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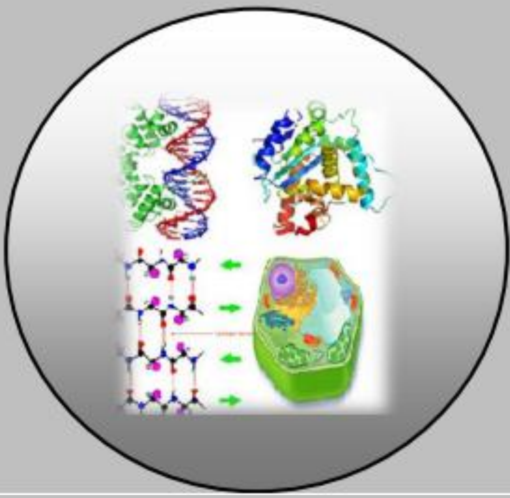

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# Re-Use of Petro-Chemical Industry Wastewater in Agriculture for Crop Production

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## ABSTRACT

*A split-plot designed field experiment was conducted at the experimental Farm of Mathura Refinery, Mathura (India), to study the effect of four doses of inorganic fertiliser on the productivity of pigeon pea grown either with ground water (G) or treated wastewater (W) discharged from the refinery, on the basis of growth and yield characteristics. Both irrigants were analysed for their quality and a higher concentration of soluble salts was noted in W. Under main plot treatment, W elicited better crop performance. The crop responses to the sub-plot treatments (fertiliser doses) was linear, with $N_{10}P_{30}K_{50}$ proving optimum. W x $N_{10}P_{30}K_{50}$ out yielded all other combinations. It can therefore, concluded that Treated Mathura refinery wastewater can be used profitably as irrigant with 10kg N, 30 kg $P_2O_5$ and 50 $K_2O$ per hectare for the cultivation of pigeon pea.*
*Keywords: Pigeon pea, refinery wastewater, fertiliser, growth and yield.*

## INTRODUCTION

Mathura Refinery, Mathura discharges about 16000 $m^3$ wastewater per day after proper treatment, and it is made available to local farmer for crop production. Samiullah *et. al*, (1994) , Aziz *et. al.* (1994) and Aziz *et. al*. (1996) have concluded that this treated wastewater is beneficial for field grown wheat, triticale and berseem respectively. As the local farmers grow grain legumes extensively, it was considered desirable to study the effect of waste water on the growth and yield of “arhar”, a popular pulse crop commonly known as pigeon pea (*Cajanus cajan* L. Millsp).

## MATERIALS AND METHODS

### Experimental system and treatments

Healthy seeds of pigeon pea (*Cajanus cajan* L. Millsp) cv.Upas-120 were surface sterilised and were sown after being inoculated with *Rhizobium* according to a split – plot design in 25 sq m plots at the Experimental Farm of Indian Oil Corporation Limited , Mathura Refinery , Mathura . The soil of the field was analysed before sowing of the crop (Texture :sandy loams ; pH :8.1; E.C :472 m mhos/cm : N:125 ; $P_2O_5$ : 32.35 and $K_2O$: 220 kg per hectare).

Main plot treatment consisted of treated waste water from the refinery (W) and fresh ground water (G). The sub - plot treatments included the fertiliser doses: $N_0P_0K_0$ ($T_1$), $N_5P_{15}K_{25}$($T_2$) , $N_{10}P_{30}K_{50}$ ($T_3$) and $N_{20}P_{60}K_{100}$ ($T_4$) applied at the time of sowing. Whereas N, P and K indicate nitrogen, $P_2O_5$ and $K_2O$, the subscripts 0-100 indicated the amount of fertiliser (kg $ha^{-1}$) applied to each plot. The sources of N, P and K were urea, mono calcium super phosphate and muriate of potash respectively. The crop received four irrigations at 30, 60, 90 and 120 days after sowing (DAS) at the rate of 2500 litres of irrigant. A 90 $^0$ - V notch weir box was used for measuring the flow using following formula:

$Q=1417\ H^{2.5}$

Where, Q = discharge (1/sec) and
H = height of the water level over the apex of the notch, cm.

### Parameter and their determinations

The growth characteristics studied at 90, 120, and 150 DAS, included shoot length (cm), leaf number, branch number, fresh weight (g) and dry weight (g) per plant. At harvest (190 DAS), pod number per plant, seed number per pod, 1000 seed weight (g), seed yield (quintal / hectare) and harvest index were noted. Both irrigants were analysed for various physico – chemical properties according to Standard Methods (1985).

## STATISTICAL ANALYSIS

All growth and yield data were analysed statistically using F-test according to Gomez and Gomez (1984).

## RESULTS AND DISCUSSION

The physico-chemical analysis of irrigants revealed that the concentration of nutrients ($NO_3$ - N, $PO_4$ , K, Ca and other ions ) was higher in W than in G. The pH of the irrigants was almost same: however, a slightly higher value for electrical conductivity (E.C.) and sodium adsorption ratio (SAR) was noted in W (Table 1).

Compared with G irrigation , W elicited better performances of the crop as indicated by higher values for shoot length (4.98 , 5.12 , and 5.07%), leaf number ( 5.45 , 4.27 and 5. 7%) , branch number (15.4, 9.9 and 17.0%), fresh weight (4.8 , 4.0 and 6.9%) and dry weight (10.1, 8.0 and 9.7%) per plant at 90 , 120, 150 DAS respectively (Fig. 1. ). As a consequences, the yield performance of pigeon pea was better in main plots, irrigated with W, than in those receiving G. For example, pod number per plant was increased by 7.62%, seed number per pod by 6.52%, 1000 seed weight by 5.93%, seed yield by 15.4% and harvest index by 7.0% in W compared with g (Fig.2).

As would be expected , the improved high yielding cv. (Upas-120) responded significantly to the added fertiliser as revealed by the data for vegetative and yield parameters (sub- plot means ). There was a linear increase in the growth and yield with increase in the fertiliser dose. Treatment $T_3$ ($N_{10}$ $P_{30}$ $K_{50}$ ) proved optimum for almost all growth and yield characteristics , except pod number per plant but the recorded values were at par with those for $T_4$ ($N_{20}$ $P_{60}$ K $_{100}$). Compared with the fertiliser treatment ($T_1$) , ($T_3$) improved pod number by 20.8%, seed number by 34.2% , 1000 seed weight by 19.3%, seed yield by 40.6% and harvest index by 11.2% (Fig.2).

When interaction effects (main plot x sub-plots) were taken into account, it was noted that main plot W gave better results than G in response to fertiliser application. Among the various combinations, W x $T_3$ out yielded all others for almost all the parameters studied. For example, compared with G x $T_3$, W x $T_3$ gave 18.5% higher value for seed yield , which is the most important parameter from economic point of view (Fig.2)

Similarly, when the interaction effects of various fertilizer doses, constituting the sub – plots, were compared at the same level of main plot ( sub- plot x main plot) ; the values for growth and yield parameters were noted to be highest in T3 x W in most cases. Considering seed yield again, T3 x W showed an increase of 38.2% over T1 x W (Fig.2).

**Table 1. Physioco-chemical characteristics of ground water (G) and Treated waste water (W) at different intervals of time (all determinations in mg/l or as specified)**

| Determinations | Irrigations | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | 60 DAS | | 90 DAS | | 120 DAS | |
| | **G** | **W** | **G** | **W** | **G** | **W** | **G** | **W** |
| TDS | 746 | 825 | 810 | 996 | 804 | 856 | 780 | 820 |
| E.C. (dS/m) | 0.81 | 0.99 | 0.86 | 1.04 | 0.82 | 1.07 | 0.97 | 1.12 |
| pH | 7.9 | 7.6 | 8.1 | 7.9 | 7.4 | 7.6 | 7.6 | 7.8 |
| BOD | 4.2 | 4.6 | 4.4 | 4.3 | 5.2 | 4.2 | 4.4 | 4.0 |
| COD | 39 | 68 | 37 | 72 | 41 | 73 | 46 | 69 |
| Calcium | 14.6 | 30.4 | 15.4 | 42.3 | 18.6 | 53.2 | 16.4 | 39.6 |
| Magnesium | 48.6 | 52.4 | 52.2 | 57.4 | 46.9 | 49.6 | 62.6 | 63.9 |
| Potassium | 9 | 13 | 8 | 12 | 7 | 9 | ND | 7 |
| Sodium | 69 | 84 | 72 | 79 | 76 | 91 | 80 | 82 |
| Bicarbonate | 204 | 206 | 208 | 219 | 223 | 227 | 217 | 229 |
| Carbonate | ND | 7 | ND | 19 | ND | ND | ND | 6 |
| Chloride | 154.6 | 167.8 | 121.4 | 127.4 | 89.2 | 92.4 | 106.7 | 134.3 |
| Sulphate | 78 | 83 | 84 | 87 | 88 | 92 | 82 | 89 |
| Phosphate | 0.09 | 0.62 | 0.12 | 0.59 | 0.22 | 0.78 | 0.16 | 0.59 |
| Nitrate | 0.63 | 1.25 | 0.74 | 1.53 | 0.72 | 1.42 | 0.59 | 1.26 |

DAS – Days after sowing

ND – Not detectable

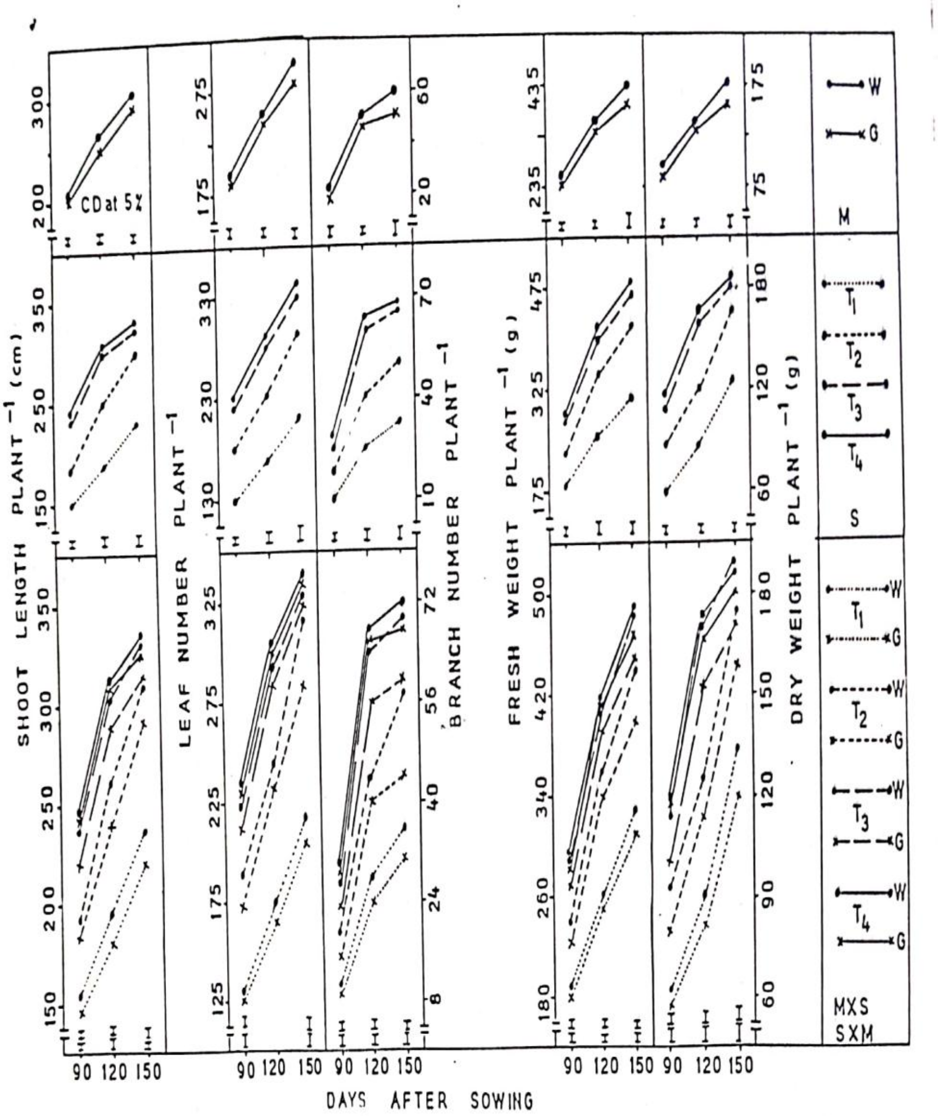


**Figure 1. Effect of waste water (W) and ground water (G), with and without fertilizers ($T_1$ – $N_0P_0K_0$ ; $T_2$ – $N_5P_{15}K_{25}$; $T_3$ – $N_{10}P_{30}K_{50}$; $T_4$ – $N_{20}P_{60}K_{100}$) , on growth characteristics of Pigeon pea cv Upas – 120 at 90, 120 and 150 DAS (M – Main plot treatment means; S – Subplot treatment means ; M x S and S x M – interactions effects).**

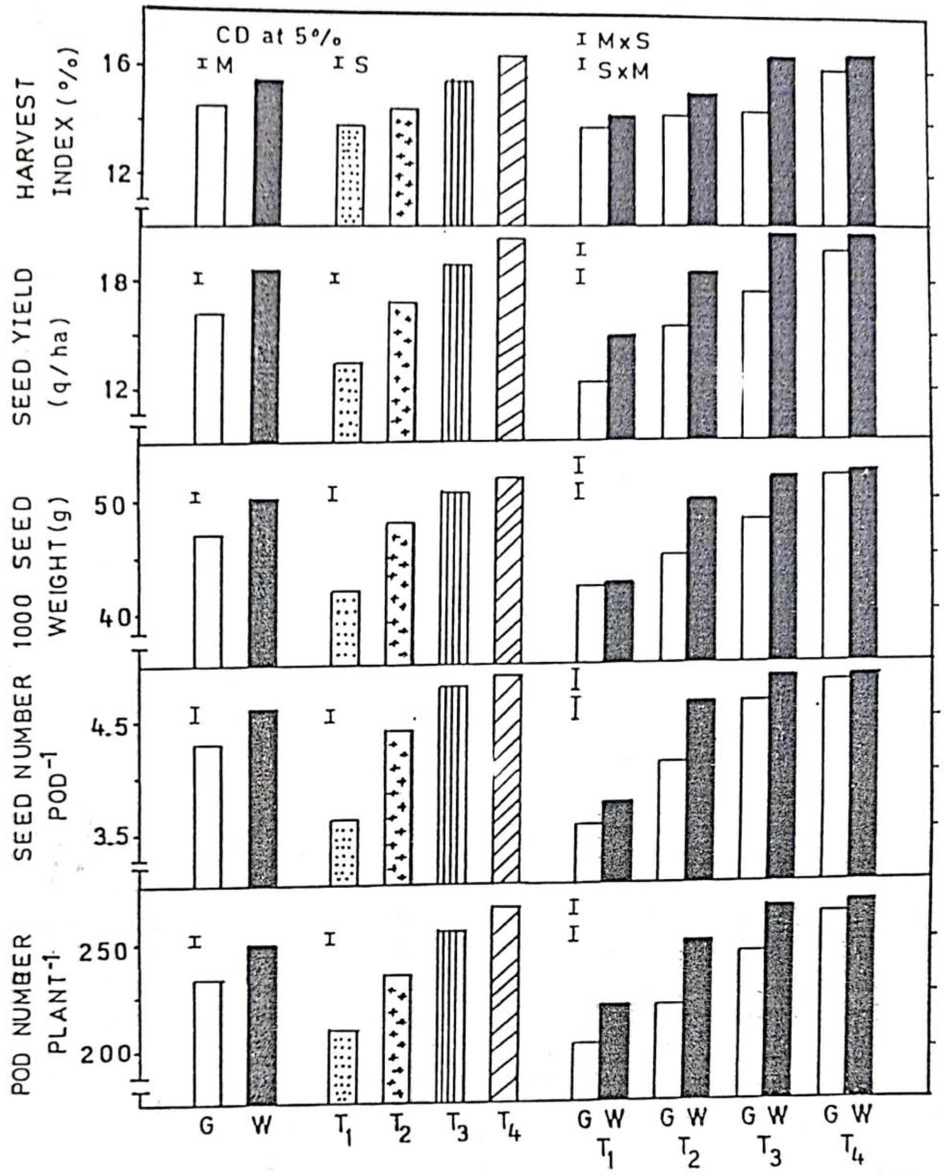


**Figure 2. Effect of waste water (W) and ground water (G), with and without fertilizers( $T_1$ – $N_0P_0K_0$ ; $T_2$ – $N_5P_{15}K_{25}$; $T_3$ – $N_{10}P_{30}K_{50}$; $T_4$ – $N_{20}P_{60}K_{100}$) , on yield and yield characteristics of Pigeon pea cv Upas – 120 (M – Main plot treatment means ; S – Sub - plot treatment means; M x S and S x M – interactions effects).**

The better response of pigeon pea crop to treated waste water irrigation noted above may probably be due to the presence of higher concentrations of nutrients in the W (Table 1) If this is true, then addition of fertilizers to the soil would be expected to give more spectacular results, which is borne out by the beneficial effect of added fertilizers on all the vegetative and yield characteristics (Figs, 1 and 2). The observation is self-explanatory, as the indigenous fertilizers in the soil were insufficient for optimum growth of the fertilizer intensive cultivar of pigeon pea selected for the field experiment.

These findings are also in agreement with the data of Day *et. al.,* (1975); Sahai *et. al*. (1985); Aziz, (1991); Samiullah *et al*., (1994); Aziz *et al*., (1994); Aziz *et.al*., (1996) on other crops. The growth of plants organs results from orderly cell division, expansion and differentiation. These processes are dependent on proper supply of nutrients (Moorby and Besford, 1983). These influence plant growth both directly by providing vital macromolecules and indirectly via their effect on the supply of assimilates and growth substances. Incidentally, the present study also confirmed the well-established effect of fertilizer application on crop plants in general as it clearly indicated that during vegetative growth, the crop response to added fertilizer increased with age.

Treated waste water supplemented with fertilizer increased the vegetative and reproductive growth as is evident from increase in seed yield (Fig. 2). The sub plot treatment $T_3$ ($N_{10}P_{30}K_{50}$) together with W gave the maximum seed yield through its beneficial effect on almost all of the yield characteristics. Thus, pod number per plant; seed number per pod, seed weight was increased most by this treatment. Higher seed yield (q/ha) may be due to more seed weight and pods per plant. These findings are in conformity with the results of Inam, 1978; Afridi *et. al.*, 1983 and Aziz, 1991.

It may, therefore, be concluded that treated waste water from the Mathura Refinery, which met the quality criteria normally prescribed for irrigation water, may be used profitably for the cultivation of pigeon pea, as its application not only increases productivity, but also results in saving of fertilizer, at the same time conserving large quantities of water which is no doubt a precious resource.

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