J Integr Sci Technol, 2014, 2(2), 80-84 Article

Journal of Integrated
SCIENCE & TECHNOLOGY

Effect of sewage irrigation on yield of Pea and Pigeon Pea

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Received: 18-January-2014

ABSTRACT

Irrigation is the important factors which determine the productivity of any crop. In this study, the source of irrigation is sewage effluent and observations were recorded on important food crops like pea & pigeon pea. Results showed at higher concentration of effluent there were reduction in growth and yield as compared to diluted conc. (50%) which showed normal growth or without affecting yield, which might be due to lots of organic matter and essential nutrient in sewage effluents.

Keywords: Plant Growth, Sewage Irrigation, Crop productivity

INTRODUCTION

Water scarcity is a severe problem in arid and semiarid regions of the world. Re-use of waste water (sewage effluent) is an appreciable and self controllable source so far irrespective of many impediments and restrictions should be reclaimed. Irrigation with sewage effluent are extensively used throughout world since hundreds of years, also a way of disposal of waste water (domestic waste). Yet it is practiced at a small level in developing countries. In addition to organic nutrient like Nitrogen, phosphorus, it is also having few amounts of heavy metals.

Pulses are the most important source of nutrient of vegetarian in India as well other developing countries, wherever increasing population menace made their availability (35 gm per head per day) much lower than recommended (104 gm per head per day by WHO) World Health Organization. Moreover pulses are endowed with capacity to fix atmosphere nitrogen and improve soil fertility. Field pea (*Pisum sativinsh*) and Pigeon Pea (*Cajanus Cajan L.)* are the most important pulse crop grown in India both for vegetables and dry seed purpose. Peas have nutritive value and are richer and cheaper source of protein. On an average, it contains 93 calories, 72 per cent moisture 15.9 percent carbohydrates and 20-22% protein in addition to 0.1 g fat, 9.0 mg vitamine, 0.25 mg thiamine, 0.01 mg riboflavin, and 21.5 mg mineral per 100g of edible portion (Bose and Som, 1985). Among winter season pulses, field pea is ranked second after chickpea in India. Pigeon pea on the other hand is an important Kharif legume crop[1] for semi-arid tropics. It ranks first among Kharif pulses and second after gram among all pulse crop with regard to area and production. Irrigation provide moisture, essential nutrients for proper plant growth, so it is an integral part of plant growth regarding source, type as well as frequency of irrigation.[2] The aim of present study is to see the toxicity of sewage if used for irrigation in scarcity of water on Pea and Pigeon pea. In this study we studied all growth parameters in both crops and compared with normal irrigation.

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Cite as: *J. Integr. Sci. Technol., 2014, 2(2), 80-84.*

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MATERIALS AND METHOD

In order to observe the effect of sewage on growth and yield of Pea and Pigeon Pea was studied in Arkal and Manak varieties respectively. 30 pots were selected for the experiment, one set of ten pots for control, another for 50% and another for 100% sewage irrigation. Initially for control, irrigation was done with Hoagland nutrient solution and later on with available tap water. Observations were recorded at the regular intervals.

BIOLOGICAL YIELD

1.1 Periodic Growth Studies

The growth studies were done on 6 randomly selected plants from all pots of a treatment. These plants were tagged for recording of plant height and number of branches per plant. These plants were also utilized for yield attributes studies.

1.2 Dry Matter Accumulation

Dry matter accumulation per plant were recorded by taking 6 plants randomly selected first at 30 days after sowing and subsequently at 25 days intervals and at the time of harvest. The plant matter was dried in sun and in oven at 70° C till constant weight was achieved. The dry samples were weighed for recording average dry weight in gram per plant.

1.3 Height of Plant

The height of plant was measured in centimeters from base of soil to the top of shoot. First at 30 days after sowing, later at 25 days interval and finally at maturity of crops.

1.4 Number of Branches per plant

These were recorded first at 30 days after sowing and subsequently at 25 days interval and finally at the time of harvesting.

1.5 Yield Attributes

1.5.1 Number of Pods per plant

All pods from six tagged plant were picked up and counted and average number of pod per plant were calculated.

1.5.2 Pods weight per plant (g)

The total number of pods from six randomly selected plants samples were weighed and average weight of pods per plant was worked out.

1.5.3 Number of Seed per pod

Pods from six tagged plant were threshed and seeds were obtained. The average number of seeds per pod was calculated in this way.

1.5.4 Hundred seed weight (g)

A sample of hundred seeds from bulk of each treatment pots yield was taken and then weight was recorded.

1.5.5 Seed yield per plant (g)

Average seed yield per plant was worked out from the six tagged plant of each individual treatment pots.

1.5.6 Straw yield from each treatment was recorded separately deducing seed yield and converted into quintal per hectare.

1.5.7 Harvest Index (%)

This was calculated as follows:

$$\text{Harvest Index} = \left[\frac{\text{Economical yield} \times 100}{\text{Biological yield}}\right]$$

RESULTS

BIOLOGICAL YIELD

Pea

The growth parameter under the two gradients of sewage irrigation were studied (table 1 & table 2).[3] Dry matter accumulation at maturity of pea in 50% sewage concentration was more than 100% sewage. It was 67% of control, 22% of control in roots of 50%, 100% sewage irrigation respectively. While in stem at 50% the dry matter accumulation was 62% more than 100% even slightly more than control. Leaves showed 58% more accumulation at 50% concentration while 7% more in case of 100% irrigation. As compared to control, seeds dry matter at 50% was 53% more than 100% conc. & it was comparable to control. So general trend for growth parameters were 50%> control>100%.

Table 1. Fresh weight mg/part of maturity 10 ± SD of Pea

Conc. of Sewage	Root	Shoot	Leaves	Pods
Control	280±18.5	520±20.2	360±15.4	110±8.6
50%	250±12.3	470±28.4	368±11.5	98±3.13
100%	180±13.5	347±18.5	285±15.3	72±2.17

Table 2. Dry matter (g/pot) at Maturity

Sewage Conc.	Root	Stem	Leaves	Pods	Seeds
Control	2.79±0.42	5.57±0.24	3.51±0.07	3.46±0.13	13.53±1.31
50%	3.43±0.21	5.63±0.42	3.78±0.16	3.12±0.16	13.67±2.61
100%	2.31±0.01	3.50±0.04	2.19±0.21	2.43±0.06	7.35±0.90

Table 3. Effect on plant height of Pea

Days# →	30	40	50	60	70	80	90
Sewage conc.↓	Plant Height of Pea (mean value)						
Control	17	19.5	21.1	22.4	23.1	24.3	25.6
50%	15	17.3	20.4	21.2	22.0	23.2	25.0
100%	8	10.2	12.0	12.8	13.5	14.4	17.8

#Days after sowing

Table 4.

Days# →	59	69	76	83	90
Sewage conc.↓	Average No. of pods/pot				
Control	1.3±0.04	2.8±0.01	8.9±0.05	13.8±0.15	16.7±0.10
50%	20.+0.18	3.0±0.02	9.1±0.1	14.5±0.28	20.8±0.6
100%	0.8±0.01	1.5±0.09	3.2±0.2	5.7±0.41	7.6±0.2

#Days after sowing

Table 5. No. of pods at Maturity in Pea

Sewage Conc.	Control	50 %	100 %
No. of pods	19.7±1.3	18.4±0.88	12.1±1.11
No. of seeds per plant	52.6±0.65	50.1±0.81	31.3±1.6
Pod length (cm)	7.8±0.54	6.26±0.20	3.61±0.80

Table 9. No. of pods at Maturity in Pigeon Pea

Sewage conc.	Control	50 %	100 %
No. of Seeds/plant	3.53±1.21	3.15±0.72	2.20±0.89
No. of leaves/plant	148	141	130
No. of branches/plant	18	11	7.0
Grain yield (g/plant)	42.7±2.0	35.4±1.2	22.5±0.3

PIGEON PEA

Table 5 shows dry matter accumulation per plant of pea. It was 76% of control at 100% sewage irrigation, & 95% at 50% sewage conc. Increase in dry matter accumulation was maximum for upto 110 days after which it become more or less static plant height table 6 at 50% is comparable to control and lesser at 100% conc. IT was maximum in between 50-100 days & then become steady upto maturity of crop where plant height were 191cm, 184cm, 174cm, in control, 50% & 100% sewage irrigation respectively showing same trend as like dry matter accumulation.

ECONOMIC YIELD

Pea

Result in table 4 & table 5 shows that the number of pods (18.15) in pea at 50% sewage irrigation as comparable to control and lesser for 100% irrigation (14.34) followed by control (18.40). Pod weight also showed similar trends with 9.87, 9.44, 6.12g in control, 50% , 100% sewage irrigation

Table 6. Plant height of Pigeon Pea (cm)

Days after sowing→ Sewage Conc.↓	30	40	50	60	70	80	90	100	110	120	130
Control	19.5	34.6	45.5	59.2	73.3	100	116.7	125.7	130.1	132.7	131.2
50 %	20.2	26.5	40.5	59.8	75.7	105	118.4	125.1	131.3	133.6	130.0
100%	17.3	24.8	32.1	39.6	49.4	52.5	55.8	67.9	62.5	54.3	53.2

Table 7. Dry weight of roots (Pigeon Pea)

Days after sowing→ Sewage conc. ↓	30	40	50	60	70	80	90	100	110	120	130
Control	0.28	0.37	0.46	1.10	1.63	2.16	2.45	2.56	2.62	2.50	2.27
50 %	0.30	0.36	0.42	1.11	1.65	2.20	2.50	2.59	2.68	2.57	2.38
100%	0.21	0.25	0.36	0.48	0.56	0.94	1.21	1.48	1.46	1.37	1.21

Table 8. Dry weight of Pigeon Pea (stem)

Days after sowing→ Sewage conc. ↓	30	40	50	60	70	80	90	100	110	120	130
Control	0.19	0.28	0.37	1.45	2.15	3.67	5.83	7.35	7.46	7.49	7.10
50 %	0.15	0.26	0.40	1.56	2.32	3.75	5.54	7.28	7.47	7.53	6.83
100%	0.11	0.18	0.27	0.86	0.97	1.31	2.85	3.21	4.88	5.42	3.48

Similar trends were observed for plant height at 50% sewage concentration was comparable to control plants, but it is 69% of control at 100% sewage conc.

respectively. Number of seeds per pod were almost similar in control and 50% irrigation, it is less in 100% irrigation. Hundred seed weight of pea at 50% conc. is slightly fewer than the control (98%) while in case of 100% it was 80% of control.

Pigeon Pea

The table 9 showed the number of pods per plants showing same trend of growth as noticed in case of pea. Number of pod per plant for 50% were 170as compared to 158 of 100% sewage irrigation which were 97% & 90% of control plant. Number of seed per pods were comparable for 50% and control plant while 62% lesser for 100% conc. Hundred seed weight in table 10 of control, 50%, 100% sewage irrigation were 25.5, 22.3, 18.7g respectively, so the economic yield of 50% was comparable to control and more than 100% irrigation.

Table 10.

Days after sowing→	**0-90**	**90-95**	**95-100**	**100-105**	**105-110**	**110-115**	**115-120**
Sewage Conc.↓	**No. of flower per plant Pigeon Pea**						
Control	65±1.54	116±1.87	98±0.56	60±1.38	35±0.58	13±0.06	2±0.01
50 %	59±1.01	110±2.17	95±0.75	53±0.83	31±0.90	11±0.03	1±0.02
100 %	42±0.62	87±0.78	73±1.03	38±0.41	20±0.37	60.+0.01	---

DISCUSSION

Waste utilization provides slight improvement in plant management,[4] conditions and suitability due to increased nutrients and better timing of applications.[5] Municipal waste water and solids are applied to agricultural lands as a nutrient source.[6] The growth of various crops has been reported to be influenced by different type of effluents. Even treated effluents[7] of chemical industry was effective in enhancing germination, growth, chlorophyll and protein contents of crops. Pea and pigeon pea is one of the important leguminous crops grown extensively for its varied uses as vegetable pulse, feed and fodder. They can contribute very effectively in augmenting the total production of pulses thus meeting the ever increasing demand of leguminous proteins.[8,9]

Height of crop plants growing under various concentrations of effluent increased or decreased tremendously with increasing concentration of effluent.[10] They revealed better growth of plants due to promoting effect of nitrogen and other nutrients present in the effluent irrigated soil.[11] Researchers have reported reduction of size of plant at higher concentration due to reduced photosynthesis owing to pollutants and heavy metal ions. This in turn affecting the stress over coming capability of plants either due to higher concentration of sodium monovalent cation present in effluent which upset tolerance of nutrients in soil. Increased biomass[12] could be ascribed to nitrogen, Ca^{2+}, Na^{+} and Cl^{-} from effluent to plant via soil.[13] Gadallah studied effect of sewage on plants that the decreased moisture percentage of sewage treated plants could be due to effect of sewage effluents on membrane permeability and increased resistance to water flow or due to insufficient root system to compensate for water loss by transpiration, unavailability of water in soil. The present results were corresponding with these reports or studies. It has been showed that in Pigeon peas and water stress reduces plant height, leaf number, chlorophyll content, dry matter, pod formation. Pea also showed reduction in yield parameter with increasing concentration of sewage irrigation. Yield was minimum in 100% sewage irrigation in both crops and comparable to control in 50% concentration which may be due to dilution of toxic substances like heavy metal in the water while in 100% effect was much pronounced because of higher level of toxic substances. Reduction in growth parameter in 100% irrigation may be due to retranslocation from the root to the photosynthetic part of the plant, availability of plant toxic substances depend upon various factors like sources of effluent, cation, anion, pH, EC of the soil. Heavy metals also present in sewage effluent in considerable amount,[13] therefore at 100 percent sewage irrigation the reduction in growth parameters and yield as reported by earlier workers in almost all growth parameters. Reduction in growth parameters of black gram may be attributed to the toxic effects of effluents such as heavy metals, excess or deficient, deficit level of micronutrients, decomposition products. At low conc. of waste water, increase in yield might be due to addition of sodium, potassium, calcium, phosphorous, manganese, magnesium as well as loads of organic matter which acts as fertilizers through the proper use of nutrient by the plants. So we observe higher yield at 50% concentration. The reasons behind the normal growth at lower conc. may be due to dilution of hazardous chemicals especially heavy metals so that could not significantly hinders the growth, but at 100% conc. the amount of toxins gets elevated which completely percolate through soil and enters to the plant root through the transloction to all plant parts but at varying conc. few heavy metals and micronutrients are able to form ligands. Thus stays for longer time in that system without leaching. The present study proofs completely dilution can reduce the toxicity by reducing the concentration of harm ful substance, thus can be used in place of normal irrigation water in case of scarcity of irrigation water with good yield to the farmers. Sewage effluent is a mixture of organic matrix which enhances content of micronutrients like Fe. Zn, Cu, Mn.[14] But the continuous irrigation with sewage effluent cause accumulation of Pb, Cd, Cu, Cr, Ni in surface and sub surface soil[15] through which it enters the food chain and shows magnification till it reaches to human & animals.

CONCLUSION

Sewage irrigation affects the plant growth and yield, both biological and economical yield. Both biological & economical yield decreased at 100% sewage irrigation in pea & pigeon pea after complete maturation of crops. Diluted conc. of 50% sewage yield was comparable to control in almost all parameters. Diluted sewage concentration is recommended for irrigation in crop fields as it has no deleterious effects on seed germination, plant growth biological and economic yield. Both plants shows reduction in growth at 100% sewage irrigation which might be due to presence of heavy metals like copper, cadmium, lead, zinc which in turn retards the mobilization and synthesis of

various reserve food material during seed germination and also reduce the activity of hydrolytic enzymes[16] upto a significant level thus ultimately affecting the growth parameters of both crops.

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