۱۲ دوره
۲ شماره

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Effect of Municipal Waste Leachate on Growth and Yield of Wheat

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ABSTRACT

In arid and semi arid regions, water quality and availability is always questionable and the use of any liquid bio-wastes such as treated waste water and municipal waste leachate (MWL)-produced during composting of solid waste refuses- for irrigation considered to be an efficient mean for recycling valuable water resources. A pot experiment was carried out to study the effects of MWL on soil, growth and yield of wheat in green house condition during 2004. The treatments consisted of four MSWL to water mixtures(v/v) of 0, 20, 40 and 60 percent on wheat in a completely randomized design with three replications. Municipal solid waste leachate was applied at three leaf stage and continued till the experiment terminated. At harvest, grain and straw yields and yield contributing characters were determined and chemical properties of treated soils were analyzed. Grain and straw yields were increased by 1.6 and 1.5 folds respectively in T_{20} compared to T_0 (no MSWL) where as yields were decreased in T_{40} and T_{60} treatments. Grain number and weight per spike were highest in T_{20} by 1.4 and 1.6 folds respectively and lowest in T_{60} compared to T_0. 1000 grain weight in T_{20} found maximum with 95.9% and100% increase respectively in T_{40} and T_{60} treatments. Spike length and plant height in T_{20} compared to T_{40} and T_{60} were maximum.

It is concluded that although MWL is rich in OM and plant nutrients, it may be used as a liquid fertilizer along with irrigation water in calcareous soils, but due to the high salinity, its frequent application and rates should be in accordance with soil type, plant tolerance, time, season and climatic conditions.

Keywords: *MSWLechate, grain, straw yields and yield contributing parameters of wheat*

1. INTRODUCTION

Erosion and nutrient-mining cropping systems are having detrimental effects on the environment and have generated serious problems in associated with declining soil fertility and inadequate feed supply for livestock.

Water poverty is widespread in arid and semi-arid regions. Seventy percent of the dry lands, which constitute 25% of world agricultural land, are used for agriculture. Dry areas; provide habitat and livelihoods for more than one billion people. Water scarcity in these regions has already hampered development in most of developing and under-developed countries. Clearly water must be managed differently. In supplemental irrigation, a limited amount of water is applied, resulting in substantial improvement in yield and water-use efficiency. Application of water to satisfy less than full water requirement of crops was found to increase water productivity. Such strategies are important in arid and semi-arid regions because water, not land, is the most limiting factor in agricultural production. As scarcity is growing this situation requires, an immediate adjustment to the conventional guidelines of irrigation in these regions.

The amount of municipal solid waste (MSW) generated annually in Iran is increasing due to increasing rate of urbanization and industrialization as a result, its disposal is a major environmental problem. MSW compost is being manufactured from organic fraction of the MSW stream. Land application of MSWC, an alternative to conventional land fill disposal, allows for the recycling of nutrients, and produces a relatively low-cost product that can be used as a soil amendment in agriculture, horticulture, and land reclamation. Considerable attention has been paid to the land application of MSWC and sewage sludge worldwide in recent years (10,11). A large volume of leachate is produced in the process of recycling of urban solid waste into compost due to the high moisture content of urban solid waste in Iran. Municipal solid waste leachate (MSWL) production is expected to reach more than 6000 m^3 per day, if all the MSW produced in the country is converted into compost. MSW leachate has been reported to affect soil physical and chemical properties (20,5). It had a positive impact on soil aggregation, soil organic matter, reduced surface crusting and reduced pH in calcareous soils. (20,2).

A two years application of sewage effluent of animal husbandry (320 t/ha) with 2.4 % dry matter increased corn yield significantly (7). The growth and yield of vegetables irrigated with a secondary sewage effluent increased many folds (19).

Rice straw and grain yields and the nutrient accumulation level were highest with 300t/ha of MSWL , but low crop yield obtained with 600 t/ha MSWL application due to high soil salinity. They found a significant correlation between crop yield and any measured soil nutrition. They concluded that due to the nature of MSWL acidity, rich source of plant nutrients and organic matter, in calcareous soils of Iran it promoted rice growth, yield and nutrient accumulation, but its application and use must be at reasonable rates especially for saline – sensitive crops(8).
Application of residues or refuse to soil usually increases availability of macro-and micronutrients (3,2,7,12). Alleviation of macronutrient deficiencies by application of manure (7), poultry refuse (18) and sewage sludge (15) has been reported.

The addition of refuse to soil can increase organic matter , cation exchange capacity, soil microbial and enzymatic activities (10), heavy metal concentration in the soil, especially when industrial sludge is used or when high rate of sewage sludge is applied to the soil (10,9). The aim of this research work was to study the effect of different MSWL to water ratios on wheat yield and yield contributing parameters.

2. MATERIALS AND METHODS

A green house study was conducted with four treatments (mixtures of municipal solid waste leachate (MSWL) to potable water): 1) T_o=100% potable water (control), 2) T_{20} = 20 % MSWL, 3) T_{40} = 40% MSWL, 4) T_{60}=60% MSWL, each with three replications on wheat by using completely randomized design (CRD).

Soil used in this experiment was collected from 0-30 cm depth of Agricultural farm, passed from 2 mm screen and 10kg of air-dried soil was added to plastic pots. Soil physical and chemical properties (table 2) such as pH was measured in soil saturation paste on a digital pH-meter (18). Available – P content in the soil was determined by a colorimetric method (12) and available –k was extracted with NH4-Ac (flame photometer) (4). Available Fe, Zn, Cu, Mn were extracted with EDTA (12,13) and then determined using AAS technique (11,13). Soil N was determined by kjeldahl method (13,16), Soil organic carbon by titration method (4,16), Soil electrical conductivity of saturation extract by EC meter (4,16) and soil particle size analysis was determined by the pipette method (16). Chemical properties of MSW leachate (4,11,12,16) is presented in table 1.

15 seeds – " Kavir variety"- of wheat sown in 2 cm depth of each plastic pots and all pots irrigated with potable water. Two weeks after sowing, seedlings were tinned to 7. Irrigation with treated waters was applied at plant three leaf stage and continued twice a week to meet crop water needs. Wheat was harvested (90 days after sowing) and plant height, spike length, number of grain per spike, grain weight per spike, 1000 grain weight, grain and straw yields per pot were measured.

Statistical analysis was performed by using MSTAT-C (SAS program) and treatment means were compared by Duncan Multiple Range Test ($P=0.05$).

Table 1. Chemical properties of municipal solid waste leachate.

pH	-	5.9
EC	($dS\ m^{-1}$)	29.4
TOC	($mg\ kg^{-1}$)	12948
Dry mater	(%)	2.5
Total Nitrogen	(%)	0.175
.P	(%)	12.94
.K	(%)	0.27
Cl^-	(%)	0.45
SO_4^{2-}	(%)	0.33
Fe	($mg\ kg^{-1}$)	155.48
Mn	($mg\ kg^{-1}$)	15.1
Zn	($mg\ kg^{-1}$)	30.43
Cu	($mg\ kg^{-1}$)	1.89

Table 2. Physico-chemical properties of soil before experiment

Texture	-	Loam
pH	-	7.65
EC	($dS\ m^{-1}$)	1.7
Total Nitrogen	(%)	0.021
$N\text{-}NH_4$	(%)	0.0024
$N\text{-}NO_3$	(%)	0.0084
Organic carbon	(%)	0.195
Soluble Cations	($me\ l^{-1}$)	
K		0.176
Ca		3.25
Mg		4.75
Na		6.7
Exchengeable Cations	($Cmol_{(+)}\ kg^{-1}$)	
K		0.15
Ca		11.6
Mg		4.3
Na		0.77
P	($mg\ kg^{-1}$)	2
Fe	($mg\ kg^{-1}$)	3.81
Mn	($mg\ kg^{-1}$)	4.38
Zn	($mg\ kg^{-1}$)	0.56
Cu	($mg\ kg^{-1}$)	0.66
CEC	($Cmol(+)\ Kg^{-1}$)	16.8
$CaCO_3$	(%)	15.6
Bulk Density	($g\ cm^{-3}$)	1.4

3. RESULTS AND DISCUSSION

3.1 Effect of MSWL on Yield Contributing Parameters

Results obtained in table 3, clearly indicates the positive significant effects of different MSWL to water ratios on yield contributing parameters of wheat.

Table 3. Analysis of variance for wheat yield and yield contributing parameters

Source of variance	df	Mean Square							
		Plant height	Spike length	No. of grain/Spike	Grain Wt./Spike	1000 grain Wt.	Straw Yield	Grain yield	Grain Wt./Straw Wt.
Irrigation	3	579.245**	10.546**	386.235**	0.811**	307.71**	19.547**	49.1**	0.594**
Error	8	2.655	0.303	2.86	0.003	5.468	0.49	0.088	0.003

* $P \leq 0.05$

** $P \leq 0.01$

ns = nonsignificant

Plant height of T_{20} (Fig. 1) increased significantly compared to T_{40} (+56.3%), T_{60} (+85.7%) and control (+13.8%). But plant height of T_{60} decreased significantly ($P<0.05$) compared to control (-38.7%) and T_{40} (-15.9%) probably due to high salinity and salt accumulation in soil of this treatment (1).

Maximum spike length noted at T_{20}, with a significant increase of 70% and 97.3% respectively compared to T_{40} and T_{60} treatments and T_{60} had the lowest spike length (Fig.2).
Number of grain per spike of T_{20} increased significantly by 2, 1.4 and 5.5 folds respectively compared to T_{40}, control and T60 treatments (Fig.3).
Grain weight per spike in T_{20} found to have an increase of 10.8, 4 and 1.6 times respectively compared to T_{60}, T_{40} and control (Fig.4).

Highest 1000 grain weight noted in T_{20}, with an increase of 95.9% and 100% respectively compared to T_{40} and T_{60} (Fig.5). 1000 grain weight of T_{60} and T_{40} decreased significantly ($P<0.05$) compared to T_{20} and control (Fig.5). The increase in yield contributing parameter of wheat irrigated with MSWL of 20% may be attributed to its high plant nutrient contents, soluble organic matter and acidic nature of MSWL which is similar with findings of Mohammdinia (10). Khoshgoftarmanesh and Kalbasi (8) reported rice plant growth and yield by application of 300 t/ha of MSWL and Reddy et al.(15)

The use of MSWL to potable water above 20% in this study, resulted in a drastic reduction in yield contributing parameters, probably, due to high electrical conductivity of MSWL (table 2), application of 600 t/ha MSWL reduced rice growth and yield due to mainly high salinity in soil (8,1,9,2).

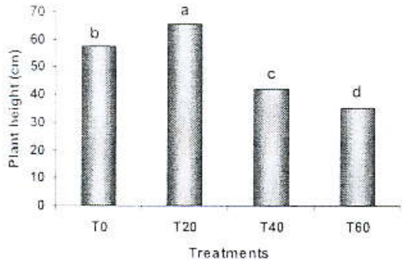


Figure 1. Effect of different MSWL to water ratios on plant height

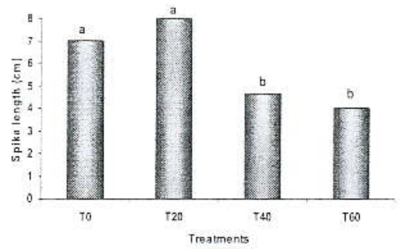
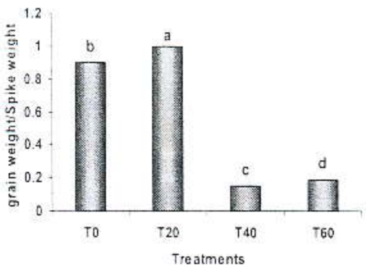


Figure 2. Effect of different MSWL to water ratios on spike length.



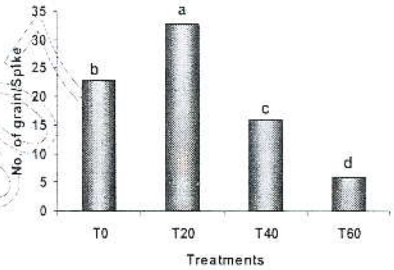


Figure 4: Effect of different MSWL to water ratios on grainweight per spike weight.

Figure 3: Effect of different MSWL to water ratios on number of grain per spike.

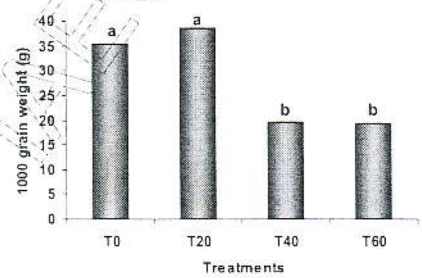


Figure 5: Effect of different MSWL to water ratios on 1000 grain weight

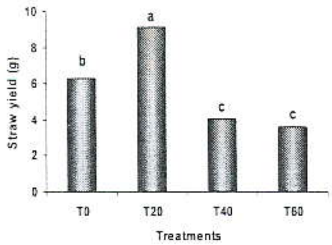


Figure 6: Effect of different MSWL to water ratios on straw yield.

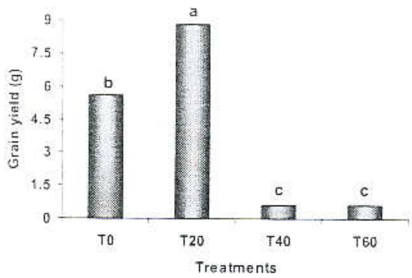


Figure 7. Effect of different MSWL to water ratios on grain yield

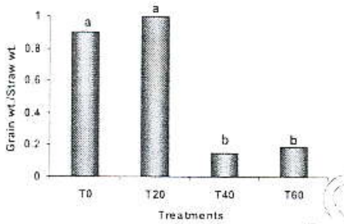


Figure 8. Effect of different MSWL to water ratios on grain weight to straw weight ratio.

3.2 Effect of MSWL on Wheat Yield

Application of MSWL to potable water ratio of 20% (T_{20}) increased straw yield of wheat significantly ($P<0.05$) by 2.3, 1.5 and 2.5 folds respectively compared to T_{40}, control and T_{60} treatments (Fig.6).

Grain yield of wheat in T_{20} treatment increased significantly by 13.8, 14.7 and 1.6 folds respectively compared to T_{40}, T_{60} and control (Fig.7).

Grain weight to straw weight ratio (Fig.8) of T_{20} had an increasing trend by about 5.1 and 6.5 folds respectively compared to T60 and T40 treatments ($P<0.05$). Similar results reported by Khoshgoftarmanesh and kalbasi (8) and Mohammadinina (10) by application of MSWL and Astaraei (1) by saline water application on test crops (14,17). High electrical conductivity of MSWL proved to have a deleterious impact compared to high nutrient contents and its positive effects when used in higher concentrations than 20% in this study (2,5,20).

The best relation between straw and grain yields with MSWL to potable water ratios by regression. The regression equations presented in Fig 9 and Fig10, clearly, indicates that the changes in straw and grain yields were about 60 and 55% respectively related to changes in MSWL treatment.

4. CONCLUSIONS

The correlation between yield and MSWL based on regression equations suggests that increasing MSWL application above 20% have a negative impact on wheat yield. Therefore, the MSWL application at reasonable rate associated with highest yields of straw and grain seems to be less than 40% of MSWL to potable water considering physical and chemical properties of soil and crop tolerance to salinity.

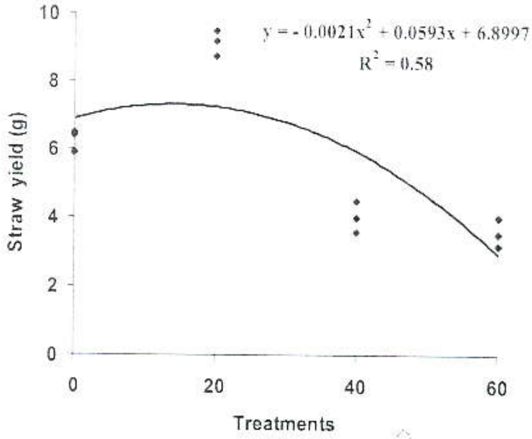


Figure 9: Regression correlation between straw yield and MSWL treatments.

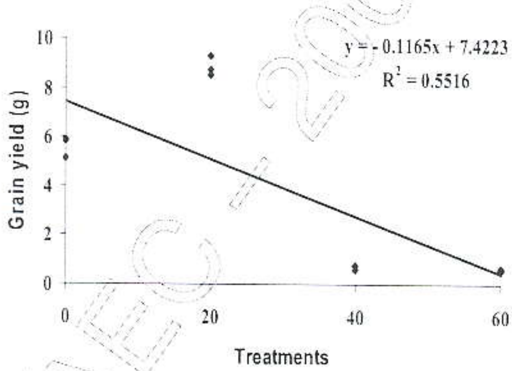


Figure 10. Regression correlation between grain yield and MSWL treatments.

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