Summary
SUMMARY

The Seshasayee Paper and Boards Limited, Pallipalayam, Tamil Nadu releases 30-40 ML of treated effluent every day. It is being supplied to the dry land farmers in the nearby villages as irrigation water to raise sugarcane and occasionally paddy, sorghum and peanut in about 650 hectares. The present study was designed to investigate the effects of both short-term and long-term effluent irrigation on crop plants and soil characteristics.

The treated effluent was dark brown in colour and carried heavy loads of suspended and dissolved solids. The pH was alkaline and the BOD and COD values were higher. The effluent was generally poor in plant nutrients (N, P and K) while the levels of sodium, calcium, sulphate and chloride were higher. However, most of the studied parameters, with the exception of total solids, fall within ISI tolerance limits for effluents discharged on land for irrigation purpose.

The effect of short-term effluent irrigation was studied in a coarse, sandy loam under pot and field conditions using Vigna mungo (L.) Hepper as test plant. Soaking the seeds in 75% and 100% effluent concentrations led to decreased and delayed seed germination. The plant growth as measured by shoot length, root length and plant biomass was significantly higher in all growth stages when irrigated with 50% effluent concentration under pot and field conditions. Growth retardation was observed only in treatments receiving undiluted effluent. However, under field condition, the root length showed significant increases with 100%
effluent concentration. The plants grown under field condition, generally, produced more biomass, with the 60- and 80-day-old plants registering about 1.5 to 2.0 times more biomass than the potted ones.

Accumulation of the various biochemical constituents, viz., chlorophyll, proteins, soluble carbohydrates and reducing sugars in the plant tissue was promoted by effluent irrigation with the optimum effluent concentration being 50%. The effluent treatment in its undiluted (100% concentration) form, however, decreased their contents both under pot and field conditions. Generally, 40-day-old plants registered the highest accumulations of chlorophylls, proteins and soluble carbohydrates while the maximum contents of reducing sugars was observed in the 20-day-old plants. Interestingly, the contents of the said biochemical constituents were not obviously altered by the varying concentrations of effluent treatment in the 80-day-old V. mungo raised under field conditions.

Effluent irrigation also influenced N, P and K contents in V. mungo. Treatment of plants with 50% effluent concentration lead to their maximum accumulation in the plant tissue, the only exception being the 25% concentration which gave the maximum accumulation of P under field condition. The 100% effluent concentration decreased the tissue nutrient contents in the field whereas under potted condition, the nutrient levels were slightly higher than or on par with the controls. With reference to N and P, their maximum contents were recorded respectively in the 60-day-old and 40-day-old plants. On the other hand, higher level
of K was observed in the 80-day-old plants in pots or 40-day-old plants in field.

*V. mungo* recorded maximum yield in terms of pod length, number of seeds per pod, number of pods per plant, grain yield per plant and 1000 seeds weight when irrigated with 50% effluent concentrations under pot and field conditions. Further increase in the effluent concentrations (75% and 100%) significantly decreased the yield. The seed nutrient quality as protein, soluble carbohydrate and reducing sugar contents also showed similar trend where the 50% effluent concentration promoted their accumulation while higher concentrations decreased the contents. Generally, the field grown plants gave better yields than potted ones, with the parameters like number of pods per plant and grain yield per plant registering as high as 150-200% increases. The seed nutrient contents also increased in the field grown plants but the increases were not pronounced as the yield.

Impact of the effluent irrigation on the chemical characteristics of soil was studied in pots and field. All the studied parameters, *viz.*, pH, electrical conductivity, chlorides, nitrates, kjeldahl nitrogen, total phosphorus, total potassium and organic carbon showed progressive increases with the effluent concentration. At the time of harvest, the potted soil samples registered higher contents of chlorides and nitrates whereas the field soil showed increased status of N, P and K.

The rhizosphere populations of bacteria and fungi were enhanced by the effluent irrigation, with the 50% effluent concentration resulting in their maximum in pots and field. Conversely, the undiluted effluent
treatment decreased their populations markedly. Among the different age levels of *V. mungo* studied, the 40-day-old plants supported the highest populations of bacteria and fungi. Though the bacterial populations were comparable between pots and field, the fungal density was 2 to 4 times higher in the latter. The spore density of arbuscular mycorrhizal fungi in the pot and field soils also showed similar trend as those of fungi. Unlike the soil microbial populations, the AM fungal root colonization and rhizobium nodulation in *V. mungo* were not adversely affected by the undiluted effluent irrigation. The extent of the said symbiotic associations were markedly higher under field conditions and were highly favoured by treatment with 50% effluent concentrations. Higher mycorrhizal per cent root infection was observed in the 60-day-old plants while the maximum number of nodules per plants were recorded in the 40-day-old ones.

The impact of long-term effluent irrigation on plant growth and soil characteristics and the ameliorative potential of farmyard manure amendment were evaluated in pot culture experiment. Growth of *V. mungo* measured as shoot and root lengths and plant biomass were enhanced, though insignificantly, by the 2-years effluent irrigated soil. However, the soil biometric values were lower in the plants raised in soils effluent irrigated for 10 and 15-years. The leaf tissue contents of chlorophylls and proteins also showed similar trend. In the case of soluble carbohydrate and reducing sugar levels of the leaf tissue, the decreases were seen even in the 5-years effluent irrigated soils, with the 10 and 15-years effluent irrigated treatments showing significant decreases. The 40-day-old plants, generally, showed higher contents of
chlorophylls and soluble carbohydrates while the accumulation of proteins and reducing sugars were pronounced in the 20 to 40-day-old plants.

The effluent irrigation for varying periods also enhanced the contents of tissue nutrients like N, P and K. Among them, the N and K accumulations over control were statistically significant. Often, the plants in the flowering to fruiting stages registered higher contents of the said nutrients.

Two-years effluent irrigated soil gave significant yield increases in *V. mungo* expressed in terms of pods per plant, number of seeds per plant and grain yield per plant. On the other hand, the yield was significantly reduced in the 10 and 15-years effluent irrigated soils. A similar trend was obtained with the protein, soluble carbohydrate and reducing sugar contents of the seeds.

Amendment of soil, effluent irrigated for varying durations, with farmyard manure enhanced the shoot and root lengths, plant biomass, chlorophyll, protein, soluble carbohydrate and reducing sugar contents of leaf tissue and the N, P and K accumulation in *V. mungo*, though the changes were often statistically not significant. The yield of the crop plant was also enhanced with the number of seeds per pod and grain yield per plant registering significant increases.

A number of physico-chemical parameters of the soil were altered by the length of effluent treatment. As a consequence of long-term effluent irrigation, both the pre-sowing and post-harvest soil samples registered significant increases in the water holding capacity, porosity,
pH and levels of chlorides, nitrates, nitrogen, phosphorus and potassium. The electrical conductivity and organic carbon contents also increased with the years of effluent irrigation but the bulk density decreased, though the said changes were statistically not significant. Respiration increased in 2-years effluent treated soil but the long-term effluent irrigation decreased it. Amendment of the soil with farmyard manure significantly promoted water holding capacity, porosity, EC, and nitrate and total nitrogen levels. The post-harvest soil samples were generally comparable with those of pre-sowing ones except that the former exhibited higher contents of nitrates.

All the studied microbiological parameters, viz., bacterial and fungal populations, AM fungal spores density, per cent AM fungal root colonization and the extent of rhizobium root nodulation increased their values significantly in the two-years effluent irrigated soil. In the case of bacteria, a slight decrease in population was evident only in the 15-years effluent treated soil. On the other hand, the fungal population and the AM fungal spore density registered significant decreases with 5-years of effluent irrigation and beyond. The root colonization of AM fungi was adversely affected as a result of 10 to 15-years of effluent irrigation while the rhizobial nodulation was in the 15-years effluent treated soil. Generally, the 40-day-old plants exhibited the highest bacterial and fungal populations while the AM fungal colonization was at its best on the 60th day after sowing. The nodulation activity was at its peak in 20 to 40-day old plants while maximum AM spore density was noted in the rhizosphere soils 40-80 days after sowing of V. mungo. Farmyard manure amendment significantly enhanced the microbiological status of both the
effluent treated and control soils. These increases, however, were pronounced in the 2-years effluent treated soil.

Impact of the years of paper mill effluent irrigation on the growth and yield of sugarcane (*Saccharum officinarum* L.) was studied under field condition. The growth as assessed by the number of canes in a hill, height of tillers and length of internodes improved in the 2-years effluent irrigated soil, but the increases were statistically not pronounced. However, this treatment recorded significantly higher cane yield. Conversely, in the long-term (10 and 15 years) effluent irrigated fields, the growth of sugarcane was significantly retarded which was reflected in the significant reductions in yield.