluble salts (Shirokova et al., 2000). Thus, for transforming such salt affected soils into cultivable a multitude of strategies are in vogue (Dogantar et al., 2010). The most promising means to render such soils fit for agriculture is the use of organic chemical/materials, because these materials improve soil health to sustain the cropping systems in terms of maintaining reasonable amount of soil organic matter as well as providing essential nutrients (Timsina & Conner, 2001). Sugarcane filter cake (SFC) also known as press mud (PM) being produced in abundant amounts by sugar mills has been used as an organic fertilizer for rendering sodic and saline-sodic soils fit for optimal crop production (Barry et al., 2001) and for the extraction of a variety of economically important chemicals (Partha & Sivasubramanian, 2006). Analogous to a number of organic materials, SFC has been widely reported to affect the physico-chemical and biological properties of soils (Barry et al., 2001).

Livestock and ruminants are a potential source of a variety of food commodities. However, their health and productivity are adversely affected because of malnutrition mainly due to low levels of trace minerals in their usual feed (Yusuf et al., 2002). However, its productivity is greatly affected if required amount of fertilizer is not added to the soil. There are some reports which show that the yields of various crops including maize and millet can be markedly improved with SFC applications (Rangaraj et al., 2007; Elsayed et al., 2008). Sugarcane filter cake is a good source of organic manure (Bokhtiar et al., 2001) as well as an alternate potential source of vital nutrients (Razzaq, 2001). As soil and forage are main sources of minerals for plants and animals, respectively, so for the proper animal diet it is obligatory to analyze the mineral levels in forage and soil. Since SFC has been reported to comprise a variety of mineral nutrients including iron (Razzaq, 2001; Parthasarathi & Ranganathan , 2001) so the chief goal of the present study was to appraise Fe status in the forage of oat (Avena sativa L.) and soil after treatment with SFC and whether Fe levels present in the soil and forage are toxic or deficient for animals. There are also reports which depict that low availability of Fe for plant uptake in many soils causes Fe chlorosis in plants which is a key limiting factor for crop production in many areas of the world, most particularly the arid and semiarid regions (Ranganathan & Parthasarathi, 1999). The incidence of Fe paucity is thus a dilemma of monetary worth, in view of the fact that crop quality and yield can be brutally affected, furthermore the exploit of costly curative processes is requisite to save agricultural returns (Fernández & Ebert, 2005; Fernández et al., 2008) thereby adversely affecting the productivity all those animals being reared therein. The research was carried out to investigate the Fe status in soil and forage that were subjected to varying doses of sugarcane filter cake (SFC).

Materials and Methods

This experimental work was conducted during December 2008 to April, 2009 at the University of Sargodha, Pakistan, which falls under semi-arid climatic conditions. Oat (Avena sativa L.) seed was sown in the first week of December 2008 in pots filled with loamy soil at a rate of 10 seeds per pot. Following were the climatic conditions during the experiment: 18-25/10-17°C day/night temperature, 55-60% RH and 12-hour photoperiod. Sugarcane filter cake obtained from a local
Wet digestion and analysis: of H₂SO₄ were added to each tube. All tubes were then incubated incubated overnight at room temperature. Then H₂O₂ (25 ml) was poured down through the sides of the digestion tubes and placed them on a hot plate to heat them until the complete digestion of the material. The volume of the extract was made up to 50 ml with distilled water. After filtering the extract, it was used for the analysis of Fe concentration. The contents of iron in soil and leaves were determined using an atomic absorption spectrophotometer (Model #AA-6300, Shimadzu, Japan).

Statistical analysis: The data obtained from all analyses was statistically tested for significance at 0.05, 0.01 and 0.001 by using the software SPSS (Steel & Torrie, 1986). Standard error values were worked out to compare the mean values of each attribute.

Results and Discussion

From the analysis of variance of data for iron content in soil and plant material it was observed that different treatments of sugarcane filter cake (SFC) had a similar effect on Fe accumulation in soil or oat leaves (Table 2). Fe content in soil or oat leaves increased significantly due to exogenously applied SFC. Fe contents in soil ranged from 105.08 to 128.14 mg/kg. Soil Fe content did not show a consistent pattern of increase or decrease at different treatments of SFC. The highest value of Fe concentration (128.14 mg/kg) was found for the soil samples of 5th SFC treatment (1500 kg/ha) and the lowest (105.08 mg/kg) for at the 1st one (control) (Fig. 1). Generally, SFC applied as full doses before sowing had a more pronounced effect than its split doses in enhancing Fe content in both soil and oat leaves. The split doses of SFC did not differ significantly in altering the Fe content in both soil and oat leaves. However, the soil Fe values observed in the present study, were above the established critical level (2.5 mg/kg) (Viets & Lindsay, 1973), and these were far higher than those reported in some earlier by Mortvedt et al., (1991). It has been reported that if the soil pH increases by one unit, the solubility of iron species decreases 1,000 times (Jones, 1972).

The Fe concentrations in the early leaves ranged from 16.5 to 24.25 mg/kg. The lowest values of leaf Fe were found in the 1st treatment SFC (control) while the highest Fe values at the 5th treatment (1500 kg/ha) (Fig. 2). Fe contents of the early harvested leaves at the 2nd and 3rd treatments of SFC were almost similar but lower than those at the 4th and 5th treatments. The leaves from the 7th, 8th and 9th treatments were found to be statistically equal in Fe content.

The Fe concentration in the late harvested leaves ranged from 23.21 to 45.45 mg/kg, this range being much higher than that found in the early leaves. Lowest Fe contents were found in the leaves of 1st treatment (control) and highest for those of the 5th SFC treatment (1500 kg/ha) (Fig. 3). There was a gradual increase in Fe contents in the leaves from the split doses 6 to 9 of SFC. Overall, the full doses of sugarcane filter cake were more effective in enhancing the Fe contents of the oat leaves compared to the split doses. This trend supports the idea that application of organic manures should always be done before sowing as a single dose for an effective supply of mineral nutrients to a variety of fodder and other crops.

The fodder Fe concentration was lower than the critical value (50 mg/kg) recommended earlier (Khan et al., 2005), and it was much lower than the adequate level required for the optimal growth of grazing animals (Anon., 1980). Although the soil amended with sugarcane filter cake had considerably higher levels of Fe, it was not absorbed by the A. sativa. It could have been to an antagonistic behaviour of some other metals maybe present in higher amounts in soil particularly Cu and zinc (McDowell, 2003; Campose, 1997). The other reason of the low Fe contents in oat leaves might have been due to high pH of the soil which hampers the availability of different minerals including Fe to plants (Campose, 1997).

Taken overall, we assume that only a small proportion of the Fe in fodder was derived from the sugarcane filter cake. These preliminary findings suggest that filter cake fertilizers are not a significant source of supply of Fe to fodder crops. Additional studies are considered indispensable to validate these findings and evaluate other biotic and abiotic factors affecting low accumulation of Fe metal by A. sativa fodder.

Table 1. Different treatments of filter cake applied to soil before and after sowing.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Full dose applied before sowing</th>
<th>Dose in two equal splits (1st split applied before sowing and the 2nd before flowering)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source of variance</td>
<td>Degrees of freedom</td>
<td>Mean squares</td>
</tr>
<tr>
<td>S. O. V.</td>
<td>Applied dose (kg h⁻¹) 0 (Control) 600 900 1200 1500 600 900 1200 1500</td>
<td>Soil Early leaves Late leaves</td>
</tr>
<tr>
<td>Treatment</td>
<td>8</td>
<td>36</td>
</tr>
<tr>
<td>Errors</td>
<td>ns</td>
<td>non significant</td>
</tr>
</tbody>
</table>

**Table 2. Analysis of variance data for Fe concentrations in soil and leaves (early and late) at different doses of filter cake.**

**Table 1. Different treatments of filter cake applied to soil before and after sowing.**
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Conclusion

Addition of sugarcane filter cake to the soil substantially enhanced the soil Fe content, but the oat plants were not able to absorb significant amount of the Fe metal from the soil amended with the filter cake. Thus, the levels of iron in oat fodder were much lower than the critical level determined for the normal growth and functioning of grazing animals. Mineral supplementations containing fair quantity of Fe sources are recommended to prevent complications caused by Fe deficiency as well as to achieve an optimal animal production of ruminants being reared on the pasture.

References


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