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IMPACT OF SEWAGE SLUDGE ON PEA (*Pisum sativum*) IN SALINE USAR SOIL

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ABSTRACT

Salinity in the arid and semi-arid regions is a serious threat to agriculture in the World. It is known one third of irrigated land is already affected by salinity and the level of is still rising. It is therefore, becomes very much important to explore the possibilities of overcoming this limitation in raising the good crops under the conditions of high salinity without much substantive decrease in the yield and the quality of grains. The present work was planned to study the effect of sewage sludge application on growth and productivity of pea *(Pisum sativum)* in saline user land. Four different types of treatments i.e. untreated saline soil (T), saline soil: fertilizer (10:1, v/v; T1), saline soil: sludge (10:1, v/v; T2) and saline soil: sludge (2:1, v/v; T3) were used for the present study. The experiments were conduct in earthen pots (35 cm diameter). The pH, organic matter, EC, CEC, mineral elements and heavy metals were measured in soil and sludge. The seed germination, plant height, shoot and root dry weight, root to shoot ratio and various yield and biochemical parameters of pea plant were improved drastically in sludge treated soil. Improvements were observed in all the parameters in the sequence of saline soil< soil: fertilizer (10;1)<soil: sludge(10:1)< soil: sludge(2;1) and the maximum improvement occurred in the T3 treated pot.

KEYWORDS: *Pisum sativum*, Soil, Seeds, Grains, Sewage Sludge, Usar

The saline usar soils are characterized by impermeability, extreme hardness and occasional presence of undesirable salts on the surface, all of which affect adversely the plant growth. Locally known as 'Usar' or 'Reh' in U.P., 'Kallar' in Punjab and 'Chopan' in Maharashtra, these soils are so far regarded as unsuitable for perennial irrigation and cropping. Soil salinity has multifarious effects on plant growth and productivity. Production of legume is particularly vulnerable because of their low tolerance to salinity and initiation of symbiotic nitrogen fixation, infection of root hairs by rhizobia and subsequent nodule development are sensitive to salinity (Yousef and Sprent, 1983) (Elsheikh and Wood, 1990) (Ashraf and Waheed, 1993) (Soussi *et al.*, 1999) (Rao *et al.*, 2002). Pea is also very sensitive to salinity. It therefore, becomes very much important to explore the possibilities of overcoming this limitation in raising the good pea crop under conditions of high salinity without much substantive decease in the yield and the quality of the grains.

Sewage sludge is the insoluble residue from the waste treatment after aerobic or anaerobic digestion procedure comprises resistant organic compunds, nitrogen, phosphorus, a wide range of *macronutrients* and non essential trace metals, microorganisms with eggs of parasitic organisms. The substantial N and P concentrations in sludge render it as a useful material and organic constituents provide beneficial soil conditioning properties.

Use of sewage sludge in agriculture is a worldwide practice, and is a very effective sludge disposal technique (Singh and Agrawal, 2007). Sewage sludge enables the recycling of valuable components such as organic matter and many plant nutrients (Logan and Harrison, 1995). The macronutrients in sewage sludge such as N, P, K e.t.c. serve as good source of plant nutrients. Application of sludge has long been known to improve physical and biological properties of soil in addition to providing several nutrients including N (Pagliai *et al.*, 1981) (Wei *et al.*, 1985) (Sigua *et al.*, 2005) (Ofori *et al.*, 2005) (Casado-Vela *et al.*, 2006). Some author also reported that the addition of sewage sludge to agricultural land increases crop production. Some author reported that the increase in crop yield by sludge application often exceed that of well managed fertilized controls. Effect of sludge on some leguminous crops has also been worked out. The growth of soyabean can be improved by sewage sludge at a low application rate without the necessity of additional phosphorus fertilization. Growth of alfalfa was also increased in sludge amended soil. Although, the sewage sludge falls in an area of intensive research in several industrial countries are available on the effect of application of sewage sludge to agricultural soils in different countries are.

The present study, the "Impact of sewage sludge on pea (*Pisum* sativum) in saline usar land" has been undertaken to observe the effect of sewage sludge in usar field.

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MATERIALS AND METHODS

Soil and Sludge Origins

The saline soil was taken from the field of village 'Sewarhi' of Varanasi district, U.P. (India). The experimental site is situated in East of Varanasi city at a distance of about 40 km from Varanasi Cantt railway station, now it is in Chandauli district. The geographical situation of the site is 25.15 North lattitude, 82.3 East lattitude and 76.19m above sea level. The sludge was an aerobically digested secondary sludge from the sewage treatment plant of Assi (Varanasi). It is covering the sewage from Varanasi city as well as Diesel Locomotive Works (D.L.W.) factory, Varanasi.

Soil Analysis

The pH of soil was measured in the suspension of 1:5(w/v) with help of pH meter (Model EA940, Orion, USA) standardized with pH 4.7 and 9.2 reference buffer and electrical conductivity was determined in the clear suspension solution of 1:2 soil to water suspention using conductivity bridge meter (Model 303, Systronics, India). Organic carbon was estimated by Walkley and Black rapid titration method as described by Jaction. The cation exchange capacity was determined by the method by distillation with sodium hydroxide and total N was estimated by alkaline permagnate method as described by Chopra and Kanwar. Available phosphorus was determined by Oslen's method using N/2 $NaHCO_3$ of pH 8.5 and available potassium was determined as described by Jackson and analysed with the help of Flame Photometer (K). Available metals were determined as described by Allen *et al* by using Atomic absorption spectrophotometer.

Sludge Analysis

The organic carbon, total N, total P, were determined using the analytical methods as described for the soil. The total metals and non metals in sludge were analysed by the method of McLarean and Crawford.

Experimental Design

The soil from the usar field was collected and transferred in November, 2006 to pots with upper diameter of 35 cm. The pots were filled with soil with different treatments as shown below. Pots were divided in 4 groups of pots each. Every group of pots provided with different treatment during the experiments. The saline soil of installation area or mixture of it with fertilizer or sludge was used to fill the pots in all four groups:

Treatments

T: Soil only

T1: Soil and fertilizer (10:1)

T2: Soil and sludge (10:1, v/v)

T3: Soil and sludge (2:1, v/v)

Irrigation of the pots was executed daily with predetermined quality of that fertilizer or sludge could not be washed out of the pot.

Crop Tested

Seeds of pea (*Pisum sativum*) were obtained from Central Soil Salinity Research Institute Karnal, Haryana, India. Seeds were rinsed with tap water and grown in pots prepared as stated above. After germination, thinning of plants was done and three plants of uniform size were maintained in each pot .Plants were sampled and analyzed for the following parameters at the time of harvest. Two pots with 3 plants in each sampled per treatment.

Seed Germination and Seedling Emergence

The percentage of seed germination were recorded when new seedlings cease to emerge. The number of plants emerging and surviving in each pot was recorded daily. About a weak after the time that new plants cease to emerge, the plants in each pot were thinned to achieve three plants per pot. The time from seeds to initial seedling emergence to 95% of peak emergence as a percentage of maximum emergence attained (%/day), final emergence and survival to harvest, as a percentage of maximum survival attained in the test (%) were measured.

Growth and Yield Parameter

At the time of harvest, average plant height (cm), shoot and root dry weight (g), root and shoot ratio, yield attributes like number of flowers, number of pods, number of seeds and grain yield per plant were measured. Dry weights were taken after drying the samples in an electric oven for 72 h at 70+_C.

Biochemical Parameter

Total protein in grains was estimated by the modified method of Lowary *et al* given by Herbert *et a*l. Total starch was estimated as described by Mc Cready *et al.* and total water soluble carbohydrate (WSC) content in grains were estimated according to the method given by Dubois *et al* .Shoot N,P,K and heavy metals (Zn, Mn, Cu, Fe) were determined as methods described in the soil analysis.

Statistical Analysis

Statistical analyses were performed using SPSS version 12.0 (SPSS Inc., USA). Results were analysed using one-way ANOVA, with =0.05. Mean differences due to sludge treatment were evaluated using critical difference (CD) at a 5% significance level.

RESULTS

Soil and Sludge Chemical Characteristics

The physico-chemical charecteristics of saline soil and sewage sludge has been shown in Table 1. The saline soil pH value (8.8), electrical conductivity (EC, 17.8 dS/m), cation exchange capacity (CEC, 8.6 meq 100/g), organic matter (0.4 % dry wt) and other characters clearly showed that the soil was unable to support a better plant growth. The sewage sludge contained a higher concentration of organic matter (54% dry wt.), N (2.56%), P (686.2 mg/kg), k (198.2 mg/kg) and heavy metals (Fe, Cu, Mn) than those hound in soil (Table1).

Seed Germination, Emergence and Early Survival of Seedlings

Uniform healthy seeds of *Pisum sativum* were sown in pots having saline soil with different treatments (T, T1, T2, and T3). The germination of pea seeds were minimum in untreated soil which gradually increased with different treatments of fertilizer and sludge as in T1 it is 55%, in T2 74% and it is maximum i.e. 88% in T3. So, the sludge treatment enhanced the germination of pea plant in saline soil (Table 2).

Table 1: Physico-Chemical Properties of Soil and sludge

Property	Soil	Sludge
pH	8.8	6.9
Organic matter (% dry wt.)	0.4	54
Organic Carbon (% dry wt.)	0.24	5.86
N (%)	0.16	2.56
P (mg/ kg)	38.3	686.2
K (mg/ kg)	112.1	198.2
Fe (Mg/ kg)	4.26	24.6
Zn (mg/ kg)	0.38	645.4
Cu (mg/ kg)	2.25	255.2
Mn (mg/ kg)	8.32	142.5
EC (dS/ m)	17.8	2.28
CEC (meq/100 g)	8.6	16.5

The sludge treatment also decreased the time required for initial emergence of seedling i.e. lag period. The maximum lag period (18 days) was for untreated soil and minimum (9.8days) for T3 (soil:sludge, 2:1). The 0ther were in between asT1 has 12.2 and T2 has 10.2 days lag period (Table 2). After number the initation of emergence, a period of rapid emergence followed, during which the of new plants protruding above the seed bed surface increased by every day. The average daily emergence rate during rapid emergence period was expressed as percentage of greatest maximum for T3 treatment (28.2%), minimum for untreated soil for T (11.6%day) and gradually increased with the treatment as T1 (20.4%/day), T2 (21.2%/day), T3 (28.2%/day).

Table 2: Table Seed germination parameters of pea grown in saline soil with different treatments (mean±SE)

Treatment	**%** germination	Lag period (Day)	Emergence rate (%Day-1)	Post germination survival (%)
T	45	11.7	11.6	4 ± 0.08^{a}
T_1	55	9.3	20.4	36 ± 1.0^{b}
T_2	74	8.3	21.2	76 ± 2.9^{c}
T_3	88	6	28.2	92 ± 2.4^{d}
C.D.	1.003	1.5	2.9	2.34

Different letters in each group show significant difference at $p < 0.05$

DISCUSSION

The present series of experiments were designed to evaluate the potential of using sewage sludge on the growth and productivity of leguminous plant *Pisum sativum* (Pea) in saline usar soil for their morphological and biochemical changes during various stages of growth. Soil salinity adversely affects the growth and productivity of the plants (Rao *et al.*, 2002). Grain legumes are very sensitive to salinity and pea was also reported as salt sensitive (Ashraf and Waheed, 1993). Therefore, in the present work, we had tried to improve the saline usar soil to support a better growth of pea plant by using sewage sludge.

Sewage sludge is known to enhance the plant growth (Sigua *et al.*, 2005). There is an increasing interest in the agricultural application of sludge obtained from waste water treatment plants, with the possibility of recycling valueable components, organic matter, N, P, K and other plant nutrients. In general, it has been shown that the addition of sewage sludge to agricultural land increases crop production.

The beneficial effects of sludge on growth of different leguminous plants have also been studied. Some author reported that growth of alfalfa was enhanced in sludge amended soil. Soyabean growth can also be improved by sewage sludge. The latter can also be used as an effective medium for rhizobial growth. Therefore, studies on sludge are important due to the economic and environmental implications of wide application of this material to agricultural lands having saline usar soil.

Soil and Sludge Characteristics

The physico-chemical properties of usar soil had high pH value, electrical conductivity, cation exchange capacity, low organic carbon, N, P, K content and low heavy metal content. The properties clearly showed that a better crop could not grow in this saline soil

The sewage sludge collected from Assi sewage pump, Varanasi contained a low pH value, electrical conductivity and a high concentration of organic carbon, nitrogen, phosphorus, potassium and heavy metals. Fe (24.6 Mg/kg), Mn (142.5 mg/kg), Zn (645.4 mg/kg) and Cu (255.2 mg/kg). Singh and Agrawal (2007) have also found almost the same composition of sludge with pH 7.0 and high concentration of organic carbon (5.52%), nitrogen (1.73%), phosporus (716.7 mg/kg), potassium (208.96 mg/kg) and heavy metals, Mn (186.2 mg/kg), Zn (785.3 mg/kg) and Cu (317.7 mg/kg). The sewage sludge produced from Ankara region also has pH 7.08, EC 2.1 dS/m and organic C (14.2%), P (581 mg/kg), N (1.54%), which are in the range of the charecters of sludge used in present case.

Seed Germinaton and Seedling Survival

Seed germination of pea is drastically affected by the salinity as only 45% seeds were germinated (Table 2) which is in agreement with other repot as only 54% seeds germinated in green gram in high saline condition. The percent germination of seeds in pea, in present case, increased with various treatments of sludge and fertilizer and followed the trend as untreated saline soil (T) < soil: fertilizer (10:1, w/w) < Soil: sludge (10:1) < soil: sludge (2:1) (Table 2). Kumar *et al*. studied the behaviour of a effluent and found that the effluent of lower concentrations increased the percentage of seed germination. The increase in seed germination in our case may be attributed to the reduction in soil pH by sludge treatment as reported by Singh and Agrawal (2007).

The lag period i.e. time for initial emergence of seedling was reduced by 6 days when sludge was applied to the soil (T3). The high lag period in untreated soil may be due to occurrence of a moderate quantity of excess salt in root zone which tended to delay emergence.

Some workers also reported a lag period of 12.7 days for pea in moderate saline condition. Sludge treatment also decreased the lag period (Table 2). A period during which the new plants continued to emerge from the seed bed surface is called rapid emergence period and the rate at which the plants emerge every day is called daily emergence rate (Rmax). The higher emergence rate will facilitate a better crop. The lower emergence ratevwas observed for untreated saline soil (Table 2), which was in accordance with the reports of Steppuhn *et.* Where the emergence rate of pea seedling was 11.3%/day and for green pea, it was 6.3 % /day. In order for crops to establish in the soil, not only must they emerge from seed beds but they must also survive in a hostile environment. The post germination survival for *Pisum sativum* in T3 treatment was 9 times higher (95% ref. Table 2) than untreated soil. The data clearly showed that almost all seedlings emerged were survived when sludge was added to the soil. The survival rate was only 26% for pea in fertilizer treated soil suggesting that fertilizer cannot support a good a good crop in saline usar land.

On the basis of percentage seed germination, lag period, emergence rate and final emergence and survival, it can be said that the sludge treatment to saline usar land can support the better crops of pea.

CONCLUSION

From the present study, it may be concluded that using sludge in usar land can improve the pea plant growth and yield and may be economically favourable.

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