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The efficacy of chlorinated water used for irrigation purpose on plant initial growth

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Abstract
Recycled irrigation water is one of the major sources of inoculum and may spread plant pathogens in agricultural land or nurseries. Although the recycling of irrigation water has both environmental and ecological benefits, but if not disinfected, it can result in serious disease epidemics and crop losses. Chlorination is the most economical method of disinfecting water and has been adopted by commercial growers in modern age. The given research was carried out in the department of botany, Jinnah University for women, Karachi, for evaluating the disinfecting ability of Chlorine in irrigation water. The growing plants were irrigated with water containing 0, 50, 100, 150, 200 ppm of free chlorine for 2 weeks. The following physical measurements were used to assess the treatments: *Shoot length, Root length, Fresh weigh, Dry weight.* The observed data indicated the efficiency of free chlorine present in irrigation water for promoting the initial growth level of plant in account of its disinfection capability that suppressed pathogen activity and promotes growth.

Keywords: Irrigation Water; Pathogens; Chlorination; Disinfection

1. Introduction
With environmental regulations focused on water quality and reducing pollution discharge associated with nutrient and pesticide applications, recycling irrigation water has been increasingly adopted by commercial nursery and greenhouse growers (Hong and Moorman, 2005; Ryu and Beuchat,2005; Schoene *et al.,* 2006) [6, 11, 13]. Plant pathogens detected in water supplies and irrigation systems include fungi, fungal-like organisms, nematodes, viruses, and bacteria (Schnitzler, 2003) [12]. Hong and Moorman (2005) [6] reported that 17 *Phytophthora* spp., 26 *Pythium* spp., 27 genera of fungi, eight species of bacteria, 10 viruses, and 13 species of plant parasitic nematodes have been detected from ponds, rivers, canals, streams, lakes, runoff water, watersheds, reservoirs, wells, holding tanks, effluents, ebb and flow systems, recirculating systems & hydroponic systems. The most destructive pathogens are *Pythium* and *Phytophthora* followed by viruses, bacteria, and nematodes (Schnitzler, 2003) [12]. Research related to agricultural water microbial quality is limited. Most research regarding water microbial quality (e.g., pathogen prevalence, indicator organisms) has been conducted mainly for objectives related to reclaimed water, drinking and recreational water supplies but not specifically for the quality of irrigation water used in agricultural fields.
Several disinfection techniques have been studied for their efficacy in minimize the spread of plant pathogens in recycling systems, which include slow sand-bed filtration, ultraviolet irradiation (Igura *et al.,* 2004) [8], heating (Lin *et al*., 1998) [10], ozonation, nonionic surfactants, and chlorination (Hong *et al.,* 2003) [6] Chlorination is an economical method of disinfecting water and remains the primary method of treating municipal water (Havard, 2003) [5]. Chlorination technology has already been adopted by some growers to disinfect their irrigation systems and water. However, specific recommendations for use in nursery or greenhouse irrigation to control the spread of plant pathogens have not been fully assessed (Hong *et al.,* 2003) [6]; LeDantec *et al.,* 2002) [9]. Researchers have shown that sensitivity to chlorine is pathogen-dependent. Hong *et al.* (2003)[6] reported that zoospores of *Phytophthora nicotianae*, *P. capsici*, *P. cinnamomi*, *P. citricola*, *P. citrophthora*, *P. cryptogea*, and *P. megasperma* were killed with free chlorine ranging from 0.25 to 2 $mg \cdot L^{-1}$; however, there are no studies for control of *P. infestans* and *P. cactorum*. There are also no studies regarding chlorine's efficacy in controlling *Pythium aphanidermatum*, *F. oxysporum*, and *R. solani*.
The given research focused on the disinfection of irrigation water through *Chlorination,* which is one of the most economic and the most effective methods.

Addition of Chlorine in recycled water prevents bacterial growth in water distribution systems. Sodium hypochlorite (NaOCl) solution is normally used for surface purification, bleaching, odor removal and water disinfection. Sodium hypochlorite is effective against bacteria, viruses and fungi. This chlorinated water also used to irrigate lawn and garden. Under normal conditions, chlorinated water will not threaten microorganism populations. Researchers found that 2.0 $mg \cdot L^{-1}$ of free chlorine can efficiently kill *Pythium aphanidermatum*, *Phytophthora cactorum* zoospores and *Phytophthora infestans* sporangia (Cayanan *et al.,* 2008) [2]. Frink & Bugbee (1987) [4] and Brown (1991) [1] reported on phytotoxic effects of Cl^- on several greenhouse crops and their free chlorine thresholds, which ranged from 2 $mg \cdot L^{-1}$ to 77 $mg \cdot L^{-1}$. However, there is no known published information regarding the use of chlorinated irrigation water under typical nursery practices. The objective of the present study was to determine whether a chlorine concentration of given range would harm growing plants when applied during the period of shoot emergence and growth and whether such a treatment would minimize the dispersal of common plant pathogens in recycled irrigation water. The main goal of this research is to develop knowledge about the efficiency of chlorinated water for irrigating crop to minimize soil contamination harmful for plant growth.

2. Material and Method

Chemically sterilized seeds of black gram were sown in pot filled with garden soil. Different range of Cl^{l-} concentrations, i.e. 50ppm, 10ppm, 150ppm & 200ppm were prepared with sodium hypochlorite NaOCl. There were two irrigation treatments: (1) Non Chlorinated Water (Control) and (2) Chlorinated Water (Treatment). Pots of all treated plants were laid out in a completely randomized block design with four replicates and four treatments (T1, T2, T3, T4). Plants were overhead-irrigated with their respective treatment daily for 2 weeks. After that plants were harvested and the data were recorded as root length, shoot length, Fresh weight & Dry weight. The data was analyzed by statistic software SPSS 16 (version 4). The differences were considered significant at $p<0.05$ when treatments' mean compared with control.

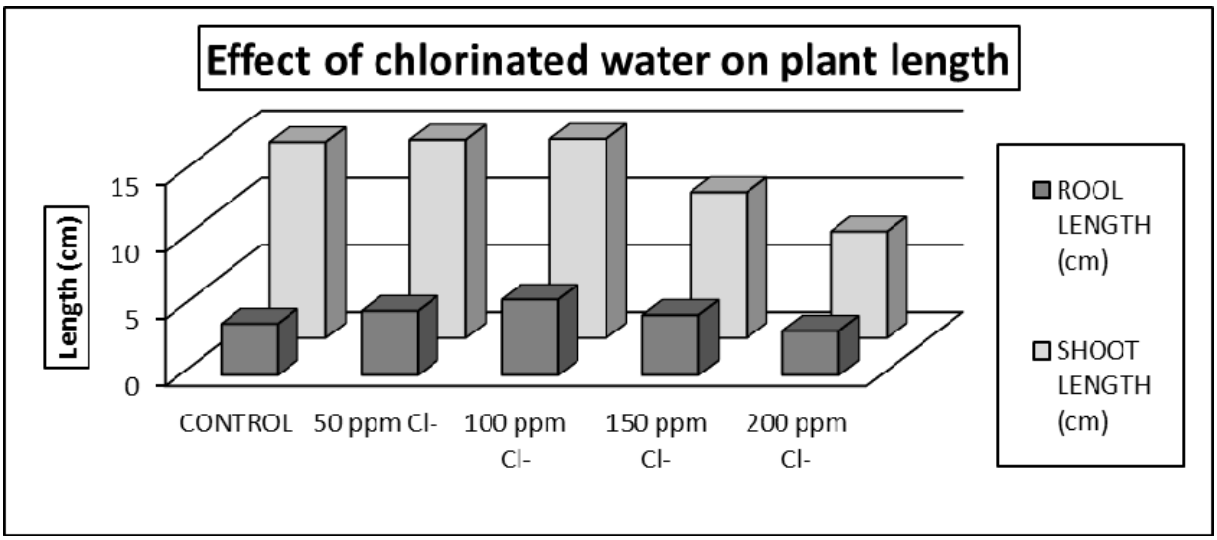
3. Result and Discussion

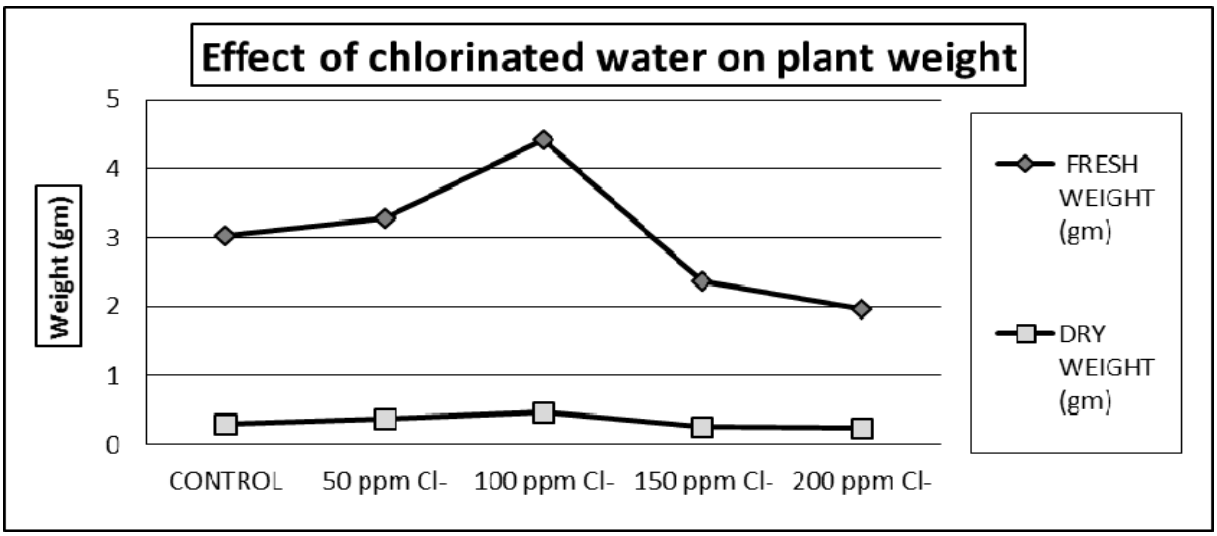
The observed data showed that, the growth of studied plant respond differently to the chlorine treatment (Table). *Shoot length, Fresh weight, Dry weight* of treated plants were first increased and then gradually reduced along with concentration gradient i.e. from low to high Chlorine in supplied water, whereas the *Root length* was significantly improved with increasing Cl^- dose from 50 - 150ppm (0.5 - 1.5mg L^{-1}) in irrigation water. This is due to the disinfection of harmful activities of pathogenic microorganism i.e. *Phytophthora infestans*, *Phytophthora cactorum*, *Pythium aphanidermatum*, *Fusarium oxysporum*, and *Rhizoctonia solani,* present in the surrounding vicinity of growing crop that may restricted the initial growth of growing plants, although the high dose i.e. 200ppm of Cl- caused decrease in root length and all the other physical parameters may be due to the inhibition of beneficial Microbial activities required for the surplus growth of crop. In agreement with this work, Hong *et al.* (2003) [6] reported that zoospores of numerous *Phytophthora* sp. may be killed with free chlorine concentrations ranging from 0.25 to 2 $mg \cdot L^{-1}$ which supports our results that low free chlorine *concentrations can kill* soil pathogens*.* In conclusion, the research found that up to 100 ppm of free chlorine in irrigation water was safe to treat plants for the disinfection of soil microbial contamination.

Table: Effect of chlorinated water used for irrigation purpose on plant initial growth

Treatment	Root Length (cm)	Shoot Length (cm)	Plant Fresh Weight (gm)	Plant Dry Weight (gm)
Control 0 ppm Cl^-	3.825 (0)	14.57 (0)	3.02 (0)	0.3 (0)
50 ppm Cl^-	4.775 (+24.8)	14.75 (+1.2)	3.29 (+23.3)	0.37* (+8.94)
100 ppm Cl^-	5.62 (+47.1)	14.82 (+1.68)	4.43* (+60)	0.48* (+46.6)
150 ppm Cl^-	4.47 (+17.01)	10.85 (-25.55)	2.38* (-13.33)	0.26 (-21.1)
200 ppm Cl^-	3.30 (-13.6)	7.925 * (-45.62)	1.96* (-20)	0.24 (-35.09)

Each value is the mean of 3 replicates. Values in parenthesis indicate % increase (+) or decrease (-) over control. Means bearing * in each column are significantly different with respective control at $p<0.05$(LSD).





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