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RESEARCH ARTICLE

Effect of Sewage Water Irrigation on the Uptake of Some Essential Minerals in Canola (*Brassica napus* L.): A potential Forage Crop for Ruminants

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ABSTRACT

The current effort was intended to cram the effect of sewage water on morphology and chemical symphony of cv. Dunkeld of canola (*Brassica napus* L.) in Sargodha, Punjab, Pakistan. The obtained information showed that there was an explicit effect of each metal on the growth and yield of the canola cultivar. Sewage water treatment had a significant effect on number of leaves and leaf area. The presence of heavy metals in the sewage water increased the plant growth and yield but up to a certain level, however, higher concentration of heavy metals reaching to toxic level, caused the reduction in plant growth and yield. When sewage water was diluted the toxicity became abridged. Ten levels of sewage water serial dilutions were used in present studies. Statistically completely randomize design with three replications for each experiment unit was implemented. At 50% sewage water dilution, plants got the reasonable quantity of micro and macro nutrient which resulted in increase in growth, yield and yield components. From the analysis of variance of data, Ca, Mg and Mn concentrations were affected substantially by the treatments in soil as well as in forage and showed consistence pattern of augment with increase in the treatment level of sewage water.

INTRODUCTION

Water shortage for the last few years is putting enormous pressure on the economy of Pakistan which is agro-based. At the same time, sewage water is being used to irrigate crops and pastures. The use of wastewater is a major concern to environmental issues like water quality, heavy metal accumulation and health concern for plant, animals and human population. Due to availability of limited number of water treatment establishments, the water quality and its utilities which is exclusively associated with the disposal treatment is a great concern (Ahmed et al., 2012; Khan, 2009). Water treatment often belongs to the addition of alum or ferric chloride for coagulation and removal of suspended solids waste present in the sewage water. Biogeochemical processes can be used to mobilize these toxic metals in soils, which become source of water pollution or contagion of food crops. Solubility of metals entirely depends on different reactions which include the waste, soil and its properties and explicit desired metal. Uptake of metals through plant-soil interaction and ultimately its fate in food chain from land irrigated with metropolitan wastewater have been in focus for last few decades (Chaney, 1988).

The effect of various concentration of metropolitan waste water effluents induced reductions in growth and yield parameters like harvest index, seed weight which was more susceptible to the applied effluents stress than straw weight (Saeed et al., 2010; Khan et al., 2009).

Soils of Pakistan have intrinsically least amount in fertility to support in achieving the yield potential of economic crops (Jamal et al. 2002; Rashid, 1993). Due to high cost and scarcity of chemical fertilizers, the disposal of agricultural, municipal and industrial wastes is widely practiced as a cheaper source of nutrients and organic matter for growing crops by poor farmers in third world countries especially in Pakistan (Ashraf et al., 2011; Khan et al., 2011; Ahmed et al., 2010).

As a suitable source of edible oil and its significance for healthiness oil, Canola (*Brassica napus* L.) is cultivated in different regions of the world including Pakistan (Francois, 1994). It is a specific type of rapeseed which has slightly lower in protein and fiber than wheat and higher in energy due to oil content. For livestock, it is treated as a concentrate crop than a forage crop. Canola made up no more than 75% of the ration with the other 25% made up of high fiber hay.

The current research work was carried out to explore the affect of sewage water effluents on soil chemistry, morphological and yield features of *Brassica napus* L (Canola) cultivar Dunklad. Canola was also be used as forage for animals as well as a biological indicator to determine the potential uptake of various minerals i.e. Ca, Mg and Mn. These three metals were repeatedly monitored and regulated in waste land application systems through sample analysis.

MATERIALS AND METHODS

The present work was carried out at Botanical Garden of the University of Sargodha, Sargodha, Punjab, Pakistan. In addition to its agricultural importance, Sargodha accommodates a variety of industries and is also renowned for its best citrus-production. It has extreme climatic conditions, too in summer with highest temperature ranging from 45 to 50°C and too cold in winter with temperature decreasing below freezing point occasionally. Mean daily precipitation at the experimental site is 1.20 mm. *Brassica napus* L (Canola) cultivar Dunklad was used with ten serial dilutions of sewage water with three replicates for each level. The detail of all procedures has already been described by Ahmad et al. (2011).

RESULTS AND DISCUSSION

Morphological parameters

Data regarding morphological attributes, as influenced by sewage water treatment are given in Table 1. Plant height, number of leaves, leaf area per plant, shoot and root length of canola plants means affected by effluents differed significantly in these measurements. The maximum values for this parameters were observed by applying T_5 (50% sewage water+50% tap water) expect leaf area per plant which showed max value in T_4 (40% sewage water+60% tap water). Lowers values in these attributed were related to T_{10} (100% sewage water only) as the concentration of micro and macro elements increased by increasing sewage water concentration which were toxic in excess amount. The same decreased growth in different plants due to mineral accumulation in water has been earlier described by other researchers Andaleeb et al., 2008; Meagher, 2000;).

The current study showed that sewage water at full potency contained some micro and macro elements in surfeit which are poisonous to plants when they are abounding in over-indulgence, due to which growth and yield components of plants got reduced. However when sewage water is diluted the toxicity becomes reduced. At T_5 (50% sewage water) dilution plants got the reasonable amount of micro and macro nutrient which resulted in increase in growth, yield and yield components. Similar findings were also reported by Day et al. (1990). It was very clear from present investigation that the dilution beyond 50% is not beneficial which may be due to the less supply of nutrients necessary to enhance the growth and yield.

Yield attributes

Yield parameters responded very well to the applied concentrations of sewage water and showed significant decreases in treated plants (Table 2). There was gradual reduction in the number of siliqua per plant, number of seeds per siliqua, number of seeds per plant and seed weight per plant from T_6 to T_{10} while the application of T_5 which gave the maximum response for these attributes. It was therefore, noticed that canola cultivar significantly affected by the wastewater effluents stress. Reproductive growth of the plants (Table 2) was clearly a reflection of their vegetative growth performance in the subsequent effluents treatments. Effects of sewage water in reducing the crop yield have been reported earlier by some workers (Khan et al., 2009). Tamoutsidis et al. (2002) reported that increasing doses of municipal wastewater application on vegetables for edible leaves (lettuce, endive and spinach) and roots (radish, carrots and beets), reduced the overall yield of plants.

Bio-chemical attributes

Soil calcium: There was significant treatments effect ($P<0.001$) on Ca^+ concentration in soil (Table 3). The lowest level of soil Ca^{2+} was observed at T_0 where as highest level of Ca^{2+} concentration was found during tenth treatment T_{10} with Ca^{2+} values consistently increased with the treatments (Fig.1a). The concentration of Ca^{2+} ranged between 33.34 and 53.78 mg kg^{-1} during all treatments. In present study, all the mean values of Ca^{2+} in soil recorded were lesser then the critical values recommended by Adams and Hartzog (1980).

Soil magnesium: There was noticeable significant treatments effect ($P<0.001$) on Mg concentration of soil (Table 3). The lowest level of soil Mg was observed at T_0 where as highest level of Mg concentration was found during T_{10}. Regular increase was observed from 1^{st} to last treatment (Fig. 2a). The concentration of Mg ranged from 220.67 to 278.66 mg kg^{-1} during all treatments. In the present investigation, soil Mg^{2+} concentration was higher than those reported earlier

Table 1: Effect of sewage water on physical parameters in case of *Brassica napus.* L (Canola), cultivar Dunkald

Treatments	Physical Parameters				
	Plant Height (cm)	No. of Leaves	Leaf Area (cm^2)	Root Length (cm)	Shoot Length (cm)
T_0	19.43	13.30	110.47	18.934	80.861
T_1	19.36	13.72	111.72	18.372	81.372
T_2	20.56	14.34	112.34	19.534	82.265
T_3	21.39	14.97	113.37	19.764	82.463
T_4	21.72	15.55	113.75	19.875	82.667
T_5	22.62	16.62	112.68	20.821	83.343
T_6	20.28	16.28	86.21	20.291	80.217
T_7	19.37	15.37	79.42	18.953	78.329
T_8	19.17	13.36	67.52	17.452	77.476
T_9	18.61	12.61	63.94	16.535	72.535
T_{10}	16.95	11.65	54.62	16.000	70.903

The values are means of three replicates.

Table 2: Effects of sewage water effluents on yield attributes in *Brassica napus*. L (Canola), cultivar Dunkald

Treatments	Siliqua per Plant	Siliqua Length (cm)	Seeds per Siliqua	Seeds per Plant	100-Seed weight (g)	Seeds weight per plant (g)
T_0	260	7.8	19.3	4832.4	1.52	73.54
T_1	275	7.9	19.5	4873.3	1.56	75.83
T_2	284	8.2	19.4	4884.7	1.58	77.21
T_3	290	8.5	19.6	488.8	1.63	81.28
T_4	292	8.6	19.9	4890.1	1.69	84.56
T_5	295	8.9	20.3	4951.6	1.72	88.86
T_6	280	7.7	20.1	4773.2	1.71	78.47
T_7	168	7.3	20.0	4343.6	1.65	62.24
T_8	154	7.0	19.8	4275.5	1.54	58.51
T_9	168	6.8	19.4	4138.4	1.42	49.34
T_{10}	160	6.3	19.0	3943.9	1.28	44.73

The values are means of three replicates.

Table 3: Analysis of variance for Ca, Mg, and Mn concentrations in soil and forage of *Brassica napus*. L (Canola), cultivar Dunkald at different sewage water levels

SOV	df	Mean Squares					
		Soil			Forage		
		Ca	Mg	Mn	Ca	Mg	Mn
Treatments	10	130.531***	943.39 ***	0.83 ***	1523.95 ***	129.493 ***	2.009 ***
Errors	22	6.424	11.099	0.027	9.972	4.521	.038

*** = significant at P<0.01.

(Fardous et al., 2010; Tiffany et al., 2001; Cuesta et al., 1993). All the soil samples analyzed were above the vital level of 30 mg kg^{-1} for Mg^{2+} concentration (Rhue and Kidder, 1983). There is no need of fertilizers for pastures imminent.

Soil manganese: Analysis of variance showed that there was a highly note-worthy (P<0.001) effect of treatments on soil Mn concentration (Table 3). Manganese values were increased from T_0 to T_{10} and ranged from 2.33 to 3.71 mg kg^{-1} (Fig. 3a). Nevertheless, the Mn contents establish during our investigation were lower from the critical level of 5 mg kg^{-1} as reported by Rhue and Kidder (1983).

Forage calcium: Concentration of Ca^{2+} in forage was effected (P<0.05) significantly by the treatments (Table.3). The values ranged from between 46.67 and 107.67 mg kg^{-1} in forage (Fig. 1b). Lowest Ca^{2+} concentration was found during T_0 and highest Ca^{2+} concentration was observed T_{10} in forage. Its concentration showed consistent pattern of increase by applying sewage water treatments. Values of Ca^{2+} were recorded higher than the critical levels in forage of this region as suggested by NRC (1996).

Forage magnesium: Sewage treatments significantly affected the Mg concentration in Canola plants (Table 3). The values ranged from 19.72 to 21.92 mg kg^{-1}.

Lowest Mg concentration was found during T_0 in shoot and highest Mg concentration was observed T_{10} in shoot. Magnesium concentrations were almost near to critical level of 0.20% (McDowell et al., 1984). The values of Mg in present study was higher than the values reported by Prabowo et al. (1990) and below from the values already established by Khan et al. (2009).

Forage manganese: Forage Mn concentration were effected ($P<0.001$) significantly which ranged from

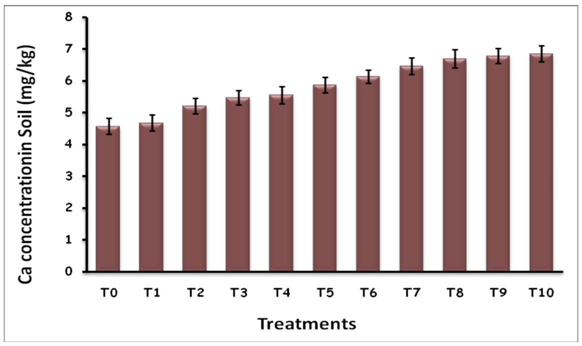

Fig. 1a: Effect of different doses of sewage water on soil Ca levels

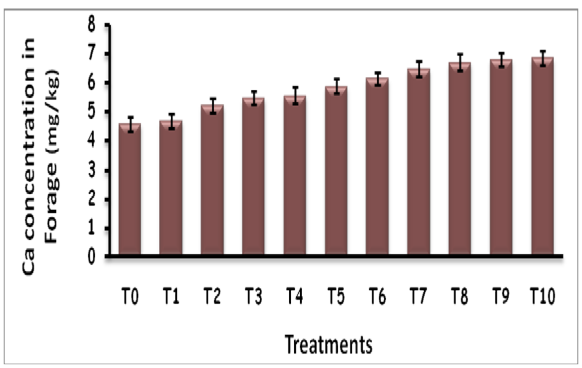

Fig. 1b: Effect of different doses of sewage water on forage Ca levels

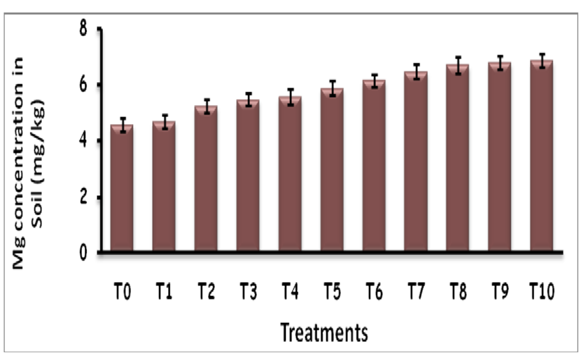

Fig. 2a: Effect of different doses of sewage water on soil Mg levels

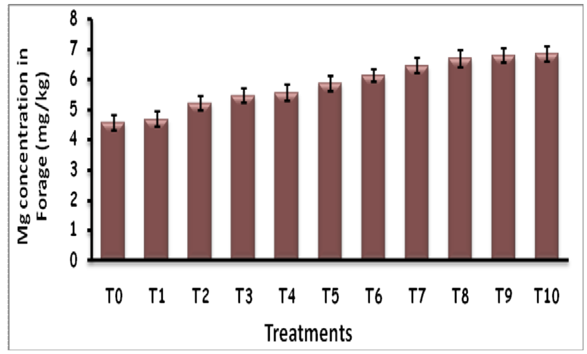

Fig. 2b: Effect of different doses of sewage water on forage Mg levels

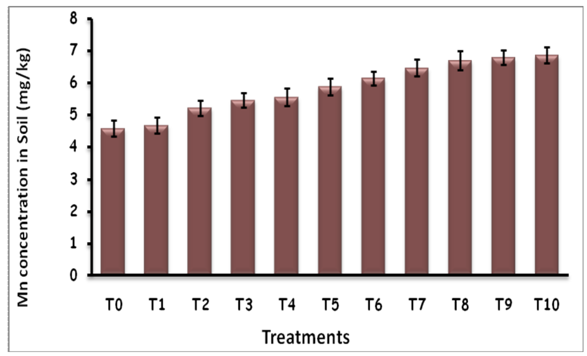

Fig. 3a: Effect of different doses of sewage water on soil Mn levels

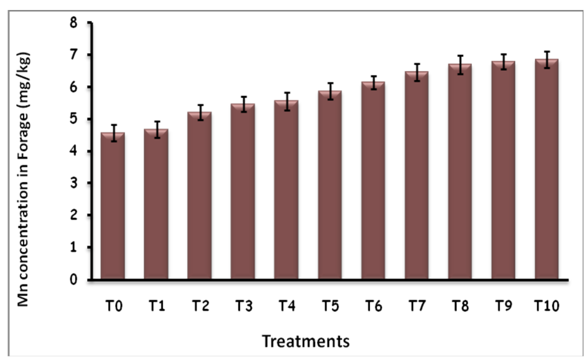

Fig. 3b: Effect of different doses of sewage water on forage Mn levels

4.57 to 6.85 mg kg^{-1} (Fig. 3b). Highest was determined during T_{10} treatment while lowest in control plants. Mean Mn value was lower from the critical level of 40 mg kg^{-1} as reported earlier (Pastrana et al., 1991; McDowell, 1985). In different regions of the world however, these values were underneath from the range to those suggested for ruminants that indicated the forage samples were deficient in Mn.

Conclusions

Findings in present study suggest that irrigation of sewage water significantly affect the growth and yield attributes in Canola. It was also determined that different treatments of sewage water not only increase the concentration of Ca^{2+}, Mg and Mn in soil but also in treated forage plants. However, plants treatments with higher levels of sewage water (60-100% sewage water) exhibited reduction in morphological and yield attributes. So it is recommended that sewage irrigation with dilution up to 50% is effective way to increase the growth and yield of forage. The levels of Mn in Canola fodder was a great deal inferior to the decisive point determined for the standard intensification and necessities of grazing livestock. However, sure methods are commended as an effective way to increase essential mineral content of soil and forage to fulfill the requirement of ruminant

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