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## Effect of Short Term Sewage Application on Nitrogen Saving in Soils of Sub-tropical Zone of Western Himalayas

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**ABSTRACT**

Reuse of sewage as irrigation water is one of the best options to reduce the stress on limited fresh water available today and to meet the nutrient requirement of crops. A study based on Split Plot Design experiment was conducted in sub-tropical zone of Himachal Pradesh to evaluate the effect of sewage with their application frequency and nitrogen fertilizer on N saving in short term nursery experiment in three fodder trees namely Grewia optiva, Leucaena leucocephala and Morus alba for producing the quality planting stock with the buildup option to the soils. The study revealed that the sewage irrigation reported to give 20.43 per cent in Grewia optiva, 9.64 per cent in Leucaena leucocephala and 5.43 per cent in Morus alba higher N saving as compared to ordinary water treated micro plots. The daily application of sewage found to give higher N saving over rest of the two frequencies i.e. alternate day and after every third day irrespective of species. It was 100 kg $Nha^{-1}$ level of fertilizer which gave 14.78, 7.73 and 12.93 per cent addition of available soil N in Grewia optiva, Leucaena leucocephala & Morus alba micro plots. In case of interactional effect of type of irrigation sources and N fertilizer (WxN), it was observed that there was net 50 per cent saving of applied N fertilizer with sewage in tested fodder trees over the ordinary water. The per cent build up of available nitrogen in soils was due to sewage irrigation. This clearly indicates a need for using the sewage water in raising the quality nursery stocks and plantations to address the prevailing sewage disposal problems by municipalities and other habitation areas across the globe.

**Key words:**

Sewage, water, N-saving, nursery, fertilizers, fodder trees, irrigation, effluent, Himalaya

## INTRODUCTION

Water is gaining importance for its conservation as of its finite nature. It is equally significant that in the current scenario, water issues are creating worldwide demand for alternative and innovative water management solutions. A number of off and on farm measures need to be imposed to use water more efficiently. Human beings use huge quantity of water for drinking, cleaning & various other cultural functions which dispose of it as waste water in sewage. With increase in population, the magnitude of waste water and/or sewage is multiplying enormously with the passing time.

The waste water is beyond the recycling capacity of the local ecosystem and results in numerous vagaries. It has been estimated that 70 to 80 per cent pollution is caused by sewage effluent and the remaining 20 per cent is because of industrial effluent. Most of the countries in the world are spending large share of their economy for recycling of the sewage effluent. The use of sewage sludge in the farming may be regarded as ecological and economical viable option which allows farmers to reduce their expenditure on fertilizers with the benefits of restoring the water for drinking quality, recharging ground water reserves and increasing tree growth. The concept of eutrophication of sewage is equally supported by the researchers like Yadav and Kapil, 1990 and Dahatonde et al 1995 and further they advocated its use as irrigation to certain crops/trees for increasing their productivity.

The use of sewage for irrigating plantations is an attractive preposition lies under the fact that it only limited to primary treatment by sedimentation. In developing countries like India most of municipal effluents are un-treated, un-characterized & un-managed and disposed off in rivers or agricultural fields. Raising plantations with effluent irrigation is a known economically suitable, practically easy, logically feasible and vastly replicate practice. The use of trees has been popular because of their reported fast growth (Stewart and Flinn 1984), higher water use efficiency and socio-economic benefits (Myers et al. 1994). Sewage irrigation can have the important social, aesthetic and environmental benefits (Gutteridge and Davey 1983). Banyal and Bhardwaj (2004) also advocated the use of sewage in the plantation establishment and growth of fodder trees.

Under the present investigations, sewage is applied to three main fodder trees of sub-tropical region namely *Grewia optiva*, *Leucaena leucocephala* and *Morus alba* under nursery conditions to assess the comparative effect with ordinary water. The raising of fodder trees make the soil poor in availability of nitrogen which results in the low production in the times to come under normal conditions. It is well known that nitrogen is highly demanded element in growth of fodder trees. It is already reported by various researchers that sewage effluent contains nutrients which are responsible for enhancement in tree growth in general and soil enrichment in particular. The ecosystems are considered as the ecologically viable option for recycling the sewage effluent. There is global pressure to increase the productivity of farming systems due to burgeoning population. Therefore, there is need to increase the use of fertilizers to combat with the arising situation. This is leading to steep hike in the prices of fertilizers along with oil and/or energy crisis.

The information on systematic studies of nitrogen saving with sewage effluent are lacking. Therefore, this present paper deals with finding out the level of N-saving with three different irrigation frequencies for raising of quality fodder trees stock to rehabilitate the degraded and abandoned areas. In addition to this, comparative study of sewage and organic fertilizer was also done to exactly find out saving of nitrogen fertilizer in case of sewage effluent.

**MATERIALS AND METHODS**

A field experiment was carried out in Dr Y S Parmar UHF, Nauni, Solan, Himachal Pradesh at an elevation of 1250 m amsl located at 30°51'N latitude and 76°11' East longitude. The experimental site falls in sub-tropical zone with mean maximum temperature goes upto 34°C during summer. The winter months are the cooler and the area experiences severe frost during December and January months. The average annual rainfall is 1100-1350mm, of which most of it received during monsoon (a short span of three months July to September). The nursery soil was sandy loam in texture, medium (354, 344 & 346 kg N $ha^{-1}$) in available nitrogen, high (24.16, 25.54 & 28.60 kg P $ha^{-1}$) in available phosphorus and medium (281.2, 276.8 & 280.0 kg K $ha^{-1}$) in available potassium with pH (7.17, 7.26 & 7.10) in the micro plots earmarked for raising of *Grewia optiva*, *Leucaena leucocephala* and *Morus alba* nursery. The organic carbon found to range from 1.05 to 1.12 per cent in the experimental site.

Sewage was procured from the students' hostel which was stored and decanted in steps (into lined tanks) for irrigation purpose. Sewage and ordinary water had pH 7.05 and 7.46, electrical conductivity ($dsm^{-1}$) 1.28 and 0.53, sodium absorption ratio (SAR) 14.32 and 01.63, residual sodium carbonate (RSC) ($meqL^{-1}$) 2.50 and 0.84, Mg/Ca ratio 0.29 and 0.42, calcium ($mgL^{-1}$) 100 and 64, Magnesium ($mgL^{-1}$) 29 and 27, Sodium ($mgL^{-1}$) 115 and 11, Potassium ($mgL^{-1}$) 21 and 2.60 carbonates ($mgL^{-1}$) 379 and 217, Sulfates ($mgL^{-1}$) 58 and 83, Phosphates ($mgL^{-1}$) 1.0 and 0.0, Chlorides ($mgL^{-1}$) 66 and 17, Nitrates ($mgL^{-1}$) 3.20 and 4.40 and Fluorides ($mgL^{-1}$) 1.10 and 0.44, respectively. It is evident that pH, Mg/Ca ratio and nitrates were low in sewage than ordinary water. All the analyzed parameters were in safe and moderately safe limits. There is no presence of phosphates in ordinary water.

The study was conducted by taking two sources of irrigation water ordinary ($W_1$) and sewage ($W_2$) applied in three different frequencies (daily: $F_1$, alternate: $F_2$ and after every third day: $F_3$) with five levels of nitrogen ($kg\ ha^{-1}$) including control ($N_0$: 0, $N_1$: 25, $N_2$: 50, $N_3$: 75 and $N_4$: 100) in the micro plots of *Grewia optiva*, *Leucaena leucocephala* and *Morus alba.* The decanted sewage was supplied to all the plots in volume fixed for each independent treatment. The depth of irrigation was kept 1.0cm and the quantity was approximately 10 liters per plot each of $10m^2$in area. Raised seed beds were prepared by working the soil up to fine tilth. Undamaged and healthy seeds were taken for sowing after giving the pre-sowing treatments of dipping the seeds in cold water for 48 hours for *Grewia optiva* and *Leucaena leucocephala.* Whereas, the *Morus alba* was raised through cuttings. After germination, fifty seedlings were maintained in each plot. The experiment was continued for two consecutive years (two growth seasons). The observations on N-saving were recorded twicely after 4 and 16 months duration (G-I and G-II). The experiment was laid out in split plot design by taking sources of irrigation and their frequency of application in main plot and nitrogen under sub-plot with four replications. The composite soil samples were taken from each micro plot as per the treatments given and analyzed for available nitrogen by the procedure given by Subbiah and Asija 1956.

**RESULTS AND DISCUSSION**

The micro plots irrigated with sewage found to add nutrients in the soil environment which improve the uptake by plants and ameliorate the degraded soils. Two years sewage addition increased the nitrogen saving mainly in treated plots. There was statistical significant increase in N-saving with respect to sources of irrigation (Table 1) under all the plots of *Grewia optiva*, *Leucaena leucocephala* and *Morus alba*. The data indicate that the sewage treated plots showed only 11.66 per cent N depletion instead of 30.00 per cent with ordinary water in *Grewia optiva* after four months of the experiment i.e. under GI. The other two fodder species also behaved similar as that of *Grewia optiva* in first category (GI) in both the groups (GI & GII). This means that the *Leucaena leucocephala* and *Morus alba* could not add the nitrogen to soil with both sources of irrigation. It is also found that the depletion was considerably less under sewage treated plots than the ordinary water. It is also observed that the rate of N depletion is drastically decreased in the second year of the experiment. The data inferred that the sewage treated plots showed addition of nitrogen (1.81%) in the group two (GII) whereas there was depletion of nitrogen to the tune of 20.70 per cent under ordinary water treated plots. So, it is clear that sewage irrigation is economically and ecologically viable option for raising the quality planting material. The addition of nitrogen in the soil under *Grewia optiva* micro plots may be attributed to the slow growth in comparison to the rest of the tested fodder species. It is also observed that there is definitely more saving of nitrogen in sewage treated plots than ordinary water irrespective of the experiment duration i.e. 4 and 16 months. These findings are in congruous with the hypothesis that sewage water has priming effect on the soil. These results are in conformity with the earlier findings of Chhabra and Chhabra (1989) and Malla et al. (2007).

It is observed from the data presented in table 1 that the effect of frequency of application of sources of irrigation was statistically significant with each other. The rate of N depletion was increased with increase in the application interval of irrigation irrespective of sources from daily ($F_1$)

**Table 1.** Effect of sewage and frequency of its application in saving of available nitrogen (Kg $ha^{-1}$) in soils under fodder trees

| Treatment(s) | *Grewia optiva* | | *Leucaena leucocephala* | | *Morus alba* | |
|---|---|---|---|---|---|---|
| **A. Source of irrigation (W)** | **GI** | **GII** | **GI** | **GII** | **GI** | **GII** |
| Ordinary water ($W_1$) | -106.2<br>(-30.00) | -73.28<br>(-20.70) | -99.87<br>(-29.03) | -67.55<br>(-19.64) | -86.23<br>(-24.92) | -39.12<br>(-11.31) |
| Sewage water ($W_2$) | -41.27<br>(-11.66) | +06.40<br>(+01.81) | -88.41<br>(-25.70) | -12.71<br>(-03.69) | -72.30<br>(-20.90) | -12.74<br>(-03.68) |
| SEd | 10.06 | 00.47 | 11.91 | 00.57 | 14.99 | 00.57 |
| $LSD_{0.05}$ | 32.02 | 01.49 | 37.90 | 01.80 | 47.70 | 01.82 |
| **B. Frequency of irrigation (F)** | | | | | | |
| Daily ($F_1$) | -55.70<br>(-15.73) | -10.65<br>(-03.01) | -56.51<br>(-16.43) | -15.48<br>(-04.50) | -63.52<br>(-18.36) | -12.16<br>(-03.51) |
| Alternate days ($F_2$) | -83.64<br>(-23.64) | -43.12<br>(-12.27) | -96.14<br>(-27.95) | -37.48<br>(-10.90) | -77.64<br>(-22.44) | -23.55<br>(-06.81) |
| After three days ($F_3$) | -81.90<br>(-23.14) | -46.26<br>(-13.07) | -129.8<br>(-37.73) | -67.43<br>(-19.60) | -96.64<br>(-27.93) | -42.25<br>(-12.21) |
| SEd | 04.00 | 00.33 | 04.35 | 00.65 | 03.90 | 00.50 |
| $LSD_{0.05}$ | 08.72 | 00.72 | 09.48 | 01.42 | 08.50 | 01.09 |

*- Depletion/+ Addition (Figures in parentheses indicate the per cent N depletion and/or addition over the initial status)*

**Table 2.** Effect of nitrogen fertilizer levels (Kg ha$^{-1}$) on N-saving of available nitrogen in soils under fodder trees

| Nitrogen levels (Kg/ha) | *Grewia optiva* | | *Leucaena leucocephala* | | *Morus alba* | |
|---|---|---|---|---|---|---|
| | **GI** | **GII** | **GI** | **GII** | **GI** | **GII** |
| **$N_0$: 0** | -143.3 | -107.5 | -149.0 | -115.7 | -127.3 | -83.85 |
| | ***(-40.48)*** | ***(-30.37)*** | ***(-43.31)*** | ***(-33.63)*** | ***(-36.79)*** | ***(-24.33)*** |
| **$N_1$:25** | -110.7 | -73.12 | -121.5 | -66.54 | -108.4 | -58.46 |
| | ***(-31.27)*** | ***(-20.66)*** | ***(-35.32)*** | ***(-19.34)*** | ***(-31.33)*** | ***(-16.90)*** |
| **$N_2$:50** | -73.25 | -37.47 | -97.04 | -38.65 | -92.89 | -41.18 |
| | ***(-20.69)*** | ***(-10.58)*** | ***(-28.21)*** | ***(-11.24)*** | ***(-26.85)*** | ***(-11.90)*** |
| **$N_3$:75** | -45.54 | -01.40 | -65.79 | -06.36 | -50.83 | +08.84 |
| | ***(-12.86)*** | ***(-00.40)*** | ***(-19.13)*** | ***(-01.85)*** | ***(-14.69)*** | ***(+02.55)*** |
| **$N_4$:100** | -03.96 | +52.31 | -37.33 | +26.60 | -16.92 | +44.73 |
| | ***(+01.12)*** | ***(+14.78)*** | ***(-10.85)*** | ***(+07.73)*** | ***(-04.89)*** | ***(+12.93)*** |
| SEd | 03.36 | 00.17 | 02.80 | 00.66 | 05.69 | 00.71 |
| **$LSD_{0.05}$** | **06.71** | **00.34** | **05.59** | **01.31** | **11.35** | **01.42** |

*- Depletion/**+** Addition (Figures in parentheses indicate the per cent N depletion and/or addition over the initial status)*

**Table 3.** Effect of sources of irrigation, application frequency and fertilizer (WxFxN) nitrogen saving in soils

| Treatment interactions | *Grewia optiva* GI | *Leucaena leucocephala* GII | *Morus alba* GI | *Grewia optiva* GII | *Leucaena leucocephala* GI | *Morus alba* GII |
|---|---|---|---|---|---|---|
| **A. Source of irrigation & frequency of application (W xF)** | | | | | | |
| $W_1F_1$ | -101.7 | -62.34 | -64.37 | -29.28 | -91.66 | -39.56 |
| $W_1F_2$ | -118.1 | -85.34 | -93.74 | -58.96 | 82.20 | -35.61 |
| $W_1F_3$ | -99.00 | -72.37 | -141.6 | -114.4 | 84.85 | -42.92 |
| $W_2F_1$ | -9.78 | +41.04 | -48.74 | -1.69 | -101.6 | -44.94 |
| $W_2F_2$ | -49.21 | -1.70 | -98.54 | -16.00 | -73.08 | -11.49 |
| $W_2F_3$ | -64.81 | -20.16 | -117.9 | -20.44 | -42.20 | +18.21 |
| SEd | 44.99 | 2.09 | 53.26 | 2.53 | 67.04 | 2.56 |
| LSD 0.05 | 98.03 | 4.56 | 116.05 | 5.51 | 146.08 | 5.59 |
| **B. Source of irrigation & nitrogen fertilizer (W xN)** | | | | | | |
| $W_1N_0$ | -162.8 | -133.2 | -160.6 | -135.0 | -129.6 | -98.33 |
| $W_1N_1$ | -140.9 | -107.7 | -127.7 | -99.70 | -116.7 | -78.04 |
| $W_1N_2$ | -108.4 | -76.40 | -104.8 | -71.50 | -108.7 | -63.27 |
| $W_1N_3$ | -81.91 | -44.68 | -67.48 | -30.67 | -56.05 | -1.88 |
| $W_1N_4$ | -37.20 | -4.42 | -38.74 | -0.93 | -20.11 | +45.37 |
| $W_2N_0$ | -123.7 | -81.87 | -137.4 | -96.45 | -125.0 | -69.37 |
| $W_2N_1$ | -80.44 | -38.53 | -115.3 | -33.37 | -100.2 | -38.87 |
| $W_2N_2$ | -38.10 | -1.47 | -89.24 | -5.81 | -77.03 | -19.10 |
| $W_2N_3$ | -9.18 | +41.87 | -64.09 | +17.94 | -45.60 | +19.56 |
| $W_2N_4$ | +45.12 | +109.0 | -35.92 | +54.13 | -13.73 | +44.09 |
| SEd | 7.31 | 7.94 | 7.94 | 1.19 | 7.12 | 0.91 |
| **LSD 0.05** | 14.57 | 15.83 | 15.83 | 2.38 | 14.20 | 1.82 |

*-Depletion from initial level of available soil N (Kg $ha^{-1}$)*
*+Addition from initial level of available soil N (Kg $ha^{-1}$)*

to after every third day ($F_3$). The highest N depletion (23.64 %) was observed in the micro plots irrigated alternatively but it is statistically at par with the frequency where irrigation was provided after every third day in *Grewia optiva*. The trend was similar in case of *Leucaena leucocephala* and *Morus alba* plots. It is also observed that the N depletion was somewhat less in the plots irrigated daily in all the three fodder species. It is further seen that the application of irrigation for longer and frequent duration gave higher N saving. This may be attributed to the earlier findings of Stewart and Salmon (1986). The best performance of daily irrigation over the rest of two frequencies lies under the fact that the experimental area falls under sub-tropical zone and therefore evaporation from soil surface is more. These results are in line with outcome of Baddesha et al 1987.

The results pertaining to the influence of different levels of nitrogen fertilizer are shown in table 2. The maximum depletion of available N was recorded in unfertilized plots while the highest addition was observed in 100 kg N $ha^{-1}$ dose over the initial status of available N in both the age groups i.e. GI & GII. The $N_0$ level gave 40.48 and 30.37 per cent N depletion while the $N_{100}$ level had 1.12 and 14.78 per cent over the initial status in *Grewia optiva*. It is also observed that $N_4$ level proved to be the best over the rest of the nitrogen doses from the soil enrichment angle. *Leucaena leucocephala* and *Morus alba* irrigated plots gave the same trend as that of *Grewia optiva*. In both the species, it was $N_4$ level which saved the maximum nitrogen over rest of the tested levels irrespective of the category i.e. GI & GII. These results are obvious that the highest depletion of available N was reported with $N_0$ level as there was no application of inorganic fertilizer which could supplement the extraction of the available N by the growing plants. On the other hand, with the increase in the level of fertilizer doses, there is somewhat natural that the level of soil N was increased with the passing time in both the groups irrespective of the species. However, the saving was not same as far as fodder trees are concerned.

Interaction between sources of irrigation with their frequency of application (WxF) gave significant effect for N saving in soils in the micro plots carrying all the tested three fodder trees (Table 3). In *Grewia optiva* plots the N saving was many folds over the initial status of available nitrogen. It was observed that the daily irrigation ($F_1$) with ordinary water could save the same quantity of available soil N as that of sewage applied after every third day ($F_3$).

The interactional effect of sources of irrigation and nitrogen fertilizer (WxN) revealed that the net 50 per cent saving was reported with sewage over the ordinary water irrespective of tested fodder trees. These findings are clearly based on the fact that sewage effluent contains higher amount of elements required by the plants for their luxuriant growth.

**CONLUSIONS**

Land irrigation will continue to be a preferred option for municipal effluent disposal. The present study advocated the use of municipal effluent for the production of quality plant material of fodder trees. It is significant technology for safe disposal of the sewage effluent with the benefits accrued from the same like nutrient buildup in the soils which finally lead to increase in the productivity of the ecosystem as whole. Sewage application can reduce the use of 50 per cent fertilizer by saving the available nitrogen in soils. Although, the experiment was short term but it clearly indicates that sewage application is beneficial to address numerous problems of the human society. The study recommends the technology for the safe and cheap disposal of the sewage effluent with alternative to chemical fertilizers to address the problem of quality planting material for rehabilitating the degraded lands and fodder scarcity in the region.

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