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SUITABILITY OF PAPER MILL WASTE-WATER AFFECTED SOIL FOR MAIZE AND MUNGBEAN CULTIVATION

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Abstract

Effect of paper mill waste-water irrigation on crop growth, nodulation and VA mycorrhizal colonization was assessed by growing mungbean [*Vigna radiata* (L.) Wilczek] and maize (*Zea mays* L.) in pot soil collected from a field with five year history of Mandhiali Paper Mill effluent irrigation, situated 20 km from Lahore on Lahore-Sheikhupura Road. Plants of both the test species were also sown in normal field soil as control. Shoot growth in both the test species was adversely affected in paper mill effluents contaminated soil (PMCS). The difference between the two treatments was significant (P=0.05) in maize. Pod number in mungbean was significantly reduced in PMCS as compared to control. Effect of PMCS on nodulation in mungbean and root growth in both the test species was insignificant. Extent of VAM infection was severely arrested showing significant reduction (P=0.01) in maize in PMCS. However, there was not any significant difference in VAM colonization between the two treatments in mungbean.

Introduction

The most important problem, the pulp and paper industries are facing today, is disposal of tremendous volumes of wastewater. This industry consumes large quantity of water and in turn lets out high volume of wastewater carrying dissolved solids and suspended organic materials (Mishra and Sahoo, 1989). The effluents from paper mills contain various chemicals like lignin, caustic soda, sodium sulphide, sodium bisulphate, chlorine, koalinite, titanium oxide, aluminium sulphate; major trace metals like Hg, Cr, Pb, etc., depending upon the manufacturing processes adopted. These effluents are generally alkaline and have high chemical and biological oxygen demands (Basu and Behera, 1989). When these effluents are discharged to the water system, they make the water unfit for drinking and create health hazards. In recent years effluents farming through land disposal are emerging as a possible solution for the prevention of aquatic pollution due to paper mills.

Irrigation of paper mill effluents have shown encouraging results in oat and orchard grasses (Hashimoto and Yokoto, 1965), on paddy, groundnut and wheat (Khambatta and Ketkar, 1969), and on germination of tomoto, rice and black gram (Rajannan and Obliswami, 1979). Besides being sufficiently nutrient rich to support growth of some crop species, these effluents also carry toxic materials, which can reduce crop growth efficiency and deteriorating soil characteristics (Somashekar *et al.*, 1984). Jorgensen (1965) reported a depression in plant growth due to irrigation with pure paper mill effluents. The chemical properties of the forest soil is also known to be changed significantly in relation to Na, Cl and N when flooded with effluents (Hansen *et al.*, 1980). In addition, pH increased throughout the soil profile and P, Mg and organic carbon content were accumulated at the surface (Mishra and Sahoo, 1989). Furthermore, the effluents may also have adverse impact on soil microbial populations. Since land fertility is directly related to it biological efficiency and negative impact of effluents on these organisms may lead to ultimate

loss of soil fertility. Therefore, before advocating for land disposal of paper mill effluents, effect of effluent irrigation on crop growth and soil sub-systems particularly on beneficial microorganisms should receive utmost attention. The present work was, therefore, undertaken to study the effect of paper mill wastewater irrigation on crop growth, nodulation and VA mycorrhizal colonization in maize and mungbean.

Materials and methods

Pots of 20 cm diameter were filled with contaminated soil collected from a field with five year history of Mandhiali Paper Mill effluent irrigation, situated at a distance of 20 km from Lahore on Lahore-Sheikhupura Road. A similar set of pots was also filled with normal field soil with BRB Canal water irrigation history, collected from University of the Punjab, Quaid-e-Azam Campus, Lahore to be used as control. Seeds of mungbean and maize were sown in all the pots @ five seeds per pot, which were later on thinned to two uniform seedlings per pot. Each treatment was replicated thrice. Pots were kept outdoor in a wire-netting house and irrigated with tap-water whenever required. Plants of mungbean were harvested 45 and 70 days after sowing (DAS). Data regarding the root and shoot growth, nodulation and pod number per plant were recorded. Maize plants were harvested 50 DAS and root/shoot growth in terms of length and fresh and dry biomass production was determined. The data was analyzed statistically through t-test. A sub-sample of fresh roots of both the test species was cleared and stained following the procedure of Phillips and Hayman (1970) for assessment of VAM colonization. Extent of mycorrhizal infection was determined by slide length method (Giovanetti and Mosse, 1980).

Results and discussion

Shoot length in *V. radiata* in paper mill contaminated soil (PMCS) was at par with control at both the harvest stages i.e., 45 and 70 days after sowing. Although shoot fresh and dry biomass in PMCS was lower as compared to control, however, the difference was insignificant statistically (Fig.7A-C). Similarly root growth and nodulation were not affected significantly (Fig.2&3). Earlier, Mishra and Sahoo (1989) in comparable studies have reported that paper mill effluents do not induce any inhibitory effects on growth and production of paddy. Similarly field experiment conducted by Vercher *et al.* (1965) indicates that the production of corn, oats, cowpeas and rice in soil irrigated with paper mills wastewater was at par with well-irrigated soil. They observed that the controlled use of wastewater could be beneficial to the growth of crops. Yakushenko *et al.* (1971) successfully utilized paper mill wastewater on crops like cucumber, squash and feed grass on sandy soils. Nesterove *et al.* (1963) did not observe any detrimental effect of paper mill wastewater on the growth of vegetables and tree seedlings. In contrast to shoot growth the pod number in the present study was significantly ($P=0.05$) reduced in PMCS (Fig.1D). However, this result needs to be reconfirmed because the pod number in both the treatments was low.

Root length as well as root biomass in maize was increased in PMCS. However, the difference was insignificant as compared to control (Fig.4). Earlier, Mishra and Sahoo (1989) have reported a similar increase in root length in 50

percent paper mill wastewater. In contrast to *V. radiata*, shoot length as well as shoot fresh and dry biomass in maize in PMCS was significantly depressed (Fig.4). These results are in line with those of Rajannan and Ovliswamy (1979) who have reported adverse effects of paper mill waste-water on germination of paddy, black gram and tomato seeds and also on growth and vigour index of seedlings. It reveals that response of crop growth to PMCS is species specific. The variability in tolerance may be attributed to species inherent morphological, physiological and genetical characteristics of the test plants involved.

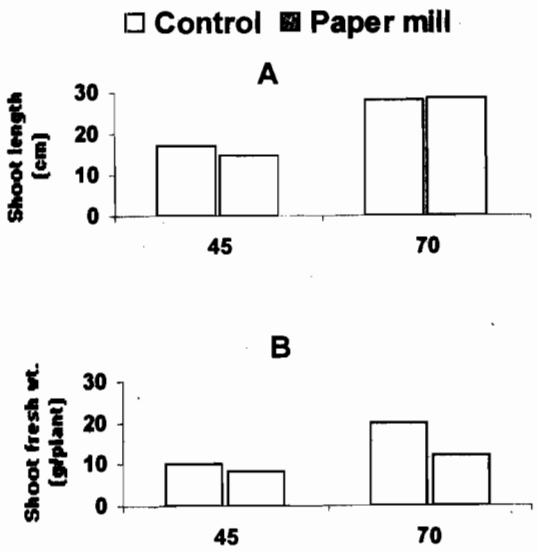
There was not any marked difference in percentage infection of VAM structure viz., mycelium, arbuscules and vesicles, between the two treatments. However, extent of VAM infection was reduced significantly (P=0.01) in maize in paper mill effluent contaminated soil as compared to control (Table 1). The severe growth losses in shoot of maize may be attributed partially due to inhibition in VAM colonization.

In Pakistan, the effect of paper mill wastewater irrigation on crop growth, microorganisms and soil characteristics has not been studied extensively. The wastewater let out from a couple of paper mills has been tapped voluntarily by the farmers for irrigation of severe crops. The informal details, based on the cultivator's experience, indicate that there has been no adverse effect on the soil and crop. However, the present and the earlier studies have revealed that paper mill wastewater is suitable for irrigation of various crops subject to the type of soil and crop (Jivendra, 1995). It is, therefore, recommended that if paper mill wastewater is to be used for irrigation purpose, prior trial experiments regarding the use of this wastewater with respect to crop and soil type are necessary.

Table 1: VAM colonization in mungbean and maize in paper mill contaminated soil.

Treatments	Mungbean				Maize			
	% VAM infection			Extent of VAM (cm/ 100 cm)	% VAM infection			Extent of VAM (cm/ 100 cm)
	Mycelium	Arbuscule	Vesicle		Mycelium	Arbuscule	Vesicle	
Control	100	100	100	10.8	100	100	100	30.11
Paper mill	100	100	100	8.87	100	100	100	3.79**

**: Differ significantly from control at 1% level of significance.


Control
Paper mill
A
Shoot length (cm)
30
20
10
0
45
70
B
Shoot fresh wt. (g/plant)
30
20
10
0
45
70

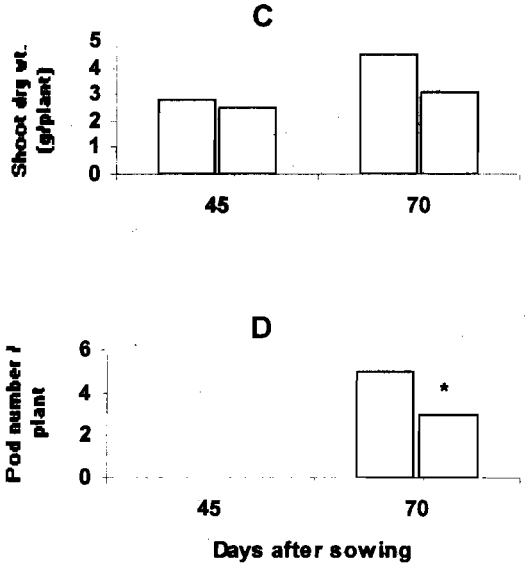


Fig. 1: Effect of paper mill waste-water affected soil on shoot growth and pod number in *Vigna radiat.*

* Differ significantly (P = 0.05) as determined by t-test.

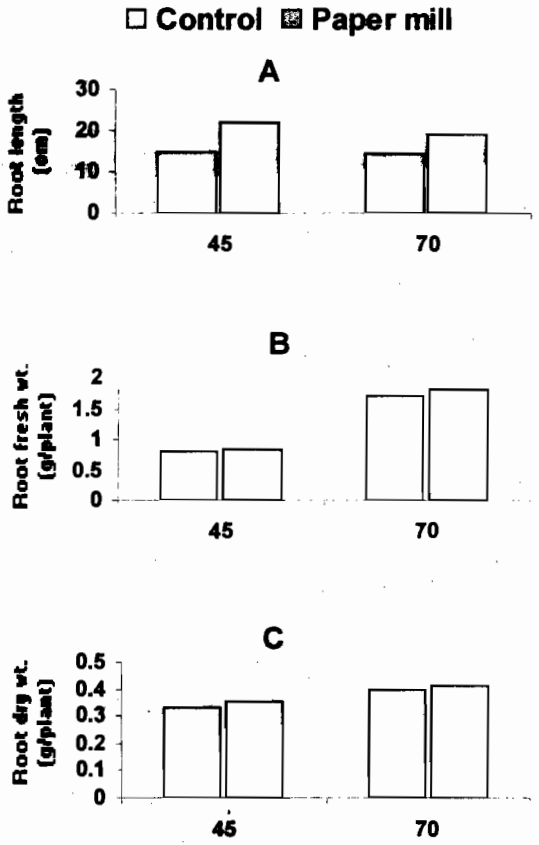


Fig. 2: Effect of paper mill waste-water affected soil on root growth in *Vigna radiat*.

The difference between the two treatments was insignificant as determined by t-test.

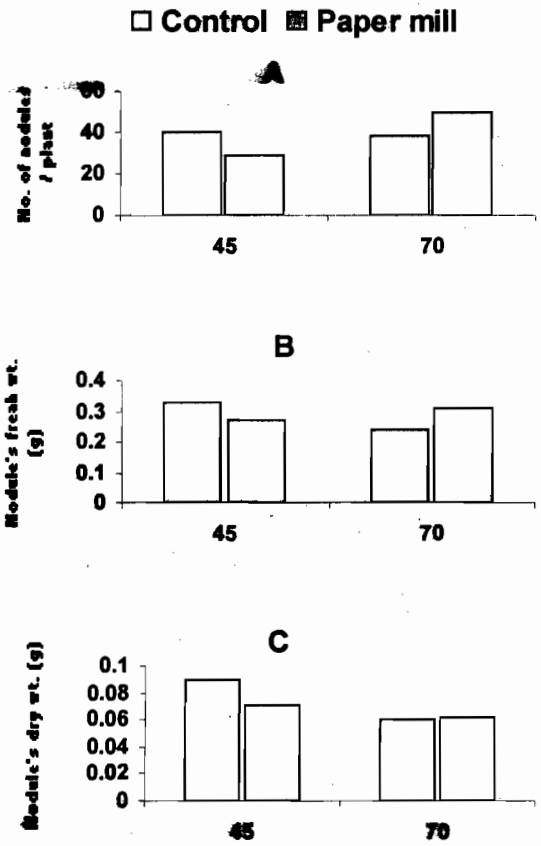


Fig. 3: Effect of paper mill waste-water affected soil on nodulation in *Vigna radiat*.

The difference between the two treatments was insignificant as determined by t-test.

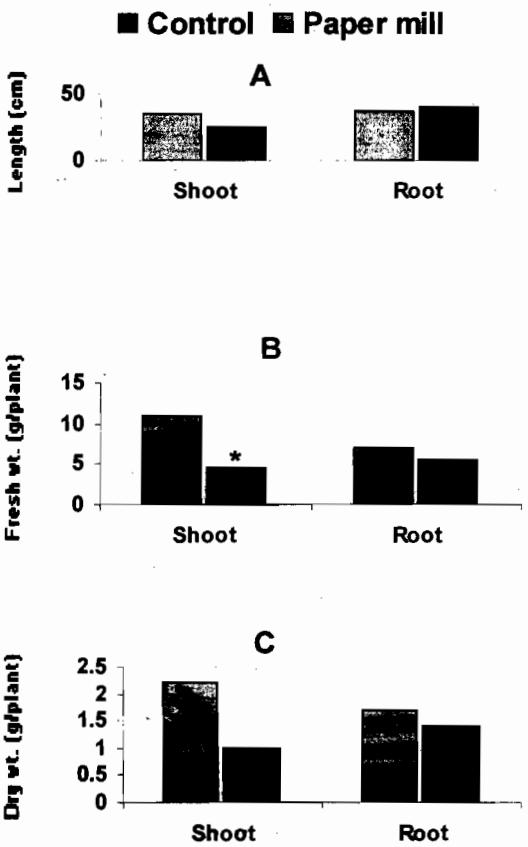


Fig. 4: Effect of paper mill waste-water affected soil on root and shoot growth in maize.

*, **, Differ significantly at 5% and 1% levels, respectively.

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