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Effect of Lupine Irrigation with Treated Wastewater on Seed Yield and Quality in Two Soil Types

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Abstract: Field trials were conducted in winter season in two sites located about 20km north east of Cairo; Gabal Asfar farm (sandy loamy) and Berka site (sandy soil). The trials aimed to evaluate the impact of lupine irrigation with secondary treated wastewater (TWW) on yield, quality and heavy metal content. The results clearly showed that the lupine crop was not suited to the sandy soil as the crop produced 40% of the seed yield achieved in the sandy loamy soil. There were significant increases in seed yield and biological yields due to NPK application in the sandy loamy soil. Treated wastewater supplied lupine with, 22, 26.4 and 97.9% of the recommended requirements of N, P and K, respectively in the virgin soil while the corresponding values in the fertile soil were 70.4, 83.6 and 228.8 % for N, P and K, respectively. Seed analysis indicated that the ranges of heavy metals were within the normal ranges expected and were far below levels that would be of concern due to the high pH of both sites.

Key words: Lupine · Treated wastewater · Yields · NPKcontent · Heavy metals

INTRODUCTION

Water crises are rising because of the ambitious land reclamation programme, growing population, steady rural development and urbanization plans and expanding the industrial sector [1]. Therefore, it is essential to develop water resources through untraditional ones. Reclaimed wastewater (RWW) is a valuable source should be regarded as the best practical option in Agriculture WRc 2000 for plant nutrients and organic matter needed for maintaining fertility and productivity of arid soils. However, there is a debate anc concernings about the reuse of RWW for irrigation field crops which may potentially cause environmental problems due to the lower treatment degrees its and management [2, 3].

The secondary treated wastewater generated from Greater Cairo is about 1.85 million m^3/day and it is estimated that the generated treated wastewater will eventually reached up to 3.5 million m^3/day in the year 2020. From environmental point of view such quantities should be disposed off safely. Under limited water resources and drought conditions wastewater has been used to support the agricultural production in many countries such as USA, Germany, India, Kuwait, Saudi Arabia, Oman, Jordan and Tunisia [4]. Several investigators indicated the beneficial role of wastewater in increasing crop yields without or with minimal risks to the plant, soil, groundwater and health [5-10].

However, under Egyptian conditions many restrictions have been adopted on wastewater reuse and it is only permitted for wooden trees production.

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Since lupine is considered a crop grown to Egypt and it needs processing before consumption, it may fit irrigation with secondary treated wastewater. Therefore, the aim of this work is to evaluate the effect of treated wastewater on lupine yield and quality under two types of Egyptian soils.

MATERIALS AND METHODS

Two field trials were carried out in winter season in two sites located about 20 km north east of Cairo; Gabal Asfar farm (sandy loam soil) and Berka site (sandy soil). The trials aimed to evaluate the impact of lupine irrigation methods with secondary treated wastewater on yield, quality and heavy metal content. The area of each trial the was 10 feddans (4.2 hectars) close to the new Gabal El- Asfar wastewater treatment plant and the soil could be classified as loomy sand soil. The same area was chosen in the second site and located inside El- Berka wastewater treatment plant; the soil is gravelly sand and could be classified as sandy soil.

Both experimental sites were cultivated using fixed tine- harrow, then leveling was carried out. The experimental area was divided to large experimental unites according to treatment. The design of each trial was based on 16 large plots, eight of which receive wastewater only and the other eight receive wastewater plus supplementary fertilizer to be adjusted for each crop according to the normal recommended rates and for each site conditions. Lupine seeds(Giza 1 variety) were grown under drip irrigation system. The irrigation water was measured by water meter for each plot. Fertilizers were applied according to the normal recommended rates in Egypt. Nitrogen, phosphorus and potassium were applied as ammonium nitrate (33.5% N), calcium super phosphate (15.5%P2O5) and potassium sulfate (48%K2O), respectively. Samples of treated wastewater from Gabal El-Asfar and El-Berka were taken during the crop cycle and analyzed for a range of agronomic parameters. Nutrient and heavy metal loading rates to field trials were calculated according to the irrigation quantities applied to each crop. Lupine yields were determined, seed oil, nutrient and heavy metal content were determined. Chemical analysis was carried out according to [11-14]. The obtained results were subjected to the proper statistical analysis using MSTAT-C programme [15].

RESULTS

Data presented in Table 1 show wastewater qualities applied to lupine in both soils, All of these parameters are well within the maximum limit values set by the Egyptian Decree 44/2000 [16] for wastewater reuse. The amounts of wastewater irrigated to each crop and fertilizer treatment at both sites were recorded accurately. Mean wastewater irrigation quantities4648m and 7192m3/ha sandy loamy soil and the sandy soil, respectively (Table 3)All nutrient additions through TWW are listed in the same table. The quantities of wastewater applied were broadly in line with normal farmer practice in the district. Calculating the major nutrients (NPK)supplied by wastewater as a percentage of the fertilizer recommended rates indicated that treated wastewater supplied lupine with 22, 26.4 and 97.9% % of the recommended requirements of N, P and K, respectively in the sandy soil while the corresponding values in the sandy loam soil were 70.4, 83.6 and 228.8% for N, P and K, respectively (Table 2 and Fig. 1).

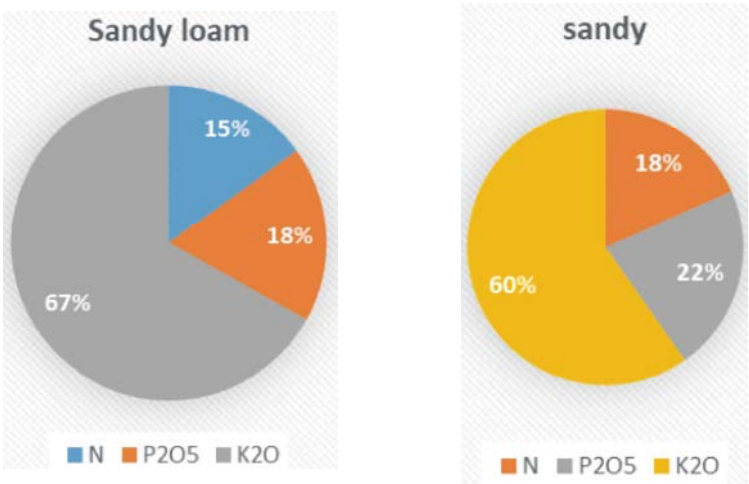

Fig. 1: Nutrients supplied by TWW as % of recommended fertilizer

Table 1: Chemical analyses of wastewater Irrigated in the experimental sites. (All parameters mg/l except pH)

Soil type	pH	Tot.N	Tot P	K	B	Fe	Mn	Cr	Ni	Zn	Cu	Cd	Pb	Co	Mo
Sandy loam	7.83	9.7	2.6	19.0	0.34	0.362	0.113	0.021	0.025	0.162	0.043	<0.005	0.069	<0.01	0.01
Sandy Mean	7.78	12.8	3.4	13.6	0.4	0.577	0.115	0.027	0.039	0.094	0.049	<0.005	0.079	<0.01	<0.005

Table 2: Proportion of Nutrients supplied by TWW to lupine compared with Generally Recommended Rates of Fertilizer in two soil types

	Fertilizer recommended (kg/ha)			Addition in TWW(kg/ha)			Nutrients supplied by TWW as % of recommended fertilizer		
Soil type	N	P2O5	K2O	N	P2O5	K2O	N	P2O5	K2O
Sandy loam	108	54	57.6	21.84	13.2	51.36	22	26.4	97.9
sandy	144	74.4	57.6	92.4	56.4	119.52	70.4	83.6	228.8

Table 3: Water quantities and nutrient additions supplied bt TWW in both soil types

	Sandy loam	Sandy
TWW (m3/ha)	4648	7192
N (kg/ha)	21.84	92.4
P2O5 (kg/ha)	13.2	56.4
K2O (kg/ha)	51.36	119.52
B (g/ha)	753.6	2625.6
Fe (g/ha)	813.6	4147.2
Mn (g/ha)	254.4	825.6
Cr (g/ha)	48	194.4
Ni (g/ha)	55.2	283.2
Zn (g/ha)	364.8	674.4
Cu (g/ha))	96	350.4
Cd (g/ha)	<12	<36
Pb (g/ha)	153.6	571.2
Mo (g/ha))	<21.6	<72
Co (g/ha))	21.6	<36

Table 4: Lupine yields (ton/ha) as affected by fertilizer and TWW Irrigation in two soil types

Soil type	Yield character	TWW	TWW+F
Sandy loam	Seed	0.924	1.188
	Straw	3.5112	3.8016
	Biological	4.4352	4.9896
Sandy	Seed	0.396	0.4752
	Straw	1.1352	1.1616
	Biological	1.5048	1.6368

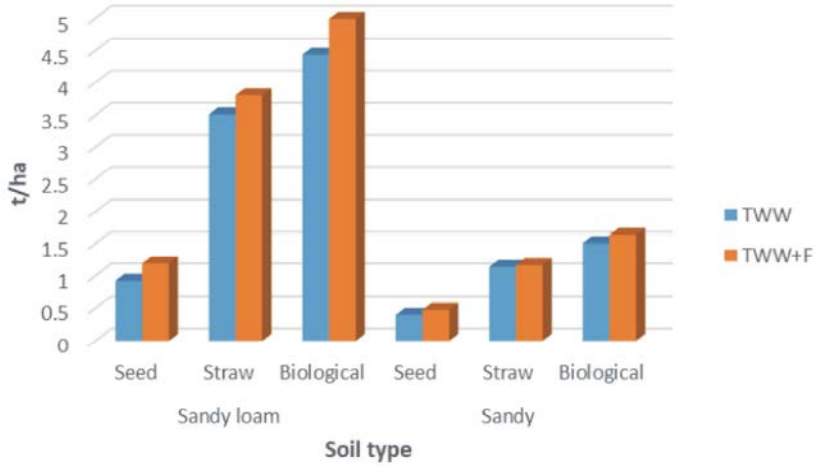

Fig. 2: Effect of irrigation with Treated wastewater on lupine yield characters
TWW (treated wastewater) TWW+F (treated wastewater+ recommended fertilizer dose)

Table 5 Effect of irrigation with Treated wastewater on N, P and K in lupine seeds

		N	P	K
Sandy loam	TWW	4.653	0.517	1.397
	TWW+F	4.389	0.495	1.441
Sandy	TWW	5.654	0.176	1.221
	TWW+F	5.632	0.209	1.188

TWW (treated wastewater) TWW+F (treated wastewater+ recommended fertilizer dose)

Table 5: Mean Concentrations (mg/kg) of Heavy Metals in Lupine seeds at Gabal El Asfar and El Berka

Soil type	Zn	Cu	Cr	Cd	Pb	Ni
Sandy loam	53.79	7.711	0.22	0.011	1.298	0.264
Sandy	33.55	4.785	0.154	0.0099	1.463	0.484

Note: Figures in bold for each element indicate the greater of pairs of mean concentrations for each crop

Fig. 3: Effect of irrigation with Treated wastewater on N, P and K in lupine seeds
TWW (treated wastewater) TWW+F (treated wastewater+ recommended)

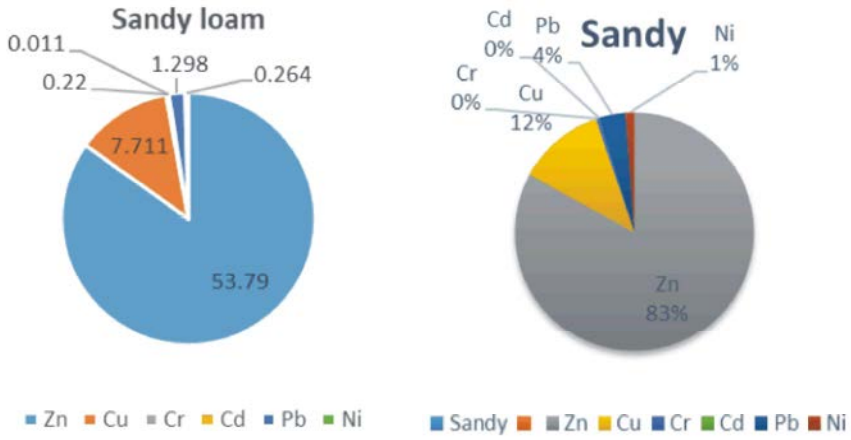

Fig 4 : Mean Concentrations (mg/kg) of Heavy Metals in Lupine seeds irrigated with TWW in two soil types

Data presented in Table 4 indicate that fertilizer increased lupine yields (seeds, straw and biological) significantly only at Gabal El-Asfar. The data also show that lupine production under sandy loam soil was greater than that under sandy soil. The effect of irrigation with Treated wastewater on N, P and K in lupine seeds is presented in Table 5 and Fig. 3. Seed analysis presented in Table 6 and Fig. 4 indicate that the ranges of heavy metals were within the normal ranges expected and were far below levels that would be of concern.

DISCUSSION

The obtained results show that lupine irrigation with wastewater provide a useful contribution to lupine nutrient needs, these are applied uniformly throughout the growing period of the crop, whereas fertilizer (specifically nitrogen) is applied deliberately in targeted split applications according to the changing crop requirements during the growing cycle. Irrigation with wastewater alone, particularly low fertility soils, results in poor early crop growth due to nutrient deficiency and normal levels of fertilizer should be applied during the early growth stages crops. Therefore, the yields achieved where fertilizer was applied were larger than from wastewater alone and were proportionately increased more on the sandy soil where nutrient demand would be greatest, although yields overall were generally much smaller than at sandy loam [18] The crop quality parameters showed that NPK contents in crop seeds were within the normal values of these elements.. Moreover, heavy metals concentrations were within the normal ranges expected for these crops and some of the crop concentrations suggest marginal deficiency for zinc and likely copper for most crops, especially in the virgin soil.

These results demonstrate the importance of applying supplementary fertilizer at appropriate levels for the crop and soil type. The small concentrations of heavy metals in the seeds were expected and attributed to the high pH of the Egyptian soil which makes the heavy metals not readily bioavailable for crop uptake and do not represent a threat to the quality of the crops grown on this for human or animal consumption., [17]. Lupine is a relatively old crop in Egypt and so its yield characteristics are not yet fully evaluated under drip irrigation with treated wastewater, but these results show clearly that lupine is unsuited to infertile soil but can respond well to wastewater when grown on more fertile soil.

REFERENCES

1. Abd El-Lateef, E.M., J.E. Hall, M.A.A. Farrag and A.A. Farrag, 2010. Agro- Economic Studies on Wastewater Reuse in Developing Marginal Areas in West Delta, Egypt. International Journal of Water Resources and Arid Environments, 1(2): 110-115.
2. Mahmoud, M.J., N. Mazahreh and M. Ayadi, 1998. Reuse of treated wastewater for irrigation of forage crops under dry land conditions. Yield nutrient uptake and soil quality. Proceedings of the Intern. Conf. of Advanced Wastewater Treatment, Recycling and Reuse, Milano, 14-16 Sept., 2: 733-740.
3. Mahmoud, M.J. and N. Mazahreh, 2003. “Changes in soil fertility parameters in response to irrigation of forage crops with secondary treated wastewater”, Communications in Soil Science and Plant Analysis, 34(9-10): 1281-1294, 2003 DOI: https://doi.org/10.1081/CSS-120020444.
4. Rowe, D.R. and I.M. Abdel-Magid, 1995. Handbook of Wastewater Reclamation and Reuse. Lewis Pub., USA.
5. Oron, G., Y. De Malach, Z. Hoffman and Y. Manor, 1991. Effluent reuse by trickle irrigation. Water Science and Technology, 24(9): 103-108.
6. Oron, G., Y. De Malach, Z. Hoffman and Y. Manor, 1992. Effect of effluent quality and application method on agriculture productivity and environment of control. Water Science and Technology, 26: 7-8, 1993-1601.
7. Shatanawi, M. and M. Fayyad, 1996. Effect of Khirbet As-Samra treated effluent on the quality of irrigation water in central Jordan Valley. Water Research, 30(12): 2915-2920.
8. Vasquez-Montiel, O., N.J. Horan, D.D. Mara, A. Angelakis and T. Asno, 1996. Management of domestic wastewater for reuse in irrigation. Water Science and Technology, 33: 10-11, 355-362.
9. Aissi, A., R. Chouker-Allah, H. Elmomari, A. Hamdi and B. Soudi, 1997. Impact of irrigation with treated wastewater on infiltration, seepage and uptake on growth of melon (*Cucumis melo* L.). CIHEAN International Conference, Valenzano, Bari, 22-26 Sept., 151-170.
10. Palacios, N.P., O.A. Pard, E. Del-Nero, F. Rodriguez and L. Sulos, 2000. Legumes for Mediterranean forage crops, pastures and alternative uses. Proceeding of the 10th meeting of the Mediterranean sub-network of the FAO-CHIEAM Inter-regional Cooprative Res. Cahiers Options Mediters, 45: 181-185.
11. APHA(American Public Health Association, 1992). Standard methods for the examination of water and wastewater. 18th ed, Washington D.C.
12. Nelson, D.W. and L.E. Sommers, 1980. Total nitrogen analysis for soil and plant tissues. J. Assoc. Off. Anal. Chem., 63: 770-778
13. Chapman, H.D. and F.E. Oratt, 1961. Methods of Analysis of Soil. Plant and Water. University of CaIifomia, USA.
14. A.O.A.C., 2000. Association of Official Analytical Chemists. Official methods of analysis, 16th edition, AOAC International, Washington, DC.

15. MSTAT-C, 1988. MSTAT-C, a microcomputer program for the design, arrangement and analysis of agronomic research. Michigan State University, East Lansing.
16. Decree 44, 2000. Egyptian Standards for Effluent Quality and the Conditions for Reuse. Ministry of Housing, Egypt; Article 15.
17. WRc, 2001. Treated wastewater reuse demonstration trials. Alexandria Effluent and Sludge Reuse Study, WRc Report No. AESRS 15.
18. Abd El-Lateef, E.M., M.A.A. Farrag, M.F El-Karamany, 1 22 B.A. Bakry, M.S. Abd El-Salam and A.K.M. Salem, 2021. Estimation of the Agro-Monetary Value of Irrigation with Treated Wastewater of Soybean and Sunflower. International Journal of Water Resources and Environmental Sciences, 11(2): 15-21, 2022