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Impact of Organic Wastes (Sewage Sludge) on the Yield of Wheat (*Triticum aestivum* L.) in a Calcareous Soil

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ABSTRACT

A pot culture experiment was carried out to study the effect of different rates of sewage sludge on the yield and yield components of Wheat (*Triticum aestivum* L.) in a calcareous soil during 2001-2002. Sewage sludge was applied @ 10, 20, 40, 60, 80 and 100 t ha^{-1} along with a basal dose of NPK; 120, 90, and 60 kg ha^{-1}, respectively. The results showed that all the yield components of wheat increased significantly with increasing rates of sewage sludge as compared to control. However, significantly maximum spike length (12.20 cm), number of productive tillers plant^{-1} (5.25), number of grains spike^{-1} (44.75), grain yield plant^{-1} (7.57 g) were obtained where sewage sludge was applied @ 40 t ha^{-1}, respectively. 1000-grain weight was maximum (45.78 g), in the treatment receiving sewage sludge @ 60 t ha^{-1}. While plant height (88.90 cm), number of tillers plant^{-1} (6.00) and straw yield plant^{-1} (15.04 g) was significantly higher with 80 t ha^{-1} sewage sludge. Owing to high content of organic matter, NPK and micronutrients, it was concluded that sewage sludge application have a favorable effect on wheat crop and its application @ 40 t ha^{-1} could be recommended for enhanced yield of wheat in a calcareous soil.

Key Words: Sewage sludge; Wheat; Calcareous soil

INTRODUCTION

Sewage sludge is an important organic waste, a good source of organic matter and plant nutrients (Tisdale *et al*., 1993). It consists of multi-element organic wastes that are used commonly as manures in the present day agriculture due to its beneficial effects on crops (Otabbang *et al*., 1997). Due to the presence of high amount of organic matter, NPK and micronutrients, sewage sludge application to most agricultural soils is of utmost importance in maintaining the tilth, fertility and productivity of the soils (Dridi & Zerrouk, 2000). Judicious use of excreta and sewage farming systems in Australia, China, Germany, India, Mexico, Tunisia and USA have been successful in cultivating grains, vegetables, fruit trees and fodder (WHO, 1989). Therefore, land application of sewage sludge for crop production provides a feasible and cost effective disposal alternative (Chu & Poon, 1999) and has a positive effect on the yield of wheat crop (Oloya & Tagwira, 1996).

As the soils of Dera Ismail Khan are calcareous in nature, deficient in organic matter, N, P and Zn (Umar *et al*., 2003), the present study was planned to utilize the sewage sludge on agricultural soils with the following objectives, (i) to characterize sewage sludge for physico-chemical characteristics, (ii) to study its effects on the yield and yield components of wheat in calcareous soil of Dera Ismail Khan, (iii) to find out an appropriate dose for higher yield of wheat crop

MATERIALS AND METHODS

The study was conducted at the Department of Soil Science, Faculty of Agriculture, Gomal University, D.I Khan, Pakistan, during Rabi 2001-2002. Bulk soil samples from 0-30 cm depth were collected from the Faculty research area before sowing of crop and analyzed for physico-chemical characteristics according to the methods as described by Page *et al*. (1982). These measurements are presented in Table I. Sewage sludge was collected from the sewerage channels of Dera Ismail Khan city and was analyzed for various characteristics (Table II). Wheat variety Fakhr-e-Sarhad was sown on 20th November 2001. The experiment was laid out in a randomized block design having four replications. Ten seeds pot^{-1} were sown in earthen pots having 20 kg of soil. Sewage sludge was applied @ 10, 20, 40, 60, 80 and 100 t ha^{-1} along with a basal dose of NPK @ 120, 90, and 60 kg ha^{-1}, respectively, before sowing of wheat crop.

The crop was irrigated at appropriate time as per crop requirements and weeds were controlled manually. After germination, thinning was done and only three plants were left in each pot. Plants were harvested at maturity and the data regarding plant height (cm), spike length (cm), number of tillers plant^{-1}, number of productive tillers plant^{-1}, number of grains spike^{-1}, 1000-grain weight (g), grain yield plant^{-1} (g) and straw yield plant^{-1} (g) were recorded. Statistical analysis of all the data was done using Fisher Analysis of Variance Technique and least significant difference test was applied at 5% probability level to determine the difference among treatment means (Steel & Torrie, 1984).

RESULTS AND DISCUSSION

The soil under investigation was low in organic matter, calcareous, having high pH value and deficient in N, P and Zn (Table I). The sewage sludge was, however, rich in organic matter contents, NPK and all micronutrients (Table II). The effect of various levels of sewage sludge on the yield and yield components of wheat could be explained as below.

Plant height and spike length. The data shown in Table III indicated that application of sewage sludge along with fertilizer increased the plant height significantly over control. This might be due to availability and better utilization of nutrients from the sewage sludge. The maximum plant height (88.9 cm) was obtained from the treatment getting 80 t ha^{-1} sewage sludge, which was statistically at par with treatments receiving 60, 40 and 20 t ha^{-1} of sewage sludge.

It is also obvious from the data (Table III) that the spike length of wheat significantly increased with various levels of sewage sludge as compared to control. Maximum spike length of 12.20 cm was recorded in the treatment where 40 t ha^{-1} of sewage sludge was applied, which was statistically at par with the treatments getting sewage sludge @ 20, 60 and 80 t ha^{-1}. The results showed that combination of sewage sludge and mineral fertilizer helped in increasing the plant height and spike length, which could be attributed to the adequate supply of nutrients by the sewage sludge application. El-Shakweer *et al.* (1998) and Zhang *et al.* (2000) also supported the results, who reported that adequate supply of organic wastes along with NPK fertilizer improve the wheat crop parameters.

Table I. Physico-chemical characteristics of soil

S. No	Characteristics	Units	Value
1.	pH		8.2
2.	EC_e	dSm^{-1}	0.38
3.	$CaCO_3$	%	16.30
4.	Organic matter	%	0.82
5.	Available K	ppm	172
6.	Total N	%	0.03
7.	Available P	ppm	7.5
8.	Textural Class		Sandy Clay Loam
9.	Cl^-	ppm	92.60
10.	SO_4^{--}	ppm	26.90
11.	CO_3^{--}	ppm	26.0
12.	HCO_3^-	ppm	100.0
13.	$Ca^{++} + Mg^{++}$	ppm	93.80
14.	DTPA Ext: Zn	ppm	1.2
15.	DTPA Ext: Cu	ppm	6.5
16.	DTPA Ext: Fe	ppm	5.4
17.	DTPA Ext: Mn	Ppm	11.0

Table II. Physico-chemical characteristics of sewage sludge

S. No	Characteristics	Units	Value
1.	pH		8.0
2.	EC_e	dSm^{-1}	3.12
3.	$Ca^{++} + Mg^{++}$	mmol$_c$ L^{-1}	124
4.	Cl^-	mmol$_c$ L^{-1}	47.4
5.	CO_3^{--}	mmol$_c$ L^{-1}	Nil
6.	HCO_3^-	mmol$_c$ L^{-1}	12.9
7.	SO_4^{--}	mmol$_c$ L^{-1}	1.20
8.	Soluble Na	ppm	420
9.	Available K	ppm	288
10.	O.M	%	19.40
11.	Total N	%	1.60
12.	Available P	ppm	70.0
13.	Fe	ppm	250.0
14.	Mn	ppm	210.0
15.	Cu	ppm	260.0
16.	Zn	ppm	640.0

Table III. Effect of different levels of sewage sludge on the plant height and spike length

Treatments	Rate (t ha^{-1})	Plant height (cm)	Spike length (cm)
T_1	0	81.42D	10.98C
T_2	10	83.66CD	11.38BC
T_3	20	86.40AB	11.77AB
T_4	40	87.42AB	12.20A
T_5	60	88.67A	12.13A
T_6	80	88.90A	11.95AB
T_7	100	84.78BC	11.49BC

Values followed by the same letter are not significantly different at ≤ 0.05.

Table IV. Effect of different levels of sewage sludge on the number of tillers and productive tillers plant^{-1}

Treatments	Rate (t ha^{-1})	No of Tillers plant^{-1}	No of Productive Tillers plant^{-1}
T_1	0	3.75C	3.25C
T_2	10	4.75B	4.25B
T_3	20	5.25AB	4.50AB
T_4	40	5.75A	5.25A
T_5	60	5.50AB	5.00AB
T_6	80	6.00A	4.75AB
T_7	100	5.75A	4.50AB

Values followed by the same letter are not significantly different at ≤ 0.05

Number of tillers and productive tillers plant^{-1}. Application of different doses of sewage sludge along with fertilizer brought significant changes in the number of tillers plant^{-1} (Table IV). The maximum number of tillers plant^{-1} (6) were recorded in the treatment getting 80 tons ha^{-1} sewage sludge, which was statistically at par with 20, 40, 60 and 100 t ha^{-1} sewage sludge treatments but was statistically different from the treatment getting 10 t ha^{-1} of sewage sludge. Minimum value of 3.75 tillers plant^{-1} was recorded in control. There was also non-significant difference between treatments receiving 10, 20 and 60 t ha^{-1} of sewage sludge. The work suggested that increase in number of tillers plant^{-1} might be due to the addition of NPK fertilizers and organic amendments. Rahman and Rashid, (2002) also reported similar findings.

Number of productive tillers plant^{-1} is a factor directly contributing towards yield. The number of productive tillers plant^{-1} was also increased significantly in all the sewage sludge treated pots as compared to control (Table IV). It was maximum (5.25) in the treatment having 40 t ha^{-1} of sewage sludge. However, it was statistically at par with the treatments getting 20, 60, 80 and 100 t ha^{-1} of sewage sludge but significantly differed from the treatments receiving sewage sludge @ 10 t ha^{-1}. The significant increase in the number of tillers and productive tillers plant^{-1} may also be attributed to the abundant supply of organic matter, macro and micronutrients present in the organic wastes (sewage sludge). Rahman and Rashid, (2002) and Cortellini *et al.* (1996) also reported similar findings during their studies on organic wastes.

Number of grains spike^{-1} and 1000-grain weight. The data pertaining to the number of grains spike^{-1} as affected by different levels of sewage sludge revealed significant effect in comparison with the control treatment (Table V). Maximum number of 44.75 grains spike^{-1} were found in treatment receiving sewage sludge @ 40 t ha^{-1} followed by

Table V. Effect of different levels of sewage sludge on the number of grains spike^{-1} and 1000-grain weight

Treatments	Rate (t ha^{-1})	No of grains spike^{-1}	1000-grain weight (g)
T_1	0	37.75B	38.50F
T_2	10	41.75AB	41.60E
T_3	20	43.00A	43.53BC
T_4	40	44.75A	44.47AB
T_5	60	44.50A	45.78AA
T_6	80	44.00A	43.13CD
T_7	100	43.25A	42.00DE

Values followed by the same letter are not significantly different at ≤ 0.05.

Table VI. Effect of different levels of sewage sludge on the grain yield (g) plant^{-1} and straw yield (g) plant^{-1}

Treatments	Rate (t ha^{-1})	Grain yield (g) palnt^{-1}	Straw yield (g) plant^{-1}
T_1	0	3.61D	8.93D
T_2	10	5.21C	12.13C
T_3	20	6.34BC	12.89BC
T_4	40	7.57A	13.93ABC
T_5	60	7.31AB	14.74AB
T_6	80	6.43AB	15.04A
T_7	100	6.30BC	14.20AB

Values followed by the same letter are not significantly different at ≤ 0.05.

44.50 grains spike^{-1} recorded in the treatment receiving sewage sludge @ 60 t ha^{-1} . The maximum 1000-grain weight (45.78 g) was recorded in the treatment getting sewage sludge @ 60 t ha^{-1} followed by the treatment receiving sewage sludge @ 40 t ha^{-1}. This increase in number of grains spike^{-1} and 1000-grain weight may also be the result of improvement in the soil fertility due to sewage sludge application. Barbarick *et al.* (1998) and Elsokkary and Salam (1998) have also reported similar findings.

Grain and straw yield plant^{-1}. The data recorded on grain and straw yield are presented in Table VI. It revealed that all the different doses of sewage sludge increased the grain yield over control significantly. Maximum grain yield (7.57 g) was obtained from the treatment receiving sewage sludge @ 40 t ha^{-1} followed by 7.31 g from the treatment receiving 60 t ha^{-1} sewage sludge, which were statistically at par with the treatment receiving 80 t ha^{-1} of sewage sludge. Minimum grain yield was recorded in the control (3.61 g). Al-Mustafa *et al*. (1995) also reported increase in grain yield of wheat due to sewage sludge application.

Significant increase was also recorded in straw yield plant^{-1}, which was 15.04 g where sewage sludge was applied @ 80 t ha^{-1} followed by 14.74 g plant^{-1} from the treatment getting sewage sludge @ 60 t ha^{-1}. The minimum straw yield (8.93 g) plant^{-1} was obtained from the control treatment. It showed that significant increase in grain and straw yield might be due to the availability of all essential elements to the wheat crop in sufficient amount by the sewage sludge application. Singh and Singh (1999) and Al-Mustafa *et al*. (1995) also reported highest increase in the grain and straw yield of wheat treated with sewage sludge.

CONCLUSION

During the studies, it was concluded from the physico-chemical analysis of sewage sludge, that it was a rich source of organic matter (19.4%), N (1.6%), P (70 ppm) and K (288 ppm). Micronutrients like Fe (250 ppm), Zn (640 ppm), Cu (260 ppm) and Mn (210 ppm) were also abundant in the sludge. The experimental results also showed that yield and yield components of wheat increased significantly with increasing rates of sewage sludge over control, which shows that sewage sludge have a beneficial effect and would prove to be an important organic fertilizer for the wheat crop. The studies further elucidated that sewage sludge @ 40 t ha^{-1} was the suitable dose for wheat crop in a calcareous soil.

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