

## **EFFECT OF CONJUNCTIVE USE OF WATER ON YIELD AND PRODUCTION EFFICIENCY OF IRRIGATED RADISH CROP (RAPHANUS SATIVUS L.CV.PUSA CHETAKI)**

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### **ABSTRACT**

This study was conducted during 2001-2002 to evaluate the effect of sewage water irrigation in conjunction with tube-well water on radish crop (*Raphanus Sativus* L.cv. Pusa Chetaki). The experiment was laid out in a randomized block design taking four treatments T<sub>0</sub>(100% tube-well water-Control plot), T<sub>1</sub>(75% tube-well water+25% sewage water), T<sub>2</sub>(50% tube-well water+50% sewage water), T<sub>3</sub>(25% tube-well water+75% sewage water), and T<sub>4</sub>(100% sewage water). It was observed that the treatment with 100% sewage water provided the maximum yield of radish as compared to other treatments. Irrigation production efficiency was also observed to be significantly higher (38.4kg/m<sup>3</sup>) with 100% sewage water treatment and found to decrease significantly with decrease in sewage content. The microbial tests showed that the fresh water mixed with 50% or less sewage can be safely used for irrigation. The economic analysis showed that the benefit ratio of 6.66 with the tube-well water and sewage water of 1:1. The study shows that the conjunctive use of sewage and fresh water can decrease the hazardous constituents by improving effluent quality.

**Keywords:** *Conjunctive use, sewage water, water management, yield and irrigation production efficiency*

### **INTRODUCTION**

With the rapid increase in population in India (16.7% of world population in 2.4% of world surface area, Indian Census 2001) the demand of water for irrigation, human consumption and industrial use has increased considerably. There has been a steady increase in the amount of waste water production from urban communities and industries.

Currently 450 cities in India generate about 17.4 million m<sup>3</sup>/day. However, due to the limited availability of treatments facilities, about 49.1% of the generated sewage sludge is collected and treated but the rest is often discharge directly into the rivers. The ecological advantage of recycling waste water is that it can be used for irrigation and to supply scarce plant nutrients for crop production. There is also the opportunity for filtra-

tion of waste water through soils into aquifers to recharge the ground water. The use of sewage effluents as a cheap source of irrigation, essential plant nutrients and organic matter for sustaining high levels of crop production acquires a greater significance in areas of water shortages.

The liquid waste like sewage and sludge contains large quantities of plant nutrients and are used for growing sugarcane, vegetables and fodder crops in many large farms. 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. (Malla R, 2006)

There is population pressure in the Uttar Pradesh, estimated more than Pakistan's population (Indian Census, 2001). Allahabad city in which India has expanded two to three fold during last fifteen years. Due to population pressure, new townships across the river Yamuna and Ganga have also been developed. The residents of these areas are entirely dependent on vegetables, cereal crops and fruits grown around the industrial establishment. Effect of sewage on the uptake of micronutrients in grain, straw and different parts of the plant (Zimakov and Zakharora, 1984; Miller, 1986) and impact of sewage irrigation on yield Lutrick, 1982; Tiwana and Puri, 1985; Unger and Fuller, 1985; Tumarkar and Shindis, 1986) have also been studied.

According to the report of USEPA (1992) effluents are reused for irrigation purposes in many countries around the world on all the populated continents. Metabolic activity of soil microorganisms have also been reported to increase when sewage effluent is used for irrigation (Meli et al., 2002; Ramirez-Fuentes et al., 2002). The other important aspect is that it contributes in reducing the stress on the amount of water that needs to be extracted from environmental water sources (USEPA, 1992; Gregory, 2000) for various purposes like for agriculture. Paliwal et al. (1998) irrigated *H. binata* seedlings with different concentration (0, 25, 50, 75 and 100%) of sewage for

75 days resulting metals in soil.

Keeping in view the necessity of sewage water irrigation with the increasing pressure of population and enhanced demand for vegetable production in the project area, it has become necessary to evaluate the impact of sewage water irrigation combined with normal water to reduce the health hazards and to get optimal yield.

#### MATERIALS AND METHODS

The present investigation was carried out during the year (2001-2002) at Allahabad Agricultural Institute-Deemed University, Allahabad; India. (25° 27' N, 81° 44' E, and 98 m above sea level). The experiment was laid out in a three factor randomized block design with three replications. The radish crop has a effective rooting depth of 60cm. Max allowable depletion= 40%. Available water Capacity 5cm/30 cm. Reference crop evapo-transpiration is calculated with the help of below mentioned formula.

$$ET_o = K_{pan} \times E_{pan}$$

$$ET_o = \text{Reference crop evapo-transpiration}$$

$$K_{pan} = \text{Pan Coefficient}$$

$$E_{pan} = \text{Pan evaporation}$$

Class A pan evapo-transpiration data was used to estimate reference crop Evapotranspiration  $ET_o$  by taking coefficient value  $K_{pan} = 0.75$

$ET_{crop}$  was calculated by

$$ET_{crop} = ET_o \times K_c$$

$$ET_{crop} = \text{crop evapo-transpiration or crop water need mm/day}$$

$$K_c = \text{Crop factor}$$

$$ET_o = \text{Reference Evapo-transpiration (mm/day)}$$

$K_c$  was estimated graphically for 4 growth stages (initial stage, crop development stage, mid stage and late season stage)

Four levels of sewage irrigation water in conjunction with normal water at 25% sewage, 50% sewage, 75% sewage and 100% sewage were applied to the field and the water samples were analysed as per the method advocated by Jackson (1967) and the mean values as shown in the Table 1.

Table 1: Chemical composition of normal and sewage mixed water

Constituents	TREATMENT				
	100% TW water	75% TW + 25% SWG	50% TW + 50% SWG	25% TW + 75% SWG	100% SWG
pH	7.73	7.78	7.86	7.88	7.89
EC, m.mhos/cm	0.918	1.036	1.124	1.208	1.312
Na, ppm	29	23.3	52.1	39.5	58.8
Ca, ppm	29.5	25.1	28.74	28.9	30.5
Zn, ppm	25	26.4	34.02	37.8	44.80
Fe, ppm	0.03	0.12	0.39	0.39	0.4
	0.14	0.19	0.26	0.32	0.4

#### Application of irrigation water

The irrigation was applied as per evapo-transpiration need of radish crop. The open pan evaporation data was collected from the Bamrauli Meteorological Station; Allahabad, India for the period of five years. The crop was irrigated when the sum of the daily mean of pan evaporation reached approximately to a pre determined value obtained by the following equations.

Net irrigation requirement, mm = Rooting depth (m) X plant available soil moisture (mm/m) X readily available soil water in fraction.

The measured quantity of tube-well water in conjunction with sewage water was supplied by the portable garden pipes from the water mixing tank.

#### Irrigation production efficiency

Irrigation production efficiency is given in terms of ratio of marketable yield in kg per hectare to total depth of water in cubic meter per hectare and is measured in kg/m<sup>3</sup>. It is calculated by the following formula

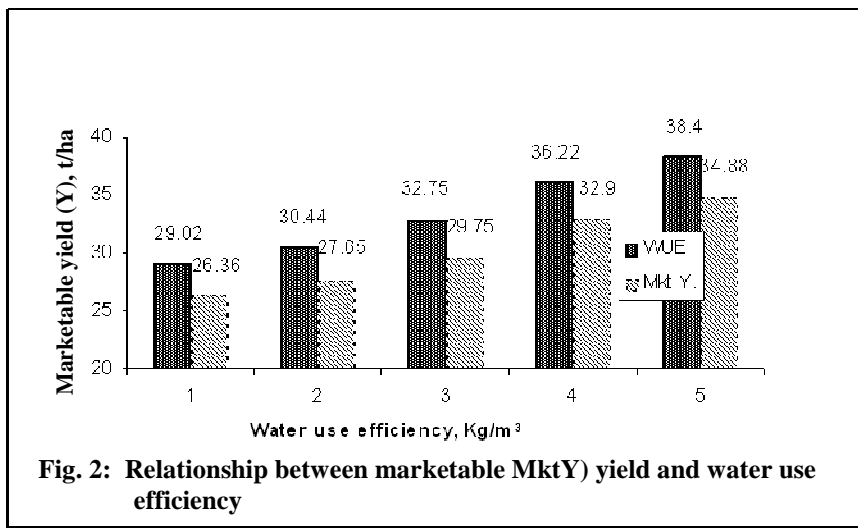
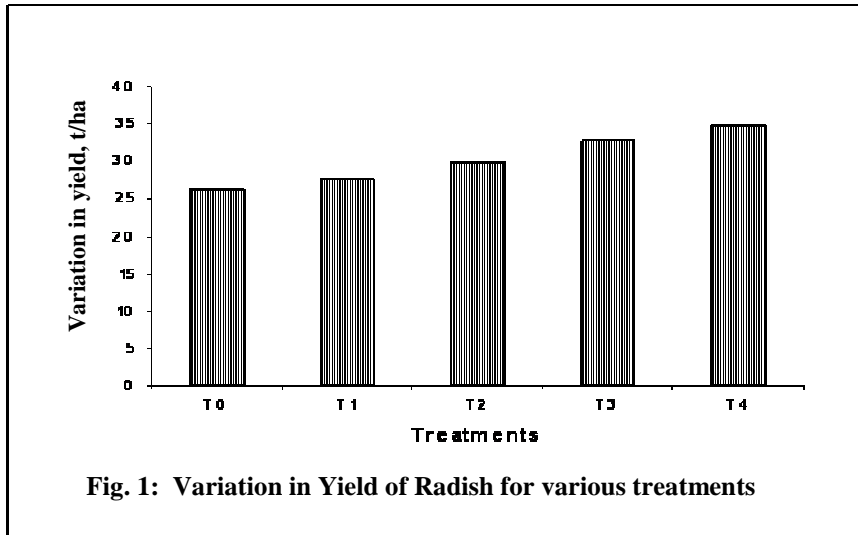
$$\text{Irrigation production efficiency, kg/m}^3 = \frac{\text{Marketable yield, kg/ha}}{\text{Total water applied, m}^3/\text{ha}}$$

#### RESULTS AND DISCUSSION

Figure 1 shows the variation in total yield of radish crop as influenced by various irrigation treatments. The maximum yield was observed for T<sub>4</sub> (fully sewage irrigated) and the lowest was achieved by T<sub>1</sub> (75% tube-well water and 25% sewage irrigated) as compared to control plot T<sub>0</sub> (tube-well water). It was observed that the highest yield was obtained by treatment T<sub>4</sub>(34.88t/ha) followed by T<sub>3</sub>(32.9 t/ha). Poletseny (1974) reported that the yield of radish increased from 6.02t-7.46t/ha by application of sewage on previously well fertilised soil. Nielson (1989) also reported that the yield with effluent irrigation was greater than or similar to yield obtained with well water. The lowest yield(27.65t/ha) was given by treatment T<sub>1</sub>.Table 2 also shows the maximum increase in yield of plot T<sub>4</sub> and this was 32.2% increase over control plot(T<sub>0</sub>).The result was found significant due to treatment and critical difference (CD<sub>T</sub>) value which found to be 0.2653

#### Irrigation production efficiency

The different irrigation treatments had significant effect on water use efficiency of radish. The water use efficiency was found to be significantly high (38.40kg/m<sup>3</sup>) when sewage water was ap-



plied. The irrigation production efficiency increases significantly with the increase in sewage water content in irrigation water (tube-well). It can be observed from the Figure 3 that the highest irrigation production efficiency was achieved by treatment, T<sub>4</sub> (38.40kg/m<sup>3</sup>) and the lowest in T<sub>1</sub> as compared to control plot, T<sub>0</sub>(29.02kg/m<sup>3</sup>). The

maximum(32.32%) increase in water use efficiency was found for plot T<sub>4</sub>(fully sewage irrigated) over the control plot T<sub>0</sub>. Irrigation with sewage water(T<sub>4</sub>) only gave a significantly higher water use efficiency(38.4Kg/m<sup>3</sup>) due to higher marketable yield(34.88t/ha) followed by T<sub>3</sub>(32.9t/ha), T<sub>2</sub>(29.75t/ha) and T<sub>1</sub>(27.65t/ha) respectively.

**Table 2: Economic analysis and Water use Efficiency for Radish Crop under Various Irrigation Treatments**

Treatments	Marketable yield, t/ha	Total Cost of Production, US\$/ha	Gross Return, US\$/ha	Net Return, US\$/ha	Benefit Cost Ratio	Irrigation Production Efficiency, Kg/m <sup>3</sup>	% increase over T <sub>0</sub> control
T <sub>0</sub>	26.36	555	3214	2658	5.79	29.02	-
T <sub>1</sub>	27.65	550	3371	2821	6.12	30.44	04.89
T <sub>2</sub>	29.75	544	3628	3083	6.66	32.75	12.85
T <sub>3</sub>	32.90	539	4012	3472	7.44	36.22	24.81
T <sub>4</sub>	34.88	533	4253	3719	7.97	38.40	32.32

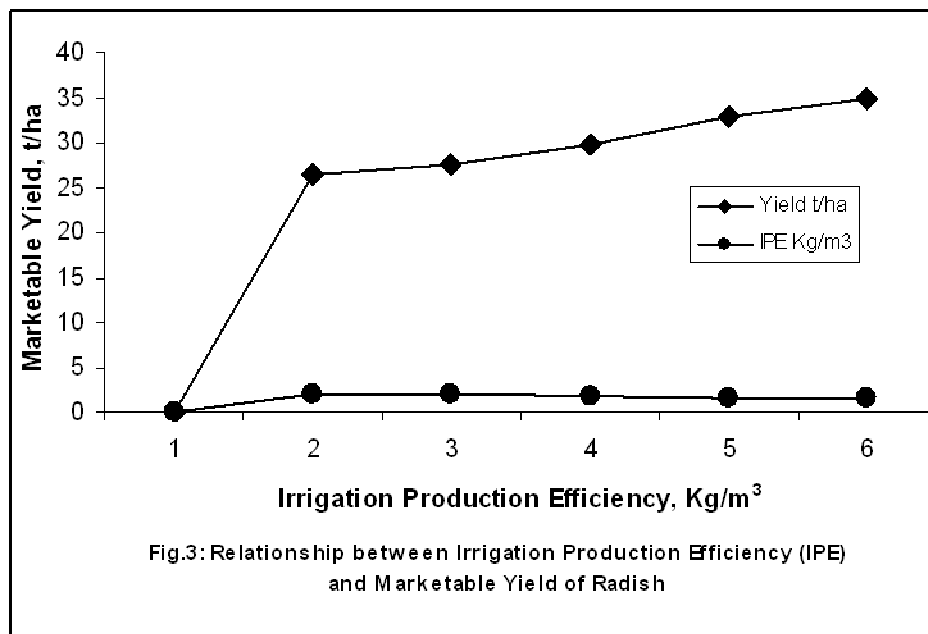
Note: 1 US\$ ~ INR 42

The irrigation production efficiency was found to decrease considerably with the decrease in sewage water content in irrigation water.

#### Quality of water and marketable yield component

Neilson (1989) reported higher yields of vegetables irrigated with municipal waste water. Mani

(1990) also found that there was a considerable increase in yield of green vegetables (spinach) after using the sewage water for irrigation. Gupta (1993) found that the grain and straw yield of wheat increases with the application of sewage sludge and Al-Nakshalbandi(1997) reported that the egg plant production under fresh water irrigation. Thus the finding of the present investigation is in line with that of the above researchers.



**Microbiological tests**

The microbiological tests for radish plant grown under various treatments showed that there were significant increase in the number of counts of pathogen and fungi above the water having 50% sewage water content although the presence of

**Table 3: Statistical Parameters using ANOVA**

Yield	F value at 5%	CD <sub>T</sub>	Result
t/ha	3.84	0.2653	Significant
Plant height	3.84	0.0426	Significant
Girth	3.84	0.142	Significant
Length	3.84	0.2478	Significant

fungi and bacteria were recorded remarkably low at 50% and 25% sewage water irrigated plots.

**Statistical analysis**

Three factor randomized block design has been used for the analysis. The results obtained through Analysis of Variance (ANOVA) for the yield, plant height, girth and length was significant. (Table 3)

**CONCLUSION**

Sewage irrigated plot produces remarkably higher yields. Maximum yield (34.88t/ha) was recorded in plot T<sub>4</sub> and the minimum in plot T<sub>1</sub>(27.65t/ha) as compared to control plot T<sub>0</sub>(26.36t/ha). There was a significant difference of water saving in terms of irrigation production efficiency for different irrigation treatments of radish crop. The highest value of irrigation production efficiency was achieved in T<sub>4</sub>(38.4kg/m<sup>3</sup>) and the lowest in T<sub>1</sub>(30.44kg/m<sup>3</sup>) as compared to the control plot T<sub>0</sub>(29.02kg/m<sup>3</sup>).The maximum net return US\$ 3674.83/ha was estimated for the treatment T<sub>4</sub> and the minimum for treatment T<sub>1</sub>(US\$ 2804.49/ha). The cost of production per hectare was the lowest US\$474.54 for sewage water (T<sub>4</sub>) irrigated plots. Sewage water for irrigation also gave the higher

cost benefit ratio and cost and benefit ratio was to decrease with the increase in volume of tube-well water. Irrigation with sewage water also resulted in the highest value of irrigation production efficiency, gross return, net return and benefit cost ratio. The above values were found to decrease with increased volume of tube-well water and vice-versa. It was observed that the yield of radish plant increased with the increase of percentage of sewage irrigation water. Irrigation production efficiency was found to be maximum at 100% sewage irrigation. Use of 100% and 75% sewage irrigation water is however not safe due to higher counts of pathogens. Although 50% and 25%sewage water can be used successfully without harm.

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