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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, Ist 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 supplementations 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 (Doganlar *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*., 2003). In Pakistan as well as in other countries lying in similar climatic conditions, malnutrition occurs frequently in poorly managed livestock. In view of a published report it is evident that grazing animals in Pakistan depend largely on poor quality feedstuffs particularly in non-developed pastures (Khan *et al.*, 2007) and even some well developed pastures do not fully provide the required amounts of mineral nutrients essentially required for the optimal growth of the livestock. If perennial grasses and forages of a pasture do not fully provide the required quantity of forage as well as the nutrients for the rearing animals then the farmers tend to grow annual fodder crops such as millets, sorghum, clovers of all kinds, *Brassica* species and oat. The value of white oat (*Avena sativa* L.) in animal nutrition is significant, because this crop can provide green fodder for 60-70 days in case of emergency situations (Finatto *et al*., 2007). The oat grain is particularly a worthwhile feed for different types of animals including ruminants of all types, horses and poultry (Hussain *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^{o}C day/night temperature, 55-60% RH and 12-hour photoperiod. Sugarcane filter cake obtained from a local sugar mills was added to the soil contained in the pots before sowing and/or before flower initiation. The detail of varying filter cake treatments has been given in Table 1. The complete randomized design (CRD) was used in this study. Polythene pots were used for sowing the seeds of plant and each plastic pot was lined with polyethylene bag. Seven kg soil was taken in each plastic pot that was lined with polyethylene bag. Plants were harvested at different intervals of time (1^{st} harvest was taken 45 days after the emergence of seedlings and 2^{nd} harvest was taken after the plant has produced the grains). Five replicates of plants from each dose were taken. All protective measures were adapted to make certain a good crop health. All the pots were irrigated with tap water throughout the experimental period.

Sample collection

Soil and plants: Samples of each soil and plants were taken randomly from pots that were given different doses of sugarcane filter cake. The samples of soil were obtained after mixing the filter cake with soil in each pot before sowing. First harvest of oat leaves was taken after 45 days of sowing and termed as early leaves, whereas the second harvest was done after grain filling. All plant samples were washed well with distilled water. These samples were then air-dried, stored in labelled sealed paper bags and placed in an oven for drying for three days at $70^{o}C$.

Wet digestion and analysis: One gram air- and oven-dried soil and plant samples were transferred to digestion tubes and 5 ml of H_2SO_4 were added to each tube. All tubes were then incubated overnight at room temperature. Then H_2O_2 (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 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 shown 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 5^{th} SFC treatment (1500 kg/ha) and the lowest (105.08 mg/kg) for at the 1^{st} 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 Mortvedth *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 1^{st} treatment SFC (control) while the highest Fe values at the 5^{th} treatment (1500 kg/ha) (Fig. 2). Fe contents of the early harvested leaves at the 2^{nd} and 3^{rd} treatments of SFC were almost similar but lower than those at the 4^{th} and 5^{th} treatments. The leaves from the 7^{th}, 8^{th} and 9^{th} treatments were found to be statistically equal in Fe contents.

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 1^{st} treatment (control) and highest for those of the 5^{th} 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 biotic 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.

Treatment	1	2	3	4	5	6	7	8	9
	Full dose applied before sowing					Dose in two equal splits (Ist split applied before sowing and the 2^{nd} before flowering)			
Applied dose (kg h^{-1})	0 (Control)	600	900	1200	1500	600	900	1200	1500

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

Source of variance (S. O. V)	Degrees of freedom (df)	Mean squares		
		Soil	Early leaves	Late leaves
Treatment	8	257.6^{ns}	31.4^{ns}	421.1^{ns}
Errors	36	2099.7	71.5	232.2

ns = non significant

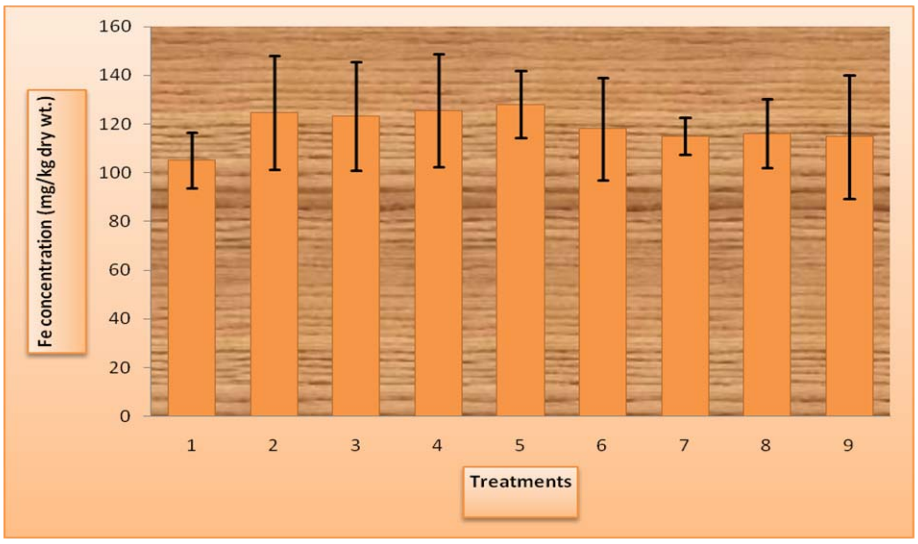

Fig. 1. Fluctuation in levels of Fe in soil at different doses of treatment (The height of the column represents mean value and vertical bar the standard error).

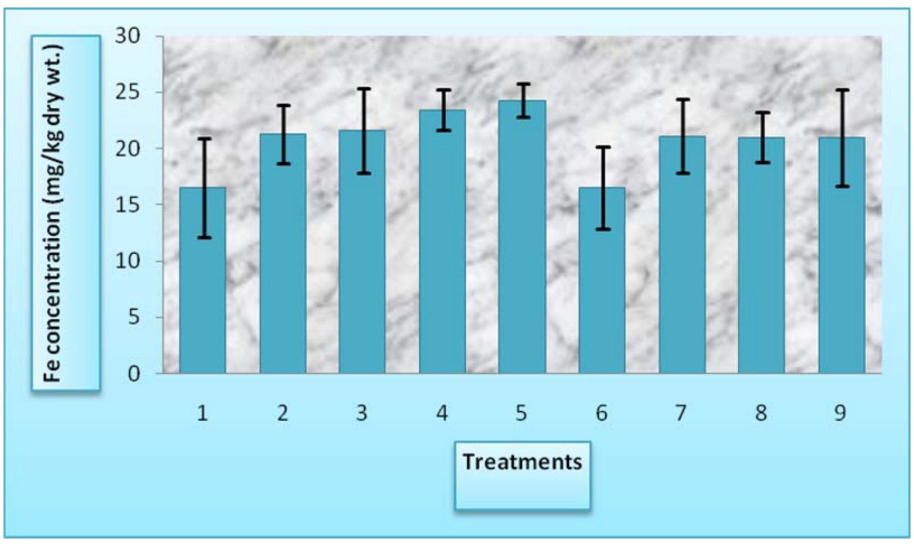

Fig. 2. Fluctuation in levels of Fe in early leaves at different doses of treatment (The height of each column represents mean value whereas vertical bar represents standard error).

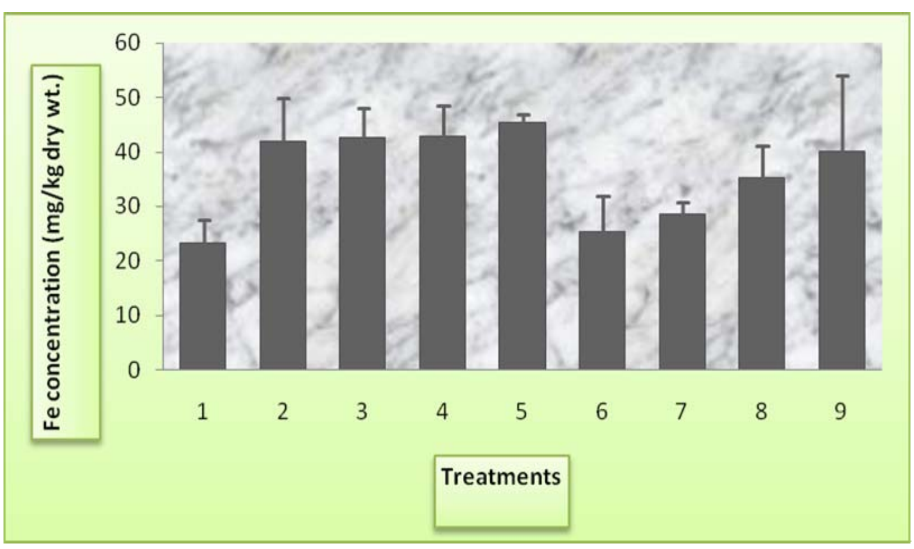

Fig. 3. Fluctuation in levels of Fe in late leaves at different doses of treatment (The height of each column represents mean value whereas vertical bar represents the standard error).

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.

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