Chapter-III

Experimental Findings
EXPERIMENTAL FINDINGS

INFLUENCE OF GRADED LEVELS OF DISTILLERY EFFLUENTS (DE) AND TANNERY EFFLUENTS (TE) SUPPLY ON SALINE SODIC FACTORS, WATER SOLUBLE ANIONS AND CATIONS OF USAR SOILS AND GROWTH METABOLISM AND MINERAL COMPOSITION OF PETRO-CROPS Pedilanthus tithymaloides L. VAR. GREEN AND Calotropis procera L. PLANTS RAISED ON SUCH SOILS UNDER POT CULTURE CONDITIONS.

Introduction:

In view of the literature cited and findings of the earlier workers like Stupiello and Pexo (1977); Brieger (1979); Marinho et al., (1982); Pande (1985); Singh (1990) and Srivastava (1991) and several others that the distillery and tannery effluents can improve soil fertility and plant growth on such soils influencing soil and tissue concentration of minerals and plant metabolism beneficially as well as help in reclamation of saline sodic soils, though tannery effluents increases soil and tissue chromium to unconsumable limits in edible cereal crop plants it was thought desirable to study the influence of graded levels of distillery and chrome tannery effluents on petrocrops (Pedilanthus tithymaloides L. Var. green and (Calotropis procera L.) raised on normal and saline sodic soils, hence this experiment.

Monteiro, (1975); Cooper, (1976); Gauthyron et al., (1970); Brieger, (1979); Perez-Escolar, (1979); Anon, (1980); Divisao Agronomica, (1980); Singh et al., (1980); Rodella et al.,

Iyer et al., (1975); Sheikh and Irshad, (1980); Kamalam and Raj, (1980); Srivastava and Srivastava, (1981); George, (1984) have reported the influence of tannery effluents on soil characters.

Iyer and Rajgopalan, (1957); Thabaraj et al., (1964); Kamalam and Raj, (1980); George, (1984); Nohlich, (1955) have worked out growth, qualitative and Quantitative characters as well as the mineral composition of plants. In view of the literature cited the experiment presented in this thesis was performed to re-examine some of the earlier findings and study certain physio-chemical properties of distillery and tannery effluents, characteristics of non saline non sodic soils treated with said effluents; growth-metabolism and mineral composition of Pedilanthus tithymaloides L. and Calotropis procera L. raised on
such soils; relationships between soil characteristics, plant characteristics and soil and plant characteristics as influenced by distillery effluents and tannery effluents supply in experiment presented.

The techniques and methods for experimental layout, collection, preparation, processing of soils for the pot culture experiment described in this Chapter, their analysis before and after the experiment for pH, E.Ce, SAR, ESP, percentage of moisture content, rate of water percolation, water required for saturation, percentage of organic matter, Ws CO₃⁻, HCO₃⁻, TSA, Cl⁻, PO₄³⁻, SO₄²⁻, Na⁺, Ca++, K⁺, Mg++, N, Fe++, Mn++, Cu++, Zn++ and Cr++; collection, application, analysis of distillery and tannery effluents for colour, odour, clarity, pH, E.Ce, SAR, Ws CO₃⁻, HCO₃⁻, TSA, Ws Cl⁻, SO₄²⁻ PO₄³⁻, Na⁺, Ca++, K⁺, Mg++, N, Fe++, Mn++, Cu++, Zn++ and Cr+++ for the treatment at L₀ (Nil), L₁ (35), L₂ (70) and L₃ (140) M³/ha supply levels respectively; raising of experimental test plants under soil pot culture, their treatment, maintenance, thinning, watering, sampling at particular stage, determination of yield; fresh and dry matter analysis respectively for chlorophyll a, b, a+b, a/b ascorbic acid content, catalase and peroxidase activities, tissue Na, K, P, S, N, Fe, Mn, Cu, Zn and Cr; statistical treatment of data and presentation of results were the same as described in Chapter II earlier.

Over all nine soils S₁ to S₉ were used for the experiment described here.
TREATMENTS

1. Distillery Effluents:

Study of physio-chemical characteristics of distillery effluents used for treatment at levels described in this Chapter showed that with pH 4.5, E.Ce 3.55 m. mhos/cm² at 25°C, SAR 0.918, Ws CO₃⁻⁻ 0.0, HCO₃⁻ 0.0, TSA 0.0, Cl⁻ 187.0, SO₄⁻⁻ 12.1, PO₄⁻⁻ 2.3, Na⁺ 4.35, Ca⁺⁺ 43.0, K⁺ 37.0, Mg⁺⁺ 7.5, N 101.7, Fe⁺⁺ 48.2, Mn⁺⁺ 7.99, Cu⁺⁺ 0.78, Zn⁺⁺ 6.92 and Cr+++ 0.0 ppm. These turbid effluents possessed carmel colour with abnoxious odour.

2. Tannery effluents:

In chrome tannery effluents with greyish white colour, tanning smell and turbidity used possessed pH 8.2, E.Ce 1.25 m. mhos/cm² at 25°C, SAR 0.698, Ws CO₃⁻⁻ 8.82, HCO₃⁻ 15.22, TSA 24.04, Cl⁻ 7.12, SO₄⁻⁻ 2.17, PO₄⁻⁻ 0.93, Na⁺ 2.3, Ca⁺⁺ 19.67, K⁺ 2.01, Mg⁺⁺ 4.93, N 87.0, Fe⁺⁺ 0.58, Mn⁺⁺ 7.99, Cu⁺⁺ 0.26, Zn⁺⁺ 0.06 and Cr+++ 0.02 ppm.

As described a head the supply of distillery and tannery effluents with its increase was found to depress soil pH, E.Ce, SAR, Ws CO₃⁻⁻, HCO₃⁻, TSA, Cl⁻ and Na⁺, and enhance PO₄⁻⁻, SO₄⁻⁻, Ca⁺⁺, K⁺, Mg⁺⁺, N, Fe⁺⁺, Mn⁺⁺, Cu⁺⁺, Zn⁺⁺ and Cr+++ content in after Pedilanthus soils (APS) and after Calotropis soils (ACS) both.

On overall average basis as for test plants pedilanthus and Calotropis are concerned increase in distillery effluent and tannery effluents supply depressed chlorophyll a/b ratio and
tissue Na and enhanced yields, tissue chlorophylls (Chl a, Chl b and Chl a+b), ascorbic acid, activities of catalase and peroxidase and tissue concentrations of Ca, K, Mg, P, S, N, Fe, Mn, Cu, Zn and Cr+++ described onwards. These influences appeared almost similar in all soil types.

As compared to L0 at L1, although the responses of DE and TE supply on soil and plant properties studied and stated above were found marked but many times failed to reach the levels of significance. In case of tissue Na and K the effects were found more pronounced. Somewhat similar picture emerged when the said soil and plant characteristics at L1 and L2 were compare. Although in this case more values found the levels of significance.

As compare to L0 and L2 almost all the responses found significant at P = 0.01. Similarly the responses were found significant at P = 0.01 when soil and plant characteristics mentioned above at L3 were compared with either L0, L1 or L2.

These results are indicative that even at levels as low as L1 at the rate of 35M³/hec DE and TE supply improved soil properties markedly for better plant growth and mineral uptake by plants. At L2 (70M³/ha) DE and TE supply level this improvement becomes significant and at L3 (140M³/ha) DE and TE supply level highly significant.
SOILS

1. Soil pH: (1:2.5 Soil-Water Suspension):

Distillery and tannery effluents supply decreased soil pH markedly. This decrease also recorded in control (L₀) in which DE and TE not supplied. It occurs due to cropping. In comparison to Virgin soils (VS) this decrease observed in every successive levels of treatments in both the soils i.e. APS and ACS.

F values for T (546.36**), L (17948.48**), S (7168.32**), TXL (205.26**), TXS (423.24**), LXS (220.64**) and TXLXS (176.32**) interactions were found significant at P = 0.01.

Overall in all the nine soils with both DE and TE treatments the respective effluent supply was found inversely related with soil pH with the increase in DE or TE treatment at L₀ as compared to Vs, at L₁ as compared to L₂ and L₃ as compared to L₂ were found significant at P = 0.01 probability level, irrespective the soil was non saline non sodic, low saline sodic or high saline sodic soils.

Over all as compared to low saline sodic soils the high saline and sodic soils and as compared to high saline sodic soils the non saline non sodic soils showed better responses to DE supply where as in comparison to non saline non sodic soils, the low saline sodic soils and in comparison to low saline sodic soils the high saline sodic soils showed better responses to TE supply for decrease in soil pH.
In all the responses with regard to decrease in soil pH were found better in DE treated soils as compared to TE treated soils.

Over all in non-saline non-sodic soils and saline sodic soils separately in both APS and ACS, L3 brought about many times more decrease in soil pH than L0 over Vs, for both non saline non sodic and saline sodic soils cropping with DE and TE supply was found more effective for lowering the soil pH. The decrease in soil pH at L3 over L0 was found more in non saline non sodic soils than saline sodic soils.

In distillery effluents treated soils, the soil pH was found positively and insignificantly related with water required for saturation \( (r = 0.5452) \), Ws Cl\(^{-}\) \( (r = 0.7683) \), SO\(_4\)^{2-} \( (r = 0.6630) \), Mg\(^{++}\) \( (r = 0.5093) \), Fe\(^{++}\) \( (r = 0.3648) \), Cu\(^{++}\) \( (r = 0.6623) \); negatively and insignificantly \( (P =0.05) \) related with Ws PO\(_4\)^{3-} \( (r = 0.8263^{*}) \), Mn\(^{++}\) \( (r = 0.7856^{*}) \), and Zn\(^{++}\) \( (r = 0.8649^{*}) \); negatively and insignificantly \( (P=0.05) \) related with percentage moisture content \( (r = 0.8647^{*}) \) rate of water percolation \( (r = 8264^{*}) \), percentage organic matter \( (r = 0.8967^{*}) \) and Cr\(^{+++}\) \( (r =0.8102^{*}) \), positively and significantly \( (P = 0.01) \) related with SAR \( (r = 0.9649^{**}) \), Ws CO\(_3\)^{2-} \( ( r = 8898^{**}) \), HCO\(_3\)^{-} \( ( r = 0.9614^{**}) \), TSA \( (r = 0.9664) \) and Ws Na\(^{+}\) \( (r=0.9860) \) negatively and significantly \( (P =0.05) \) related with Ws K\(^{+}\) \( (r = 9664^{**}) \).

In tannery effluents treated soils, the soil pH was found positively and insignificantly related with SAR \( (r = 0.7642) \), water required for saturation \( (r = 0.1264) \), Ws CO\(_3\)^{2-} \( ( r = 0.7645) \), HCO\(_3\)^{-} \( (r = 0.6246) \), TSA \( (r = 0.7643) \), Ws Cl\(^{-}\) \( (r = 0.5486) \), PO\(_4\)^{3-} \( (r = 0.7486) \), SO\(_4\)^{2-} \( (r = 0.6246) \), Mg\(^{++}\) \( (r = 0.2642) \), Mn\(^{++}\)
(r = 0.5434), Cu**(r = 0.4220), and Zn**(r = 0.5806); negatively and insignificantly related with percentage moisture content (r = 0.7643), percentage organic matter (r = 0.5764), Ws Ca**(r = 0.2593), Fe**(r = 0.2406) and Cr***(r = 0.4760); positively and significantly (P* =0.05) related with Ws Na+(r = 0.7685*) and negatively and significantly (P = 0.05) related with rate of water percolation (r = 0.7948*) and K+(r =0.7868*).
Fig. 2.1: Soil pH (1 : 2.5) soil water suspension.

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Legend:
- VS
- L0
- L1
- L2
- L3
2. Soil E.Ce. m mhos/cm² at 25°C:

Distillery and tannery effluents supply much decreased soil E.Ce. over than more so cropping. In case of L₃ level over virgin soils about more than three times decrease was recorded as compared to control (L₀). This decrease better in after Pedilanthus soils (APS) than after Calotropis soils (ACS). Alkaline soils appeared more responsive than saline sodic soils.

F values for T (14.430 **), L (8632.86 **), S(36832.84 **), TXL (7.604 **), TXS (4.864 **), LXS (186.243 **) and TXLXS (174.53 **) interactions were found significant at (P = 0.01).

In all the nine soils with both distillery and tannery effluents treatments the respective effluent supply was found inversely related with soil E.Ce and the decrease in respective soil, E.Ce with the increase in DE or TE treatment at L₀ as compared to Vs, at L₁ as compared to L₀, at L₂ as compared to L₁ and L₃ as compared to L₂ was found significant at (P =0.01) irrespecrve of the soil was non saline non sodic, low saline sodic or high saline sodic.

As compared to low saline and sodic soils the high saline and sodic soils and as compared to high saline and sodic soils, the non saline non sodic soils showed better responses to DE and TE supply for decrease in soil E.Ce. Over all the responses in regard to decrease in Ece. Were found better in DE treated soils as compared to TE treated soils.
In DE treated soils:

Soil E.Ce. was found positively and insignificantly related with water required for saturation \((r=0.4867)\), \(W_s\) Cl\(^-\) \((r=0.6547)\), \(SO_4^{2-}\) \((r=0.6269)\), Mg\(^{++}\) \((r=0.6508)\), Fe\(^{++}\) \((r=0.4542)\), Mn\(^{++}\) \((r=0.6439)\) and Cu\(^{++}\) \((r=0.4982)\); negatively and insignificantly related with rate of water percolation \((r=-0.6436)\), \(W_s\) Ca\(^{++}\) \((r=-0.5698)\), Cr\(^{+++}\) \((r=-0.5678)\); positively and significantly \((P=0.05)\) related with Zn\(^{++}\) \((r=0.7624*)\); positively and significantly \((P=0.01)\) related with pH \((r=0.9465**)\), SAR \((r=0.9684**)\), \(W_s\) CO\(_3^-\) \((r=0.8687**)\), HCO\(_3^-\) \((r=0.8668**)\), TSA \((r=0.8776**)\), PO\(_4^{3-}\) \((r=0.9816**)\) and Na\(^+\) \((r=0.9786**)\) and negatively and significantly \((P=0.01)\) related with percentage moisture content \((r=-0.8675**)\), percentage organic matter \((r=-0.8694**)\), K\(^+\) \((r=-0.9687**)\).

In TE treated soils:

Soil E.Ce. was found positively and insignificantly related with pH \((r=0.6578)\), water required for saturation \((r=0.2664)\), \(W_s\) SO\(_4^{2-}\) \((r=0.4638)\), Fe\(^{++}\) \((r=0.3268)\), Mn\(^{++}\) \((r=0.5496)\) and Cu\(^{++}\) \((r=0.5626)\); negatively and insignificantly related with \(W_s\) Ca\(^{++}\) \((r=-0.5643)\); positively and significantly \((P=0.05)\) related with \(W_s\) Cl\(^-\) \((r=-0.7688*)\), Mg\(^{++}\) \((r=-0.7682*)\) and Zn\(^{++}\) \((r=-0.6899*)\); negatively and significantly \((P=0.05)\) related with percentage moisture content \((r=-0.7864*)\) and Cr\(^{+++}\) \((r=-0.7682*)\); positively and significantly \((P=0.01)\) related with SAR \((r=0.99869**)\), \(W_s\) CO\(_3^-\) \((r=0.8967**)\), HCO\(_3^-\) \((r=0.8694**)\), TSA \((r=0.8625**)\), PO\(_4^{3-}\) \((r=0.9625**)\) and Na\(^+\) \((r=0.9876**)\) and negatively and significantly \((P=0.01)\) related
with rate of water percolation \( r = -0.8678^{**} \), percentage organic matter \( r = -0.8675^{**} \) and \( K^+ \) \( r = -0.9648^{**} \). Almost similar results were obtained whether the soil properties were tested with E.Ce. of Vs or respective APS and ACS at \( L_0 \) and \( L_3 \).
Fig. 2.2: Soil Ece. m mhos/cm² at 25°C

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis
3. Soil SAR:

Cropping was found to decrease the soil SAR. When DE and TE Supplied, this decrease much increased. Over Virgin soils as compare to L₀ and L₃ about four times decrease in soil SAR was recorded in APS and about six times in ACS over all. The figures were found about three times in APS and ACS in non saline non sodic soils and about five times and nine times in saline sodic soils, APS and ACS respectively. Indicating better effects in saline sodic soils and in ACS as compare to APS. Thus DE and TE supply was found more effective in saline sodic soils than non saline non sodic soils for decreasing soil SAR, more so under comparatively lower soil, moisture conditions of Calotropis culture.

F values for T \( (464.38^{**}) \), L \( (24602.38^{**}) \), S \( (39640.58^{**}) \), T x L \( (248.64^{**}) \), T X S \( (98.36^{**}) \), L X S \( (809.78^{**}) \) and T X L X S \( (6.13^{**}) \) interactions were found significant at \( (P = 0.01) \) probability level.

Over all in all the soils with both DE and TE treatments the respective effluent supply was found inversely related with soil SAR and the decrease in respective soil SAR with the increase in DE or TE treatment at L₀ as compared to VS, at L₁ as compared to L₀, L₂ as compared to L₁ and L₃ as compared to L₂ was found significantly at \( (P = 0.01) \) probability level, irrespective the soil was NSNS, LSS or HSS, the only exception being NSNS S₃ TE treatment the difference between L₂ and L₁ was found significant at \( (P = 0.05) \) only and the NSNS S₂ TE treatment where the
difference between $L_2$ and $L_1$ failed to reach the level of significance.

Over all as compared to NSNS soil the high saline and sodic soils and as compared to high saline and sodic soils the low saline and sodic soils showed better responses to DE and TE supply for decrease in soil SAR.

Over all the responses in regard to decrease in SAR were found better in DE treated soils as compared to TE treated soils.

**In virgin soils:**

Soil SAR was found positively and insignificantly related with Ws $PO_4^{3-}$ ($r = 0.6437$), $SO_4^{2-}$ ($r = 0.4986$), Mg$^{++}$ ($r = 0.3614$), Fe$^{++}$ ($r = 0.3864$) and Mn$^{++}$ ($r = 0.2986$); negatively and significantly related with Ws Ca$^{++}$ ($r = -0.5684$); positively and significantly ($P = 0.05$) related with Ws $er$ ($r = -0.7846^*$), negatively and significantly ($P = 0.05$) related with Ws $K^+$ ($r = -0.7468^*$) and Cr$^{+++}$ ($r = -0.7896^*$) and positively and significantly ($P = 0.01$) related with Ws $HCO_3^-$ ($r = 0.9896^{**}$), TSA ($r = 0.9986^{**}$).

**In DE treated soils:**

Soil SAR was found positively and insignificantly related with water required for saturation ($r = 0.4638$), Ws $Cl^-$ ($r = 0.6798$), Mg$^{++}$ ($r = 0.4768$), Fe$^{++}$ ($r = 0.3246$), Mn$^{++}$ ($r = 0.5643$) and Cu$^{++}$ ($r = 0.5869$); negatively and insignificantly related with Ws Ca$^{++}$ ($r = -0.6954$) and Cr$^{+++}$ ($r = -0.6582$); positively and significantly ($P = 0.05$) related with Ws $SO_4^{2-}$ ($r = 0.6871^*$); negatively and significantly ($P = 0.05$) related with
percentage moisture content \( (r = -0.7826^*) \), rate of water percolation \( (r = -0.7648^*) \) and percentage organic matter \( (r = -0.7867^*) \) positively and significantly \( (P = 0.01) \) related with \( W_s\ CO_3^- \ (r = 0.9645^{**}) \), \( HCO_3^- \ (r = 0.9694^{**}) \), TSA \( (r = 0.8964^{**}) \), \( W_s\ PO_4^{---} \ (r = 0.8968^{**}) \), \( Na^+(r = 9896^{**}) \) and \( Zn^+(r = 0.8268^{**}) \) and negatively and significantly \( (P = 0.01) \) related with \( K^+(r = -0.9868^{**}) \).

**In TE treated soils:**

Soil SAR was found positively and insignificantly related with water required for saturation \( (r = 0.2643) \), \( W_s\ SO_4^{---} \ (r = 0.8968^{**}) \), \( Mg^{++}(r = 0.6432) \), \( Fe^{++}(r = 0.2643) \), \( Mn^{++} \ (r = 0.5346) \) and \( Cu^{++}(r = 0.5643) \); negatively and insignificantly related with \( W_s\ Ca^{++}(r = -0.5684) \); positively and significantly \( (P = 0.05) \) related with \( W_s\ Cl^- \ (r = 0.7684^{**}) \) and \( Zn^{++} \ (r = 0.7459^*) \); negatively and significantly \( (P = 0.05) \) related with percentage moisture content \( (r = -0.7641^*) \), \( W_s\ Cr^{+++}(r = -0.7618^*) \); positively and significantly \( (P = 0.01) \) related with \( W_s\ CO_3^- \ (r = 0.8079^{**}) \), \( HCO_3^- \ (r = 0.8126^{**}) \), TSA \( (r = 0.8694^{**}) \), \( W_s\ PO_4^{---} \ (r = 0.8926^{**}) \) and \( Na^+(r = 0.9964^{**}) \); negatively and significantly \( (P = 0.01) \) related with rate of water percolation \( (r = -0.8976^{**}) \), percentage organic matter \( (r = -0.8972^{**}) \) and \( K^+(r = -0.8986^{**}) \).
Fig. 2.3: Soil SAR

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Soils Nos.

- S1
- S2
- S3
- S4
- S5
- S6
- S7
- S8
- S9

Treatments

VS  L0  L1  L2  L3
4. Soil ESP (Exchangeable Sodium Percentage):

Cropping more so with DE and TE supply decreased soil ESP. Range and average ESP values in Vs and APS, ACS at L₀ and L₃, over all, non saline and sodic soils and saline sodic soils and average percent increase or decrease over Vs. At L₀ over all and in saline sodic soils about ten percent decrease was recorded in APS and about five percent in ACS. At L₃, however this decrease in soil ESP in APS and ACS over Vs was found to be about 50%. In non saline non sodic soils the decrease in soil ESP at L₀ was found to be about 25% in APS and 20% in ACS, while L₃ recorded about 70% decrease over Vs in APS and 65% in ACS. This indicates DE and TE supply reduced soil ESP more in non saline sodic soils as compare to saline sodic soils.

F values for T (568.74 **), L (13568.34 **), S (30692.78 **), T x L (180.12 **), T X S (13.68 **), L X S (264.36 **) and T X L X S (268.48 **) interactions were found significant at (P = 0.01).

In all the tested soils, DE and TE supply was found inversely related with soil ESP and the decrease in soil ESP level with increasing DE and TE supply at L₀ as compared to Vs, at L₁ as compared to L₀, at L₂ as compared to L₁ and at L₃ as compared to L₂ was found to be significant at (P =0.01) level.

Over all as compared to NSNS soils the high saline and sodic soils and as compared to high saline sodic soils the low saline and sodic soils showed better responses to DE and TE supply for decrease in soil ESP.
Over all the responses in regard to decrease in ESP were found better in DE treated soils as compared to TE treated soils.

**In Vs:**

Soil ESP was found positively and insignificantly related with Ws PO$_4^{3-}$(r = 0.5642), SO$_4^{2-}$(r = 0.5689), Mg$^{++}$(r = 0.2641), Fe$^{++}$(r = 0.3648) and Mn$^{++}$(r = 0.3426); negatively and insignificantly related with Ws Ca$^{++}$(r = -0.6421); positively and significantly (P = 0.05) related with soil Cl$^-$ (r = -0.7864*) and Cu$^{++}$(r = 0.7864*); negatively and significantly (P = 0.05) related with Ws K$^+$ (r = -6984*) and Cr$^{+++}$(r = -0.7864*); positively and significantly (P = 0.01) related with soil E.Ce.; (r = 0.9843**), pH (r = 0.9848**), water required for saturation (r = 0.9684**), Ws CO$_3^{2-}$ (r = 0.9647**), HCO$_3^-$ (r = 0.8978**), TSA (r = 0.9614**), Na$^+(r = 0.9684**)$ and Zn$^{++}$(r =0.8964***) and negatively and significantly (P = 0.01) related with percentage moisture content (r = -9643**), rate of water percolation (r = -0.66884***) and percentage organic matter (r = -0.9698***)

**In DE treated soils:**

Soil ESP was found positively and insignificantly related with water required for saturation (r = 0.4438), Ws Mg$^{++}$(r = 0.3648), Fe$^{++}$(r = 0.4298) and Mn$^{++}$(r = 0.5632) Cu$^{++}$(r = 0.6423); negatively and insignificantly related with Ws Ca$^{++}$(r = -0.6428) and Cr$^{+++}$(r = -0.6843); positively and significantly (P = 0.05) related with Ws Cl$^-$ (r =0.6843*) and SO$_4^{2-}$(r = 0.7184*); negatively and significantly (P = 0.05) related with percentage moisture content (r=-7882*), rate of water percolation (r = -0.7894*), percentage organic matter (r = -0.7684*);
positively and significantly ($P = 0.01$) related with soil E.Ce.; ($r = 0.9641^{**}$), pH ($r = 0.9602^{**}$), SAR ($r = 0.9964^{**}$), $W_s \text{CO}_3^{-}$ ($r = 0.9416^{**}$), $\text{HCO}_3^{-}$ ($r = 0.8764^{**}$), TSA ($r = 0.8968^{**}$), $\text{PO}_4^{--}$ ($r = 0.8998^{**}$), $\text{Na}^+$ ($r = 0.9968^{**}$) and $\text{Zn}^{++}$ ($r = 0.8966^{**}$) and negatively and insignificantly ($P = 0.01$) related with $W_s \text{K}^+$ ($r = 0.9684^{**}$).

**In TE treated soils:**

Soil ESP was found positively and insignificantly related with pH ($r = 0.6843$), water required for saturation ($r = 0.2869$), $W_s \text{SO}_4^{--}$ ($r = 0.6438$), $\text{Mg}^{++}$ ($r = 0.6898$), $\text{Fe}^{++}$ ($r = 0.2964$), $\text{Mn}^{++}$ ($r = 0.6426$) and $\text{Cu}^{++}$ ($r = 0.6742$); negatively and insignificantly related with $W_s \text{Ca}^{++}$ ($r = -0.6843$); positively and significantly ($P = 0.05$) related with $W_s \text{Cl}^{-}$ ($r = -0.7694^{*}$) and $\text{Zn}^{++}$ ($r = 0.7843^{*}$); negatively and significantly ($P = 0.05$) related with percentage moisture content ($r = -0.7685^{*}$) and $\text{Cr}^{+++}$ ($r = -0.7614^{*}$); positively and significantly ($P = 0.01$) related with soil E.Ce.; ($r = 0.9685^{**}$), SAR ($r = 0.9896^{**}$), $W_s \text{CO}_3^{-}$ ($r = 0.9264^{**}$), $\text{HCO}_3^{-}$ ($r = 0.8649^{**}$), TSA ($r = 0.9628^{**}$), $W_s \text{PO}_4^{--}$ ($r = 0.9968^{**}$) and $\text{Na}^+$ ($r = 0.9986^{**}$) and negatively and significantly ($P = 0.01$) related with rate of water percolation ($r = -0.8968^{**}$), percentage organic matter ($r = -0.8694^{**}$) and $W_s \text{K}^+$ ($r = 8996^{**}$).
Fig. 2.4: Soil ESP

Distillery effluent treatment: Soils after Pedilanthus

Treatments vs Soils Nos.

Distillery effluent treatment: Soils after Calotropis

Treatments vs Soils Nos.

Tannery effluent treatment: Soils after Pedilanthus

Treatments vs Soils Nos.

Tannery effluent treatment: Soils after Calotropis

Treatments vs Soils Nos.

Legend:
- VS
- L0
- L1
- L2
- L3
5. **Ws soil carbonate (CO₃⁻)** meq/L WSE:

Generally higher CO₃⁻ values was observed in saline sodic soils as compared to non saline non sodic soils. Cropping decreased soil CO₃⁻ considerably in APS and ACS both. More than 80% decrease some times observed in both the soils.

F values for T (963.35**), L (237.83**), S (1748.32**), T x L (368.78**), T X S (139.64**), L X S (98.64**) and T X L X S (113.56**) interactions were found significant at (P = 0.01) probability level.

In comparison to high saline and sodic soils the non saline non sodic soils and in comparison to non saline non sodic soils the low saline and sodic soils showed better responses to distillery effluents supply for decrease in Ws CO₃⁻ content as compared to low saline and sodic soils the high saline and sodic soils and as compared to high saline and sodic soils the non saline non sodic soils showed better responses to tannery effluents supply for decrease in Ws CO₃⁻ content. Over all the responses in regard to decrease in Ws CO₃⁻ content were found better in DE treated soils as compared to TE treated soils.

**In virgin soils (Vs):**

Ws soil carbonate (CO₃⁻) was found positive and insignificantly related with Ws PO₄³⁻ (r = 0.6348), SO₄²⁻ (r = 0.4538), Mg²⁺(r = 0.3238), Fe²⁺(r = 0.2964), Mn²⁺ (r = 0.4635) and Cu²⁺(r = 0.6470); negatively and insignificantly related with Ws Ca²⁺ (r = -0.6449); positively and significantly (P = 0.05) related with Ws Cl⁻ (r = 0.7804); negatively and
significantly (P = 0.05) related with K⁺(r = -0.7650*) and positively and significantly (P = 0.01) related with Ws HCO₃⁻ (r = 0.9889**), TSA (r = 0.9986**), Ws Na⁺(r = 0.8978**) and Zn⁺⁺(r = 0.8698**).

**In DE treated soils:**

Ws soil carbonate (CO₃⁻) was positively and insignificantly related with Ws Cl⁻ (r = 0.6050), Mg⁺⁺(r = 0.3036), Fe⁺⁺ (r = 0.4136) and Cu⁺⁺(r = 0.6084); negatively and insignificantly related with Ws Cr⁺⁺⁺(r = -0.6368); positively and significantly (P = 0.05) related with Ws SO₄²⁻ (r = 0.6896*) and Mn⁺⁺ (r = 0.6694*); negatively and significantly (P = 0.05) related with Ws Ca⁺⁺(r = -0.7649*); positively and significantly (P = 0.01) related with Ws HCO₃⁻ (r = 0.9416), TSA (r = 0.9368**), PO₄³⁻⁻ (r = 0.8327**), Na⁺(r = 0.8946**) and Zn⁺⁺(r = 0.8386**); negatively and significantly (P = 0.01) related with K⁺(r = -0.9245**).

**In TE treated soils:**

Ws soil carbonate (CO₃⁻) was positively and insignificantly related with Ws SO₄²⁻ (r = 0.6145), Mg⁺⁺ (r = 0.4758), Fe⁺⁺(r = 0.1758) and Mn⁺⁺(r = 0.4563); positively and significantly (P = 0.05) related with Ws PO₄³⁻⁻ (r = 0.7468*) and Na⁺(r = 0.7864*); negatively and significantly (P = 0.05) related with Ws Ca⁺⁺(r = -0.7643*) and Cr⁺⁺⁺(r = -0.7648*); positively and significantly (P = 0.01) related with Ws HCO₃⁻ (r = 0.9895**), TSA (r = 0.9986**), Cl⁻ (r = 0.8653**), Cu⁺⁺ (r = 0.8614**) and Zn⁺⁺(r = 0.8847**) and negatively and significantly (P = 0.01) related with Ws K⁺(r = -0.8691**).
Fig. 2.5: WS Soil CO$_3$$^-$$^-$$^-$

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Legend:
- VS
- L0
- L1
- L2
- L3
6. Ws soil Bicarbonate (HCO$_3^-$) meq/L WSE:

Cropping more so decrease with DE and TE supply at L$_3$ between soil HCO$_3^-$ in APS and ACS both. Some times up to 85% decrease was recorded. In ACS however, some times an increase in soil HCO$_3^-$ even upto 80% was observed. This decrease in ACS may have been due to differences the soil moisture conditions of the two crops.

Overall and in APS, ACS and L$_0$ and L$_3$ recorded the decrease in Ws soil HCO$_3^-$ over that of Vs. In APS more decrease was reached at L$_3$ and L$_0$ recorded more decrease than L$_3$. In APS at L$_0$ and L$_3$ and ACS at L$_0$ this decrease was found more in non saline non sodic soils than in saline sodic soils but in more ACS at L$_3$ saline sodic soils recorded decrease than non saline non sodic soils.

F values for T (743.68**), L (2408.82**), S (12649.34**), T x L (2689.34**), T X S (468.68**), L X S (98.64**) and T X L X S (217.87**) interactions were found significant at (P = 0.01) probability level.

In both DE and TE treatments in all the nine soils at L$_0$ as compared to Vs the Ws HCO$_3^-$ content showed a significant (P =0.01) decrease. In all the soils at L$_1$ as compared to L$_0$, Ws HCO$_3^-$ showed significant decrease in DE treatment and a significant increase in TE treatment. In all the nine soils at L$_2$ as compared to L$_1$ and L$_3$ as compared to L$_2$, DE treatment were increase in WS HCO$_3^-$ was found significant at P = 0.01 and in TE treatment the difference in Ws HCO$_3^-$at L$_2$ as compared to L$_1$
was insignificant and in the same treatment in S4 where increase in Ws HCO₃⁻ was found significant (P = 0.01). In rest of the soils L₂ as compared to L₁ and L₃ as compared to L₂ both in DE and TE treatments Ws HCO₃⁻ showed a significant (P = 0.01) decrease.

In comparison to low saline and sodic soils the high saline and sodic soils and in comparison to high saline and sodic soils the non saline non sodic soils showed better responses to DE and TE supply for decrease in Ws soil HCO₃⁻ content were found better in DE treated soils as compared to TE treated soils.

**In virgin (Vs) soils:**

Ws soil bicarbonate (HCO₃⁻) was found positively and insignificantly related with Ws PO₄³⁻⁻ (r = 0.5216), SO₄²⁻ (r = 0.4365), Mg⁺⁺(r = 0.3468), Fe⁺⁺(r = 0.3968) and Mn⁺⁺ (r = 0.5463) and Cu⁺⁺(r = 0.6180); negatively and significantly related with Ws Ca⁺⁺(r = 0.6348); positively and insignificantly (P = 0.05) related with Ws Cl⁻ (r = 0.7868*); negatively and significantly (P = 0.05) related with K⁺(r = -0.7635*) and Cr³⁺⁺⁺ (r = -0.7985*) and positively and significantly (P = 0.01) related with TSA (r = 0.9869**), Ws Na⁺ (r = 0.8964**) and Zn⁺⁺ (r = 0.8698**).

**In DE treated soils:**

Ws soil Bicarbonate (HCO₃⁻) was positively and insignificantly related with Ws SO₄²⁻ (r = 0.6461), Mg⁺⁺ (r = 0.2908) and Fe⁺⁺ (r = 0.3468); positively and significantly (P = 0.05) related with Ws Cl⁻ (r = 0.7456*), PO₄³⁻⁻ (r = 0.7816*)
and Mn\(^{++}\)(r = 0.7891\(^*\)) and Cu\(^{++}\) (r = 0.7460\(^*\)); negatively and significantly (P = 0.05) related with Ws Ca\(^{++}\)(r = -0.6987\(^*\)) and K\(^+\)(r = -0.7872\(^*\)); positively and significantly (P = 0.01) related with TSA (r = 0.9896\(^**\)), Na\(^+\)(r = 8694\(^**\)) and Zn\(^{++}\)(r = 0.8694\(^**\)).

**In TE treated soils:**

Ws soil bicarbonate (HCO\(_3^{-}\)) was positively and insignificantly with Ws SO\(_4^{--}\) (r = 0.5684), Mg\(^{++}\)(r = 0.5964), Fe\(^{++}\)(r = 0.2968) Mn\(^{++}\) (r = 0.4662); positively and significantly (P = 0.05) related with Ws PO\(_4^{--}\) (r = 0.7864\(^*\)) and Na\(^+\) (r = 0.7948\(^*\)); negatively and significantly (P = 0.05) related with Ws Ca\(^{++}\)(r = -0.7864\(^*\)) and Cr\(^{+++}\)(r = -0.6734\(^*\)); positively and significantly (P = 0.01) related with Ws TSA (r = 0.9869\(^**\)), Ws Cl\(^-\) (r = 0.8974\(^**\)), Cu\(^{++}\)(r = 0.8697\(^**\)), and Zn\(^{++}\) (r = 0.8879\(^**\)) and negatively and significantly (P = 0.01) related with Ws K\(^+\) (r = -0.8982\(^**\)).
Fig. 2.6: WS Soil HCO₃⁻

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Soils Nos.
7. **Total soluble alkalinity (TSA) meq/L WSE:**

Soil TSA being the sum of Ws soil CO$_3^{--}$ and HCO$_3^-$ showed results similar those described for both separately, earlier. In APS soil TSA decreased even upto about 85% but in ACS it some times increased more so at L$_3$ in non saline non sodic soils. In APS L$_3$ showed more decrease than L$_0$ but in ACS more decrease in TSA was observed at L$_3$ was compared to L$_0$. This decrease was found as in nonsaline non sodic soils as compare to saline sodic soils in APS at L$_0$ and L$_3$ and ACS at L$_0$. In ACS at L$_3$ more decrease in TSA as observed in non saline non sodic soils as compared to saline sodic soils.

F values for T (5864.98**), L (2061.89**), S (10641.12**), T x L (1982.46**), T X S (358.98**), L X S (48.96**) and T X L X S (99.68**) interactions were found significant at (P = 0.01) probability level.

Except in S$_2$ at L$_2$ as compared to L$_1$ where significant (P = 0.01) increase in TSA was found in DE treatment. In all the rest soils at L$_0$ as compared to Vs, at L$_1$ as compared to L$_0$ at L$_2$ as compared to L$_1$ and L$_3$ as compared to L$_2$ in DE treatment and at L$_0$ as compared to Vs in TE treatment the TSA was found to be significant (P = 0.01) decreased. In TE treatment at L$_1$ as compared to L$_0$ in all the soils the TSA showed significant (P =0.01) increase and at L$_2$ as compared to L$_1$ except in S$_4$ and S$_7$ it showed a significant (P = 0.05) increase and in S$_4$ an insignificant increase.
Overall as compared to low saline and sodic soils, the high saline and sodic soils and as compared to high saline and sodic soils, the non saline non sodic soils showed better responses to DE and TE supply for decrease in soil TSA. Over all the responses in regard to decrease in soil TSA were found better in DE treated soils as compared to TE treated soils.

In virgin (Vs) soils:

Soil TSA was found positively and insignificantly related with Ws $PO_4^{--}$ ($r = 0.5346$), $SO_4^{--}$ ($r = 0.4615$), $Mg^{++}$ ($r = 0.3452$), $Fe^{++}$ ($r = 0.0324$), $Mn^{++}$ ($r = 0.4638$) and $Cu^{++}$ ($r = 0.6341$); negatively and insignificantly related with Ws $Ca^{++}$ ($r = -0.6384$); positively and significantly ($P = 0.05$) related with Ws $Cl^-$ ($r = 0.7894^*$); negatively and significantly ($P = 0.05$) related with $K^+$ ($r = -0.7648^*$) and $Cr^{+++}$ ($r = -0.7928^*$) and positively and significantly ($P = 0.01$) related with Ws $Na^+$ ($r = 0.8879^{**}$) and $Zn^{++}$ ($r = 0.8694^{**}$).

In DE treated soils:

Soil TSA was found positively and insignificantly related with Ws $Mg^{++}$ ($r = 0.2678$) and $Fe^{++}$ ($r = 0.3643$); positively and significantly ($P = 0.05$) related with Ws $Cl^-$ ($r = 0.7826^*$), $PO_4^{--}$ ($r = 0.7621^*$), $SO_4^{--}$ ($r = 0.6984^*$), $Mn^{++}$ ($r = 0.7849^*$) and $Cu^{++}$ ($r = 0.7684^*$); negatively and significantly ($P = 0.05$) related with Ws $Ca^{++}$ ($r = -0.7684^*$) and $Cr^{+++}$ ($r = -0.7689^*$); positively and significantly ($P = 0.01$) related with Ws $Na^+$ ($r = 0.8964^{**}$) and $Zn^{++}$ ($r = 0.8841^{**}$) and negatively and significantly ($P = 0.01$) related with Ws $K^+$ ($r = -0.8645^*$).
In TE treated soils:

Soil TSA was found positively and insignificantly related with Ws SO$_4$$^{2-}$ ($r = 0.5896$), Mg$^{++}$(r = 0.4896), Fe$^{++}$(r = 0.1876) and Mn$^{++}$ (r = 0.4561); positively and significantly (P = 0.05) related with Ws PO$_4$$^{3-}$ ($r = 0.7648^*$) and Na$^+$(r = 0.7894$^*$) and Cr$^{+++}$(r = 0.7894$^*$); negatively and significantly (P = 0.05) related with Ws Ca$^{++}$ (r = -0.7896$^*$); positively and significantly (P = 0.01) related with Ws Cl$^-$ (r = 0.8264**), Cu$^{++}$(r = 0.8894**) and Zn$^{++}$(r = 0.8898**) and negatively and significantly (P = 0.01) related with Ws K$^+$ (r = -0.8693**).
Fig. 2.7: WS Soil TSA

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Soils Nos.

Soils Nos.

Soils Nos.

Soils Nos.

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8. Ws soil Chloride (Cl\textsuperscript{-}) meq/L WSF:

Cropping decreased Ws soil Cl\textsuperscript{-}. In APS at L\textsubscript{3} DE and TE supply tends showed more decrease than L\textsubscript{0}, but in ACS a little more decrease in Cl\textsuperscript{-} was observed at L\textsubscript{0} than L\textsubscript{3}. Overall APS recorded very markedly more decrease than ACS and except in APS at L\textsubscript{0} may decrease appeared slightly more in non saline non sodic soils. In non saline non sodic soils these values was found to be less.

F values for T (216.28**), L (1896.43**), S (784.68**), T x L (86.9**), L X S (112.28**) and T X L X S (61.42**) interactions were found significant at (P = 0.01) probability level where as T X S interaction was found insignificant.

In all the nine soils in both DE and TE treatments the Ws Cl\textsuperscript{-} at L\textsubscript{0} as compared to Vs and at L\textsubscript{1} as compared to L\textsubscript{0} showed a significant (P = 0.01) decrease. At L\textsubscript{2} as compared to L\textsubscript{1} and L\textsubscript{3} as compared to L\textsubscript{2} and S\textsubscript{1}, S\textsubscript{5}, S\textsubscript{8} and S\textsubscript{9} in DE treatment and S\textsubscript{1}, S\textsubscript{3}, S\textsubscript{4}, S\textsubscript{6}, S\textsubscript{7} and S\textsubscript{9} in TE treatment Ws Cl\textsuperscript{-} showed a significant (P = 0.01) increase. However Ws Cl\textsuperscript{-} content at L\textsubscript{2} as compared to L\textsubscript{1} in DE treatment of S\textsubscript{9} failed to differ.

As compared to LSS soils the HSS soils, and as compared to HSS soils the NSNS soils showed better responses to DE supply for decrease in soil Ws Cl\textsuperscript{-} while as compared to HSS soils the LSS soils and as compared to LSS soils the NSNS soils showed better responses to TE supply for decrease in soil Ws Cl\textsuperscript{-} content.

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Over all the responses in regard to decrease in soil Ws Cl content were found better in TE treated soils as compared to DE treated soils.

**In virgin (Vs) soils:**

Ws soil Cl\(^-\) was found positively and insignificantly related with Ws PO\(_4^--\) (r = 0.4267), SO\(_4^--\) (r = 0.3849), Mn\(^{++}\) (r = 0.1528); negatively and insignificantly related with Ws Ca\(^{++}\)(r = -0.5639) K\(^+\)(r = -0.5674), Mg\(^{++}\) (r = -0.1239), Fe\(^{++}\) (r = -0.1638) and Cr\(^{+++}\) (r = -0.3648); positively and significantly (P = 0.05) related with Ws Na\(^+\) (r = 0.7628\*), Cu\(^{++}\)(r = 0.6897\*) and Zn\(^{++}\)(r = 0.7986\*).

**In DE treated soils:**

Ws soil chloride was found positively and insignificantly related with Ws PO\(_4^--\) (r = 0.3684), Na\(^+\)(r = 0.5863) and Mn\(^{++}\) (r = 0.3683); negatively and insignificantly related with Ws K\(^+\) (r = -0.5634) Mg\(^{++}\)(r = -0.3218), Fe\(^{++}\)(r = -0.1164) and Cr\(^{+++}\) (r = -0.3643); positively and significantly (P = 0.05) related with Ws SO\(_4^--\) (r = 0.7645\*), Cu\(^{++}\) (r = 0.7648\*); negatively and significantly (P = 0.05) related with Ws Ca\(^{++}\)(r = -0.7648\*) and positively and significantly (P = 0.01) related with Ws Zn\(^{++}\) (r = 0.8399\**).

**In TE treated soils:**

Ws soil Chloride was found positively and insignificantly related with Ws PO\(_4^--\) (r = 0.6438), SO\(_4^--\) (r = 0.6743), Mg\(^{++}\) (r = 0.2395), Fe\(^{++}\)(r = 0.1643) and Mn\(^{++}\)(r = 0.3648); positively and insignificantly related with Ws K\(^+\)(r = 0.6384) and Cr\(^{+++}\)
(r = 0.5684); positively and significantly (P = 0.05) related with Ws Na$^+$ (r = 0.7658*) and Cu$^{++}$ (r = 0.7847*); negatively and significantly (P = 0.01) related with Ws Ca$^{++}$ (r = -0.7648*) and positively and significantly (P = 0.01) related with Ws Zn$^{++}$ (r = 0.8215**).
Fig. 2.8: Ws Soil Cl⁻ meq/L WSE.

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Soils Nos.

S1 S2 S3 S4 S5 S6 S7 S8 S9

S1 S2 S3 S4 S5 S6 S7 S8 S9

S1 S2 S3 S4 S5 S6 S7 S8 S9

S1 S2 S3 S4 S5 S6 S7 S8 S9

VS L0 L1 L2 L3
9. Ws soil Phosphate (PO$_4^{3-}$) meq/L WSE:

Cropping increased more so with DE supply increased Ws soil PO$_4^{3-}$. This increase in soil PO$_4^{3-}$ doubled or some times triple as in case of ACS saline sodic soils. Non saline non sodic soils recorded markedly more increase as compared to saline sodic soils more so in ACS as compared to APS. L$_3$ in non saline non sodic soils APS recorded about 155 percent increase in soil PO$_4^{3-}$ over Vs while at L$_3$ in saline sodic soils. This increase was found to be about 115 percent in APS and 60 percent in ACS on the average basis.

F values for T (3278.86**), L (1896.43**), S (3689.68**), T x L (768.56**), T X S (78.68**), L X S (864.39**) and T X L X S (36.58**) interactions were found significant at (P = 0.01) probability level.

IN S$_1$, S$_2$ and S$_4$ in both DE and TE treatments the Ws soil PO$_4^{3-}$ content between Vs and L$_0$ did not differ. At S$_3$ in both DE and TE treatments at L$_0$ as compared to Vs the Ws PO$_4^{3-}$ content decreased but insignificantly. In S$_5$, S$_6$, S$_7$, S$_8$ and S$_9$ in both DE and TE treatments the Ws PO$_4^{3-}$ content at L$_0$ as compared to Vs decreased significantly (P = 0.01), while in all the soils in both DE and TE treatments at L$_1$ and L$_3$ as compare to L$_2$, the Ws PO$_4^{3-}$ content increased significantly at (P = 0.01) probability level.

As compared to LSS soils the NSNS soils and as compared to NSNS soils the HSS soils showed better responses to DE supply for increase in soil Ws PO$_4^{3-}$ content while as compared
to NSNS soils the LSS soils and as compared to LSS soils the HSS soils showed better responses to TE supply for increase in soil Ws PO$_4^{-}$ content.

Overall the responses in regard to increase in soil Ws PO$_4^{-}$ content were found better in DE treated soils as compared to TE treated soils.

**In virgin (Vs) soils:**

Ws soil PO$_4^{-}$ was found positively and insignificantly related with Ws SO$_4^{-}$ (r = 0.1878), Na$^+$ (r = 0.5643), Mg$^{++}$ (r = 0.3548), Mn$^{++}$ (r = 0.4687), Cu$^{++}$ (r = 0.3643) and Zn$^{++}$ (r = 0.5836) and negatively and insignificantly related with Ws Ca$^{++}$ (r = -0.1438), K$^+$ (r = -0.1874), Fe$^{++}$ (r = -0.2338) and Cr$^{+++}$ (r = -0.2624).

**In DE treated soils:**

Ws soil PO$_4^{-}$ was found positively and insignificantly related with Ws SO$_4^{-}$ (r = 0.3876), Mg$^{++}$ (r = 0.4674), Fe$^{++}$ (r = 0.3864), Mn$^{++}$ (r = 0.5836), Cu$^{++}$ (r = 0.3242) and Zn$^{++}$ (r = 0.6578); negatively and insignificantly related with Ws Ca$^{++}$ (r = -0.3836) and Cr$^{+++}$ (r = -0.3895); positively and significantly (P = 0.01) related with Ws Na$^+$ (r = 0.8976) and negatively and insignificantly (P = 0.01) related with Ws K$^+$ (r = -0.8986).

**In TE treated soils:**

Ws soil PO$_4^{-}$ was found positively and insignificantly related with Ws SO$_4^{-}$ (r = 0.3654), Mg$^{++}$ (r = 0.5876), Fe$^{++}$ (r = 0.1698), Mn$^{++}$ (r = 0.3264), Cu$^{++}$ (r = 0.3481) and Zn$^{++}$
(r = 0.6538); negatively and insignificantly related with Ws Ca\(^{++}\)(r = -0.3986) and Cr\(^{+++}\) (r = -0.6782); positively and significantly (P = 0.01) related with Ws Na\(^+\)(r = 0.8978\(^\ast\ast\)) and negatively and insignificantly (P = 0.01) related with Ws K\(^+\) (r = -0.8698\(^\ast\ast\)).
Fig. 2.9: WS Soil $\text{PO}_4^{3-}$ meq/L WSF

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Soils Nos.

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VS  L0  L1  L2  L3
10. **Ws Soil sulphate (SO$_4^{2-}$)** meq/L WSF:

Cropping more so with DE and TE supply was found to increase Ws soil SO$_4^{2-}$ over Vs in APS and ACS both. Over all as well as in non saline non sodic soils in APS at L$_0$ and L$_3$ both and in ACS at L$_3$ a marked increase in Ws soil SO$_4^{2-}$ was observed over Vs. In saline sodic soils, however, a decrease in Ws soil SO$_4^{2-}$ than non saline non sodic soils show more increase.

F values for T (4320.00**), L (1845.00**), S (2198.60**), T x L (1457.22**), T x S (1364.32**), L x S (1238.78**) and T x L x S (638.32**) interactions were found significant at (P = 0.01) probability level.

In both DE and TE treatments in S$_2$, S$_3$, S$_7$, S$_8$ and S$_9$ the Ws SO$_4^{2-}$ at L$_0$ as compared to Vs increased significantly (P = 0.01) while in S$_1$, S$_4$, S$_5$ and S$_6$ it decreased significantly (P = 0.01).

Over all as compared to LSS soils the HSS soils, the NSNS soils showed better responses to DE and TE supply for increase in Ws soil SO$_4^{2-}$content.

Over all the responses in regard to increase in soil Ws SO$_4^{2-}$ content were found better in DE treated soils as compared to TE treated soils.

**In virgin (Vs) soils:**

Ws soil sulphate was found positively and insignificantly related with Ws Na$^+$($r = 0.3629$), Fe$^{++}$(r = 0.3246), Mn$^{++}$(r = 0.3248), and Zn$^{++}$(r = 0.4576); negatively and insignificantly
related with Ws K$^+$($r = -0.1689$), Mg$^{++}$(r = 0.3469) and Cr$^{+++}$(r = -0.2864); positively and significantly ($P = 0.01$) related with Ws Cu$^{++}$(r = 0.8923**) and negatively and significantly related with Ws Ca$^{++}$(r = -0.9694**).

**In DE treated soils:**

Ws soil SO$_4^{2-}$ was found positively and insignificantly related with Ws Na$^+$($r = 0.3652$), Fe$^{++}$(r = 0.3680) and Mn$^{++}$(r = 0.3652); negatively and insignificantly related with Ws K$^+$($r = -0.5238$), Mg$^{++}$(r = 0.2304) and Cr$^{+++}$(r = -0.4731); positively and significantly ($P = 0.05$) related with Ws Cu$^{++}$(r = 0.7654*); negatively and significantly ($P = 0.05$) related with Ws Ca$^{++}$(r = -0.7864*) and positively and significantly ($P = 0.01$) related with Ws Zn$^{++}$(r = 0.8690**).

**In TE treated soils:**

Ws soil sulphate was found positively and insignificantly related with Ws Na$^+$($r = 0.5467$), Mg$^{++}$(r = 0.1654), Fe$^{++}$(r = 0.2678) and Mn$^{++}$(r = 0.5674); negatively and insignificantly related with Ws K$^+$($r = -0.4321$), and Cr$^{+++}$(r = -0.4089); positively and significantly ($P = 0.05$) related with Ws Zn$^{++}$(r = 0.7052*) and negatively and significantly ($P = 0.05$ related with Ws Ca$^{++}$(r = -0.7521*).
Fig. 2.10: WS Soil $\text{SO}_4^{2-}$ meq/L WSF

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis
11. *Ws soil Sodium (Na⁺) meq/L WSE:*

Ws soil Na⁺ decreased as a result of cropping more so when DE & TE were supplied. In soils studied at L₃ this decrease was found about 30% to 75% in APS, non saline non sodic soils showed more decrease than saline sodic soils, while in ACS this decrease some times appeared more in saline sodic soils as compared to non saline non sodic soils. At L₃ as compare to L₀ Ws soil Na⁺ recorded three times more decrease in APS and about two times in ACS over Vs. In saline sodic soils similar trend was observed, in non saline non sodic soils, however this decrease of Ws soil Na⁺ at L₃ as compare to L₀ was found three times more both in APS and ACS.

F values for T (866.34 **), L (8901.82 **), S (9803.86 **), T x L (396.87 **), T X S (733.36 **), L X S (876.84 **) and T X L X S (66.95 **) interactions were found significant at (P = 0.01) probability level.

Overall as compared to NSNS soils the LSS soils and as compared to LSS soils the HSS soils showed better responses to DE and TE supply for decrease in Ws Na⁺ content in soil.

Overall the responses in regard to decrease the Ws soil Na⁺ content were found better in DE treated soils as compared to TE treated soils.

**In virgin soils (Vs):**

Ws soil sodium (Na⁺) was found positively and insignificantly related with Ws Mg⁺⁺ (r = 0.3864), Fe⁺⁺ (r = 0.3216), Mn⁺⁺ (r = 0.2586), and Cu⁺(r = 0.5648); negatively
and insignificantly related with Ws Ca\textsuperscript{++}(r = -0.4826); positively and significantly (P = 0.05) related with Ws Zn\textsuperscript{++} (r = 0.7686\textsuperscript{*}); negatively and significantly (P = 0.05) related with Ws K\textsuperscript{+} (r = -0.7692\textsuperscript{*}) and negatively and significantly (P =0.01) related with Ws Cr\textsuperscript{+++}(r = -0.8609\textsuperscript{**}).

**In DE treated soils:**

Ws soil sodium (Na\textsuperscript{+}) was found positively and insignificantly related with Ws Mg\textsuperscript{++} (r = 0.4536), Fe\textsuperscript{++} (r = 0.3658), Mn\textsuperscript{++} (r = 0.4863), and Cu\textsuperscript{+}(r = 0.4231); negatively and insignificantly related with Ws Ca\textsuperscript{++}(r = -0.5278) and Cr\textsuperscript{+++}(r = -0.5624); positively and significantly (P = 0.05) related with Ws Zn\textsuperscript{++} (r = 0.7561\textsuperscript{*}) and negatively and significantly (P =0.01) related with Ws K\textsuperscript{+} (r = -0.9786\textsuperscript{**}).

**In TE treated soils:**

Ws soil sodium (Na\textsuperscript{+}) was found positively and insignificantly related with Ws Fe\textsuperscript{++}(r = 0.2361), Mn\textsuperscript{++} (r = 0.6378), and Cu\textsuperscript{+}(r = 0.4678); negatively and insignificantly related with Ws Ca\textsuperscript{++}(r = -0.4638); positively and significantly (P = 0.05) related with Ws Mg\textsuperscript{++} (r = 0.6893\textsuperscript{*}) and Zn\textsuperscript{++} (r = 0.6975\textsuperscript{*}) and negatively and significantly (P =0.05) related with Ws Cr\textsuperscript{+++}(r = -0.6989\textsuperscript{*}) and negatively and significantly (P =0.01) related with Ws K\textsuperscript{+}(r = -0.9867\textsuperscript{**}).
Fig. 2.11: WS Soil Na\(^+\) meq/L WSE

Distillery effluent treatment: Soils after Pedilanthus

![Distillery effluent treatment: Soils after Pedilanthus chart]

Distillery effluent treatment: Soils after Calotropis

![Distillery effluent treatment: Soils after Calotropis chart]

Tannery effluent treatment: Soils after Pedilanthus

![Tannery effluent treatment: Soils after Pedilanthus chart]

Tannery effluent treatment: Soils after Calotropis

![Tannery effluent treatment: Soils after Calotropis chart]

Legend:
- □ VS
- ■ L0
- □ L1
- ■ L2
- □ L3
12. Ws soil Calcium (Ca++) meq/L WSE:

Cropping more so with DE and TE supply the Ws soil Ca++ both in APS and ACS mostly increased. Some times increase upto even 300 percent. On the average basis as compare to Vs at L0 overall, in non saline non sodic soils and saline sodic soils both Ws Ca++ soil recorded a decrease. At L3, however in both APS and ACS and increase in Ws soil Ca++ over Vs was observed, though in ACS saline sodic soils at L3 differences was not found. Non saline non sodic soils showed higher values of Ws soil Ca++ than saline sodic soils. At L3 in APS and ACS non saline non sodic soils recorded about ten times and twenty times more increase in Ws soil Ca++ of non saline non sodic soils as compare to saline sodic soils respectively.

F values for T (136.34 **), L (7631.56 **), S (8936.93 **), T x L (63.85 **), T X S (8.46 **), L X S (113.98 **) and T X L X S (6.32 **) interactions were found significant at (P = 0.01) probability level.

In all the nine soils in both DE and TE treatments L0 as compared to L1 and at L3 as compared to L2 showed significant (P = 0.01) increase in Ws soil Ca++ content.

Overall as compared to NSNS soils the HSS soils and as compared to HSS soils the LSS soils showed better responses to DE and TE supply for increase in Ws soil Ca++ content.

Overall responses in regard to increase in Ws Ca++ content were found better in DE treated soils as compared to TE treated soils.
In virgin soils (Vs):

Ws soil Calcium (Ca++) was found positively and insignificantly related with Ws K+(r = 0.2641), Mg+(r = 0.3647), and Cr+++ (r = 0.4310); negatively and insignificantly related with Ws Fe++ (r = -0.2463) and Mn++(r = -0.3865); negatively and significantly (P = 0.05) related with Ws Zn++ (r = -0.7462*) and negatively and significantly (P = 0.01) related with Ws Cu++ (r = -0.9638**).

In DE treated soils:

Ws soil Calcium (Ca++) was found positively and insignificantly related with Ws K+(r = 0.4869) and Mg+ (r = 0.3269); negatively and insignificantly related with Ws Fe++(r = -0.3864) and Mn++ (r = -0.5643); positively and significantly (P = 0.05) related with Ws and Cr+++ (r = 0.6849*); and negatively and significantly (P = 0.01) related with Ws Cu++(r = -0.9624**) and Zn++ (r = -0.8964**).

In TE treated soils:

Ws soil Calcium (Ca++) was found positively and insignificantly related with Ws K+(r = 0.4675) and Cr+++ (r = 0.5684*); negatively and insignificantly related with Ws Mg++ (r = 0.1684), Fe++ (r = -0.2896) and Mn++(r = -0.3643) and negatively and significantly (P = 0.01) related with Ws Cu++ (r = -0.9378**) and Zn++ (r = -0.9648**).
Fig. 2.12: WS Soil Ca^{++} meq/L WSE

Distillery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Calotropis

Legend:
- VS
- L0
- L1
- L2
- L3
13. **Ws soil Potassium (K⁺) meq/L WSE:**

Cropping more so with DE and TE supply particularly at L₃ in APS and ACS increase Ws soil K⁺, some times even upto a more than 100 percent over Vs. Over all except at L₀ in ACS Ws soil K⁺ recorded increase both in APS and ACS as result of cropping more so when DE and TE were supplied. This increase appeared more in non saline non sodic soils as compared to saline sodic soils and at L₃ in APS as compare to ACS.

F values for T (10068.48**), L (4836.98**), S (2647.98**), T x L (4896.35**), T X S (368.89**), L X S (3860.63**) and T X L X S (196.80**) interactions were found significant at (P = 0.01) probability level.

In all the nine soils in both DE and TE treatments L₀ as compared to Vs showed a significant (P = 0.01) decrease and L₁ as compare to L₀, L₂ as compare to L₁ and L₀, L₃ as compared to L₂ showed a significant (P = 0.01) increase in Ws soil K⁺ content.

Over all as compared to HSS soils, the LSS soils and as compared to LSS soils the NSNS soils showed better responses to DE and TE supply for increase in Ws soil K⁺.

Overall the responses in regard to increase in Ws soil K⁺ content were found better in DE treated soils as compared to TE treated soils.

**In virgin soils (Vs):**

Ws soil Potassium (K⁺) was found positively and insignificantly related with Ws Fe⁺⁺(r = 0.1648) and Mn⁺⁺ (r = 0.1764); negatively and insignificantly related with Ws
Mg$^{++}$(r = -0.3643), Cu$^{++}$(r = -0.2997) and Zn$^{++}$(r = -0.5471); and positively and significantly (P = 0.05) related with Ws Cr$^{+++}$(r = 0.7984$^*$).

**In DE treated soils:**

Ws soil Potassium (K$^+$) was found positively and insignificantly related with Ws Cr$^{+++}$(r = 0.5468); negatively and insignificantly related with Ws Mg$^{++}$(r = -0.5346), Fe$^{++}$(r = -0.3293), Mn$^{++}$(r = -0.5831) and Cu$^{++}$(r = -0.3760); and negatively and significantly (P = 0.05) Ws Zn$^{++}$(r = -0.7128$^*$).

**In TE treated soils:**

Ws soil Potassium (K$^+$) was found negatively and insignificantly related with Ws Fe$^{++}$(r = -0.4606), Mn$^{++}$(r = -0.4950), Cu$^{++}$(r = -0.4852) and Zn$^{++}$(r = -0.6083); negatively and significantly (P = 0.05) Ws Mg$^{++}$(r = -0.7221$^*$) and positively and significantly (P = 0.01) related with Ws Cr$^{+++}$(r = 0.8978$^{**}$).
Fig. 2.13: WS Soil $K^+$ meq/L WSE

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Legend:
- VS
- L0
- L1
- L2
- L3
14. **Ws soil Magnesium (Mg++) meq/L WSE:**

Except in one or two soils, cropping increase Ws soil Mg++ over control more so when DE and TE were supplied. In certain soils this increase becomes more. This increase was found in saline sodic soils more as compare to non saline non sodic soils over all and in non saline non sodic soils except at L0 in APS soil Mg++ showed tremendous increase. As compare to L3 as compare to L0, this increase was found to be more than ten times.

F values for T (589.36 **), L (7804.69 **), S (560.76 **), T x L (216.51 **), T X S (72.27 **), L X S (152.34 **) and T X L X S (17.80 **) interactions were found significant at (P = 0.01) probability level.

Except in S9 at L0 as compared to Vs where both in DE and TE treatments Ws soil Mg++ content showed a significant (P = 0.01) decrease in all the soils except those mentioned at L0 as compared to Vs, at L1 as compared to L0, at L2 as compared to L1 and L3 as compared to L2, both in DE and TE treatments it showed significant (P = 0.01) increase.

In comparison to HSS soils the NSNS soils and in comparison to NSNS soils the LSS soils showed better responses to DE supply for increase in Ws soil Mg++ content while in comparison to HSS soils the LSS soils showed better responses to TE supply for increase in soil Mg++ content.
Overall the responses in regard to increase in Ws soil Mg++ content were found better in TE treated soils as compared to DE treated soils.

In virgin soils (Vs):

Ws soil Magnesium (Mg++) was found positively and insignificantly related with Ws Fe++ (r = 0.1856) and Mn++ (r = 0.1879); and negatively and insignificantly related with Ws Cu++ (r = -0.5436), Zn++ (r = -0.2264) and Cr+++ (r = -0.3683).

In DE treated soils:

Ws soil Magnesium (Mg++) was found positively and insignificantly related with Ws Fe++ (r = 0.1687) and Mn++ (r = 0.1253) and negatively and insignificantly related with Ws Cu++ (r = -0.3437), Zn++ (r = -0.3107) and Cr+++ (r = -0.3815).

In TE treated soils:

Ws soil Magnesium (Mg++) was found positively and insignificantly related with Ws Fe++ (r = 0.4675) and Cu++ (r = -0.5289); positively and significantly (P = 0.05) related with Ws Mn++ (r = 0.7432*), Zn++ (r = 0.7249*) and negatively and significantly (P = 0.01) related with Cr+++ (r = 0.8107**).
Fig. 2.14: WS Soil Mg$^{++}$ meq/L WSE

**Distillery effluent treatment: Soils after Pedilanthus**

![Bar chart showing treatments and soil numbers for Pedilanthus case]

**Distillery effluent treatment: Soils after Calotropis**

![Bar chart showing treatments and soil numbers for Calotropis case]

**Tannery effluent treatment: Soils after Pedilanthus**

![Bar chart showing treatments and soil numbers for Pedilanthus case]

**Tannery effluent treatment: Soils after Calotropis**

![Bar chart showing treatments and soil numbers for Calotropis case]
15. **Ws soil Nitrogen (N air dry soil) mg/100 g soils:**

Ws soil Nitrogen increased with cropping more so when DE and TE were supplied. Some times even upto more than 200% increase obtained. This increase was found more in saline sodic soils than in non saline non sodic soils on average basis. More than twice increase in air dry soil N over Vs was observed at L₃ as compare to non saline non sodic soils. At L₃ APS as compare to ACS in non saline non sodic soils appeared to show more increase in air dry soil Nitrogen.

F values for T (238.48 **), L (7864.96 **), S (9837.39 **), T x L (98.64 **), T X S (8.74 **), L X S (114.39 **) and T X L X S (7.36 **) interactions were found significant at ($P = 0.01$) probability level.

In all the nine soils in both DE and TE treatments L₀ as compared to Vs, L₁ as compared to L₀, L₂ as compared to L₁ and L₃ as compared to L₂ showed significant ($P = 0.01$) increase in Ws soil N content.

Over all as compared to NSNS soils the HSS soils and as compared to HSS soils the LSS soils showed better responses to DE and TE supply for increase in Ws soil N content.

Overall responses in regard to increase in Ws N content were found better in DE treatment soils as compared to TE treatment soils.

**In virgin soils (Vs):**

Ws soil N was found negatively and insignificantly related with Ws soil pH ($r = -0.413$), E. Ce. ($r = -0.317$), SAR ($r = -0.456$),
In De treated soils:

Ws soil N was found negatively and significantly (P = 0.01) related with Ws soil pH (r = -0.712**), E. Ce. (r = -0.709**), SAR (r = -0.718**), ESP (r = -0.719**), CO$_3$$^-$ (r = -0.749**), HCO$_3$$^-$ (r = -0.756**), TSA (r = -0.748**), Cl$^-$ (r = -0.739**) and Na$^+$ (r = -0.789**); positively and insignificantly at (P = 0.01) related with Ws PO$_4$$^{3-}$ (r = 0.680**), SO$_4$$^{2-}$ (r = 0.719**), Ca$^{++}$ (r = 0.784**), K$^+$ (r = 0.740**), Mg$^+$ (r = 0.724**), Fe$^{++}$ (r = 0.769**), Mn$^{++}$ (r = 0.753**), Cu$^{++}$ (r = 0.768*) and Zn$^{++}$ (r = 0.743**) and Cr$^{+++}$(r = -0.784**).

In TE treated soils:

Ws soil N was found positively and significantly related with Ws soil pH (r = -0.621**), E. Ce. (r = -0.784**), SAR (r = -0.683**), ESP (r = -0.843**), CO$_3$$^-$ (r = -0.713**), HCO$_3$$^-$ (r = -0.717**), TSA (r = -0.764**), Cl$^-$ (r = -0.711**) and Na$^+$ (r = -0.726**).
Fig. 2.15: WS Soil N (air dry soil)

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Soils Nos.

Treatments

VS  L0  L1  L2  L3
16. Ws soil Iron (Fe++) ppm WSE:

Ws soil Fe++ showed decrease over Vs as a result of cropping but with the increase in DE and TE supply. This decrease was found lessened considerably. Particularly at L3 and in APS and ACS certain soils even showed an increase in Ws soil Fe++ more about 50%. On average basis both APS and ACS, over all in non saline non sodic soils and saline sodic soils L3 showed markedly depressed decrease in Ws soil Fe++ over Vs as compare to L0. In both APS and ACS at L0 and L3 this decrease was found more in saline sodic soils as compare to non saline non sodic soils. APS appeared to showed more decrease than ACS.

F values for T (1235.36**), L (1826.55**), S (18265.58**), T x L (387.41**), T x S (13.8**), L x S (119.38**) and T x L x S (6.29**) interactions were found significant at (P = 0.01) probability level.

Ws soil Fe++ in both DE and TE treatment in S9 at L0 compared to Vs and in TE treatment in S3 at L1 as compared to L0 failed to differ. In S7 in TE treatment at L2 as compared to L1 and L3 as compared to L2 it showed a significant (P = 0.01) decrease while in all the soils except those mentioned in both DE and TE treatments at L0 as compared to Vs, at L1 as compared to L0, L2 as compared to L1 and at L3 as compared to L2 it showed a significant (P = 0.01) increase.

As compared to NSNS soils the LSS soils and as compared to LSS soils the HSS soils showed better responses to DE supply
for increase in Ws soil Fe$^{++}$ content while as compared to HSS soils the NSNS soils and as compared to NSNS soils the LSS soils showed better responses to TE supply for increase in Ws soil Fe$^{++}$ content.

Over all the responses in regard to increase in Ws soil Fe$^{++}$ content were found better in DE treated soils as compared to TE treated soils.

**In virgin soils (Vs):**

Ws soil Iron (Fe$^{++}$) was found positively and insignificantly related with Ws Mn$^{++}$ ($r = 0.1334$), Cu$^{++}$($r = 0.2358$) and Zn$^{++}$ ($r = 0.1832$); negatively and insignificantly related with Ws Cr$^{+++}$ ($r = -0.3963$).

**In DE treated soils:**

Ws soil Iron (Fe$^{++}$) was found positively and insignificantly related with Ws Cu$^{++}$($r = 0.4385$) and Zn$^{++}$ ($r = 0.3410$); negatively and insignificantly related with Ws Cr$^{+++}$ ($r = -0.3987$) and positively and significantly ($P = 0.05$) related with Ws Mn$^{++}$ ($r = 0.6718^*$).

**In TE treated soils:**

Ws soil Iron (Fe$^{++}$) was found positively and insignificantly related with Ws Mn$^{++}$ ($r = 0.4988$), Cu$^{++}$($r = 0.1983$) and Zn$^{++}$ ($r = 0.1456$) and negatively and insignificantly related with Ws Cr$^{+++}$ ($r = -0.1253$).
Fig. 2.16: WS Soil Fe^{++} ppm WSE

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Soils Nos.

Soils Nos.

Soils Nos.

Soils Nos.

VS L0 L1 L2 L3
17. **Ws soil Manganese (Mn⁺⁺) ppm WSE:**

Ranging from 0.03 to 0.18 ppm in Vs non saline non sodic soils and 0.04 to 0.25 ppm in saline sodic soils the Ws soil Mn⁺⁺ averaged almost same values. It varied from soil to soil with respective soil type non saline non sodic soils or saline sodic soils in Vs. Cropping more so the DE and TE supply brought remarkable increase in Ws soil Mn⁺⁺. Both in APS and ACS at L₀ and L₃ this increase was found more in non saline non sodic soils than saline sodic soils. ACS showed markedly higher Ws soil Mn⁺⁺ Values than APS at L₀ and L₃ both. As compared to L₀ at L₃ Ws soil Mn⁺⁺ values were found about 1.5 times more. The increase in Ws soil Mn⁺⁺ in APS and ACS ranged from about 600% at L₀ in saline sodic soils to about 1700% at L₃ in saline sodic soils indicating conversion of some water insoluble Mn⁺⁺ to water soluble forms as a result of cropping particularly with DE and TE supply.

F values for T (4390.86**), L (2044.87**), S (1826.56**), T x L (1791.16**), T X S (86.81**), L X S (316.57**) and T X L X S (93.79**) interactions were found significant at (P = 0.01) probability level.

In S₂, S₃, S₄, S₅, S₆, S₇, S₈ and S₉ both in DE and TE treatments at L₀ as compared to Vs the Ws soil Mn⁺⁺ content decreased significantly (P = 0.01). in S₁ at L₀ as compared to Vs and in all the nine soils in both DE and TE treatments at L₁ as compared to L₀, L₂ as compared to L₁ and L₃ as compared to L₂ the Ws soil Mn⁺⁺ content showed a significant at (P = 0.01) increase.
In comparison to NSNS soils the HSS soils and in comparison to HSS soils the LSS showed better responses to DE supply for increase in Ws soil Mn++ content while in comparison to HSS soils the NSNS soils and soils the LSS soils showed better responses to TE supply for increase in Ws soil Mn++ content.

Overall the responses in regard to increase in Ws soil Mn++ content were found better in DE treated soils as compared to TE treated soils.

**In virgin soils (Vs):**

Ws soil Manganese (Mn++*) was found positively and insignificantly related with Ws Cu++ (r = 0.3850) and Zn++ (r = 0.3850) and negatively and insignificantly related with Ws Cr+++ (r = -0.3658).

**In DE treated soils:**

Ws soil Manganese (Mn++) was found positively and insignificantly related with Ws Cu Manganese (Mn++) (r = 0.6484) and Zn++ (r = 0.4896) and negatively and insignificantly related with Ws Cr+++ (r = -0.5251).

**In TE treated soils:**

Ws soil Manganese (Mn++) was found positively and insignificantly related with Ws Cu++(r = 0.5261) and Zn++ (r = 0.4340) and negatively and insignificantly related with Ws Cr+++ (r = -0.1895).
Fig. 2.17: WS Soil Mn^{2+} ppm WSE

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

S1 S2 S3 S4 S5 S6 S7 S8 S9
Soils Nos.

S1 S2 S3 S4 S5 S6 S7 S8 S9
Soils Nos.

S1 S2 S3 S4 S5 S6 S7 S8 S9
Soils Nos.

S1 S2 S3 S4 S5 S6 S7 S8 S9
Soils Nos.
18. Ws soil Copper (Cu++) ppm WSE:

F values for T (984.31**), L (7827.60**), S (7156.61**), T x L (328.47**), T x S (17.82**), L x S (78.86**) and T x L x S (31.16**) interactions were found significant at (P = 0.01) probability level.

In S2 in both DE and TE treatments the Ws soil copper content between Vs and L0 did not differ. In rest of the eight soils in both DE and TE treatments at L0 as compared to Vs the Ws soil Cu++ content showed a significant decrease while all the nine soils in both DE and TE treatments at L1 as compared to L0, L2 as compared to L1 and L3 as compared to L1 showed a significant (P = 0.01) increase.

As compared to HSS soils the LSS soils and as compared to LSS soils the NSNS soils showed better responses to DE supply for increase in Ws soil Cu++ content while as compared to LSS soils the HSS soils and as compared to HSS soils the NSNS soils showed better responses to TE supply for increase in Ws soil Cu++ content.

Over all the responses in regard to increase in Ws soil Cu++ content were found better in TE treated soils as compared to DE treated soils.

In virgin soils (Vs):

Ws soil Copper (Cu++) was found negatively and insignificantly related with Ws Cr+++ (r = -0.4016) and positively and insignificantly related with Ws Zn++ (r = 0.8993**).
In DE treated soils:

Ws soil Copper (Cu++) was found negatively and insignificantly related with Ws Cr+++ (r = -0.5846) and positively and significantly related with Ws Zn++ (r = 0.8560**).

In TE treated soils:

Ws soil Copper (Cu++) was found negatively and insignificantly related with Ws Cr+++ (r = -0.5895) and positively and significantly related with Ws Zn++ (r = 0.8846**).
Fig. 2.18: WS Soil Cu$^{++}$ ppm WSE

- Distillery effluent treatment: Soils after Pedilanthus
- Tannery effluent treatment: Soils after Pedilanthus
- Distillery effluent treatment: Soils after Calotropis
- Tannery effluent treatment: Soils after Calotropis

Legend:
- VS
- L0
- L1
- L2
- L3
19. Ws soil Zinc (Zn++) ppm WSE:

F values for T (218.36**), L (5218.41**), S (3546.25**), T x L (48.97**), T x S (12.75**), L x S (24.69**) and T x L x S (13.46**) interactions were found significant at (P = 0.01) probability level.

In all the nine soils in both DE and TE treatments the Ws soil Zn++ content decreased at L_0 as compared to Vs and increased at L_1 as compared to L_0, L_2 as compared to L_1 and L_3 as compared to L_2 significantly at (P = 0.01) probability level.

Over all as compared to HSS soils the LSS soils and as compared to LSS soils the NSNS soils showed better responses to DE and TE supply for increase in Ws soil Zn++ content.

Over all the responses in regard to increase in Ws soil Zn++ content were found better in DE treated soils as compared to TE treated soils.

**In virgin soils (Vs):**

Ws soil Zn++ was found negatively and insignificantly related with Ws Cr+++ (r = -0.6574).

**In DE treated soils:**

Ws soil Zn++ was found negatively and insignificantly related with Ws Cr+++ (r = -0.6394).

**In TE treated soils:**

Ws soil Zn++ was found negatively and insignificantly related with Ws Cr+++ (r = -0.5364).
Fig. 2.19: WS Soil Zn\(^{++}\) ppm WSE

Distillery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Calotropis
20. Ws soil Chromium (Cr+++ ppm WSE

F values for T (8718.68**), L (4964.56**), S (75.24**), T x L (1934.93**), T X S (6.84**), L X S (10.41**) and T X L X S (4.97**) interactions were found significant at (P = 0.01) probability level.

In S5 and S6, both DE and TE treatments the values for Ws soil Cr+++ did not differ. In S1, S2, S3, S4 and S7 soils both in DE and TE treatments at L0 as compared to Vs the Ws soil Cr+++ showed significant (P = 0.01) decrease. In S8 and S9 at L0 as compared to Vs and in all the nine soils L1 as compared to L0, L2 as compared to L1 and L3 as compared to L2 in both DE and TE treatments the Ws soil Cr+++ content showed a significant (P = 0.01) increase. Though a tendency of increase is found in both the treatments but the increases were never found to cross the permissible limits.

Over all as compared to LSS soil the NSNS soils and as compared to NSNS soils the HSS soils showed better responses to DE and TE supply for increase in Ws soil Cr+++ content.

Over all the responses in regard to increase in Ws soil Cr+++ content were found better in TE treated soils as compared to DE treated soils.
Fig. 2.20: WS Soil Cr³⁺ ppm WSE

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Soils Nos.

Soils Nos.

Soils Nos.

Soils Nos.

VS L0 L1 L2 L3
PLANTS

Visual symptoms:

With the increase in saline sodicity of soils and decrease in DE and TE supply levels up to L0, growth of plants showed decrease. In the earlier stages of the plants raised on soils with 

\[ \text{ESP} > 20 \]

poor seed emergence was observed sometimes plumule failed to break the soil and unfold, the radical showed necrosis and death, other roots lets developed and met the same fate if plants emerged. Hence Pedilanthus and Calotropis raised in nursery was transplanted which survived and the symptoms described if approached showed negative relations with the age of the plants may be because seedlings transplanted were more tolerant due to age and may due to simultaneous changes in the soil for better growth with the passage of time.

1. Dry matter yield g/per plant:

F values for Pedilanthus tithimaloids L. are T (34.86**), L (498.38**), S (378.27**), TXL (9.76**), LXS (7.86**) interactions were found significant at P = 0.01 probability level while for TXS (8.86) And T X L X S (0.64) interactions were found insignificant.

F values for Caloropis procera are T (160.34**), L (587.56**), S (357.24**), T x L (104.96**), T X S (7.98), L X S (160.24**) and T X L X S (0.64) interactions were found significant at (P = 0.01) probability level.

In all the nine soils with both DE and TE treatments the respective effluents supply were found directly related with dry
matter yield and the increase in respective dry matter yield with the increase in DE and TE treatment at $L_1$ as compared to $L_0$, $L_2$ as compared to $L_1$ and $L_3$ as compared to $L_2$ in both the crops i.e., *Pedilanthus tithymaloids* L. and *Calotropis procera* L. was found significant at ($P = 0.01$) probability level.

As compared to NSNS soils the LSS soils and as compared to LSS soils the HSS soils showed better responses to DE supply while as compared to NSNS soils the HSS soils showed better responses to TE supply for increase in dry matter yield.

Over all the responses in regard to increase in dry matter yield were found better in DE treated soils as compared to TE treated soils.

**At control (Lo) level:**

Dry matter yield was found positively and insignificantly related with chlorophyll a/b ratio ($r = 0.2687$) and ascorbic acid ($r = 0.5721$); negatively and insignificantly related with tissue Cr ($r = 0.5678$); positively and significantly ($P = 0.05$) related with tissue Mg ($r = 0.6984^*$); negatively and significantly ($P = 0.05$) related with tissue Fe ($r = 0.7687^*$), positively and significantly ($P = 0.01$) related with Chl. a ($r = 0.5368^{**}$), Chl. b ($r = 0.8976^{**}$), Chl. a+b ($r = 0.8966^{**}$), tissue Ca ($r = 8846^{**}$), K ($r = 0.9864^{**}$), P ($r = 0.8698^{**}$), S ($r = 0.8769^{**}$), Mn ($r = 0.8876^{**}$) and Zn ($r = 0.8641^{**}$) and negatively and significantly ($P = 0.01$) related with catalase activity ($r = -0.8693^{**}$), peroxidase activity ($r = -0.9682^{**}$), tissue Na ($r = -0.9658^{**}$) and Cu ($r = -0.8769^{**}$).
Dry matter yield was found positively and insignificantly related with Ws Ca\(^{++}\) \((r = 0.5471)\), K\(^{+}\) \((r = 0.6318)\) and Cr\(^{+++}\) \((r = 0.1735)\); negatively and insignificantly related with Ws Cl\(^{-}\) \((r = -0.5674)\), PO\(_4\)\(^{-}\) \((r = -0.2717)\), SO\(_4\)\(^{-}\) \((r = -0.4672)\), Mg\(^{++}\) \((r = -0.1392)\), Fe\(^{+++}\) \((r = -0.4357)\), Mn\(^{++}\) \((r = -0.2317)\) and Cu\(^{++}\) \((r = -0.6351)\); negatively and insignificantly \((P = 0.05)\) related with Ws CO\(_3\)\(^{-}\) \((r = -0.7982\*)\), HCO\(_3\)\(^{-}\) \((r = -0.7561\*)\), TSA \((r = -0.7857\*)\), Ws Zn\(^{++}\) \((r = -0.7897\*)\); positively and significantly \((P = 0.01)\) related with percentage moisture content in air dry soil \((r = 0.8764\**\)) , rate of water percolation \((r = 0.9841\**\)) and percentage organic matter \((r = 0.9384\**\)) and negatively and significantly \((P = 0.01)\) related with Ws soil ESP \((r = -0.9721\**\)) , E.Ce \((r = -0.9820\**\)) , pH \((r = -0.9411\**\)) , SAR \((r = -0.9741\**\)) , water required for saturation \((r = -0.9489\**\)) and Ws Na\(^{+}\) \((r = -0.9850\**\))

**In DE treated soils at L\(_3\) level:**

Dry matter yield was found positively and insignificantly related with chlorophyll a/b ratio \((r = 0.3412)\) and tissue Cu \((r = 0.1564)\); negatively and insignificantly related with peroxidase activity \((r = -0.1765)\) , tissue Na \((r = -0.3586)\) , S\((r = -0.2689)\) and Fe \((r = -0.5375)\) positively and significantly \((P = 0.05)\) related with tissue Mg \((r = 0.7865\*)\) and Zn \((r = 0.6985\*)\) positively and significantly \((P = 0.01)\) related with Chl. a \((r = 0.9847\**\)) , Chl. b \((r = 0.9727\**\)) , Chl. a+b \((r = 0.9651\**\)) , ascorbic acid \((r = 0.8963\**\)) , tissue Ca \((r = 0.8920\**\)) , K \((r = 0.9553\**\)) , P \((r = 0.9730\**\)) and Mn \((r = 0.8692\**\)) and negatively and
significantly \( (P = 0.01) \) related with catalase activity \( (r = -0.8421^{**}) \) and tissue Cr \( (r = -0.865^{**}) \).

Dry matter yield was found negatively and insignificantly related with water required for saturation \( (r = -0.2440) \), Ws soil Mg\(^{++}\) \( (r = -0.1897) \), Ws Fe\(^{++}\) \( (r = -0.4374) \), Mn\(^{++}\) \( (r = -0.5643) \); positively and significantly \( (P = 0.05) \) related with percentage moisture content in air dry soil \( (r = 0.7640^{*}) \), percentage organic matter in soil \( (r = 0.6938^{*}) \), Ws soil Ca\(^{++}\) \( (r = 0.7894^{*}) \), K\(^{+}\) \( (r = 0.7827^{*}) \) and Cr\(^{+++}\) \( (r = 0.7740^{*}) \); negatively and significantly \( (P = 0.05) \) related with Ws Cl\(^{-}\) \( (r = -0.7893^{*}) \), PO\(_4^{3-}\) \( (r = -0.7843^{*}) \), SO\(_4^{2-}\) \( (r = -0.7533^{*}) \) and Cu\(^{++}\) \( (r = -0.7520^{*}) \); positively and significantly \( (P = 0.01) \) related with rate of water percolation \( (r = 0.9310^{**}) \) and negatively and significantly \( (P = 0.01) \) related with Ws soil ESP \( (r = -0.9211^{**}) \), E.Ce \( (r = -0.8750^{**}) \), pH \( (r = -0.8310^{**}) \), SAR \( (r = -0.9820^{**}) \), Ws CO\(_3^{2-}\) \( (r = -0.8427^{**}) \), HCO\(_3^{-}\) \( (r = -0.8750^{**}) \), TSA \( (r = -0.8736^{**}) \), Na\(^{+}\) \( (r = -0.8762^{**}) \), Zn\(^{++}\) \( (r = -0.9521^{**}) \).

**TE treated at L3 level:**

Dry matter yield was found positively and insignificantly related with tissue S \( (r = 0.5541) \), negatively and significantly related with chlorophyll a/b ratio \( (r = -0.1892) \), tissue Fe \( (r = -0.5615) \), Cu \( (r = -0.1861) \) and Cr \( (r = -0.3663) \); positively and significantly \( (P = 0.05) \) related with tissue Zn \( (r = 0.7657^{*}) \), peroxidase activity \( (r = 0.7571^{*}) \); positively and significantly \( (P = 0.01) \) related with Chl. a \( (r = 0.9859^{**}) \), Chl. b \( (r = 0.9845^{**}) \), Chl. a+b \( (r = 0.9786^{**}) \), ascorbic acid \( (r = 0.8974^{**}) \), tissue Ca
(r = 0.8796**), K (r = 0.9635**), M (r = 0.8842**); P (r = 0.4645**)
and Mn (r = 0.8952**) and negatively and significantly (P = 0.01)
related with catalase activity (r = -0.8452**) and tissue Na
(r = -0.9532**).

Dry matter yield was found positively and insignificantly
related with percentage moisture content in air dry soil
(r = 0.5784), percentage organic matter (r = 0.6598), and tissue
Cr (r = 0.7668); negatively and insignificantly related with soil
pH (r = -0.4187), water required for saturation (r = -0.1859), Ws
soil Mg++ (r = -0.5645), Fe++(r = -0.1859), Ws soil Mn++(r = -
0.6265); positively and significantly (P = 0.05) related with K+
(r = 0.7894*); negatively and significantly (P = 0.05) related with
Ws Cl− (r = -0.7868*), PO₄³⁻(r = -0.7341*), SO₄²⁻ (r = -0.6926*)
and Cu++(r = -0.7976*); positively and significantly (P = 0.01)
related with rate of water percolation (r = 0.8754**) and Ws
Ca++(r = -0.8727**) and negatively and significantly (P = 0.01)
related with Ws soil ESP (r = -0.8998**), E.Ce (r = -0.8793**),
SAR (r = -0.8747**), Ws CO₃⁻ (r = -0.8949**), HCO₃⁻ (r = -
0.8765**), TSA (r = -0.8854**), Na⁺ (r = -0.8548**), Zn++
(r = -0.8938**)
Fig. 3.1: Mean value of Dry matter yield g/plant

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis
2. Chlorophyll a mg/g. F. M.:

F values for *Pedilanthus tithimaloids* L. are T (53.70**), L (468.75**), S (153.38**), T X L (8.94**), L X S (6.83**) interactions were found significant at P = 0.01 probability level while for T X S (0.176) and T X L X S (0.64) interactions was found insignificant.

F values for *Calotropis procera* L. are T (86.58**), L (470.64**), S (256.38**), T X L (9.83**), L X S (16.84**) T X S (8.73**), L X S (160.24**) and T X L X S (9.34**) interaction were found significant at (P = 0.01) probability level.

In both DE and TE treatments in all nine soils and both crops i.e., Pedilanthus and Calotropis, at L1 as compared to L0, L2 as compared to L1 and L3 as compared to L2 increase in Chl. a was found significant at 0.01 probability level.

As compared to NSNS soils the HSS soils and as compared to HSS soils the LSS soils showed better responses to DE treatment while as compared to NSNS soils the LSS soils and as compared to LSS soils the HSS soils showed better responses to TE treatment for increase in Chl.a.

Overall the responses in regard to increase in Chl.a were found better in DE treated soils as compared to TE treated soils in both the crops i.e., *Pedilanthus tithimaloids* L. and *Calotropis procera* L.

**At L0 level (control):**

Chlorophyll a was found positively and insignificantly related with Chl.a/b ratio (r = 0.3864**), negatively and
insignificantly related with tissue Fe (r = -0.4568); positively and significantly (P = 0.05) related with ascorbic acid (r = 0.7628*), and Zn (r = 0.7482*); positively and significantly (P = 0.01) related with Chl. B (r = 0.9846**), Chl. a+b (r = 0.9687**), tissue Ca (r = 0.9438**), K (r = 0.9436**), Mg (r = 0.9436**); P (r = 0.9348**) and Mn (r = 0.9086**) and negatively and significantly (P = 0.01) related with catalase activity (r = -0.8936**), peroxidase activity (r = -0.9346**), tissue Na (r = -0.9324**), Cu (r = 0.9038**) and Cr (r = 0.8998**).

Chlorophyll a was found positively and insignificantly related with Soil Ws K⁺ (r = 0.5836) and Cr³⁺ (r = 0.4678); negatively and insignificantly related with Ws Cl⁻ (r = -0.5348), PO₄³⁻⁻ (r = -0.3257), SO₄²⁻ (r = -0.4836), Mg²⁺ (r = -0.1384), Fe²⁺ (r = -0.1536) and Mn²⁺ (r = -0.3869); positively and significantly (P = 0.05) related with Ws Ca²⁺ (r = 0.7648*); negatively and significantly (P = 0.05) related with Cu²⁺ (r = -0.7548*); positively and significantly (P = 0.05) related with percentage moisture content in air dry soil (r = 0.9664**), rate of water percolation (r = 0.9864**) and % organic matter in soil (r = 0.8964**) and negatively and significantly (P = 0.01) related with Ws soil ESP (r = -0.8874**), E.Ce (r = -0.8794**), pH (r = -0.8876**), SAR (r = -0.8698**), H₂O for saturation (r = -0.8976**), Ws CO₃⁻⁻ (r = -0.9468**), HCO₃⁻ (r = -0.9326**), TSA (r = -0.9847**), Na⁺ (r = -0.8964**), Zn²⁺ (r = -0.9247**).
In DE treated soil at L3 level:

Chl. a was found positively and insignificantly related with chlorophyll a/b ratio (r = 0.5436) and Cu (r = 0.3268); negatively and insignificantly related with peroxidase activity (r = -0.2649), tissue S (r = -0.3846) and Fe (r = -0.3648); positively and significantly (P = 0.05) related with Ascorbic acid (r = 0.7668*); negatively and significantly (P = 0.05) related with tissue Na (r = 0.6749*); positively and significantly (P = 0.01) related with Chl. b (r = 0.9668**), Chl. a+b (r = 0.9847**), tissue Ca (r = 0.8936**), K (r = 0.8876**), Mg (r = 0.8996**) P (r = 0.8674**), Mn (r = 0.8946**) and Zn (r = 0.8848**) and negatively and significantly (P = 0.01) related with catalase activity (r = -0.8989**) and tissue Cr (r = -0.8664**).

Chl. a was found positively and insignificantly related with Ws Ca++ (r = 0.5836); negatively and insignificantly related with H2O required for saturation (r = -0.3486), Ws Cl− (r = -0.5834), SO4−− (r = -0.4836), Mg++ (r = -0.3896), Fe+++ (r = -0.3640) and Mn++ (r = -0.5328) and Cu+++ (r = -0.3893); positively and significantly (P = 0.05) related with % organic matter (r = 0.7328*) and Cr++++ (r = 0.7684*); positively and significantly (P = 0.01) related with % moisture content in air dry soil (r = 0.8948**), rate of H2O percolation (r = 0.8869**) and Ws K+ (r = 0.8869**) and negatively and significantly (P = 0.01) related with soil ESP (r = -0.9468**), E.Ce (r = -0.9348**), pH (r = -0.8876**), SAR (r = -0.9896**), Ws CO3-- (r = -0.9384**), HCO3− (r = -0.9436**),
Fig. 3.2: Mean value of Chlorophyll a mg/g FM

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Soils Nos.

Soils Nos.

Soils Nos.

Soils Nos.

L0  L1  L2  L3
TSA \( (r = -0.9396^{**}) \), PO\(_4^{-3-} \) \( (r = -0.8936^{**}) \), Na\(^+\) \( (r = -0.9085^{**}) \), Zn\(^{++}\) \( (r = -0.8439^{**}) \).

**In TE treated soils at L\(_3\) level:**

Chl. a was found positively and insignificantly related with tissue S \( (r = 0.5638) \), negatively and insignificantly related with chlorophyll a/b ratio \( (r = -0.1546) \), tissue Fe \( (r = -0.3864) \), Cu \( (r = -0.2136) \) and Cr \( (r = -0.3436) \); positively and significantly \( (P = 0.05) \) related with tissue Mn \( (r = 0.7368^{*}) \) and Zn \( (r = 0.7326^{*}) \), negatively and significantly \( (P = 0.05) \) related with peroxidase activity \( (r = -0.7648^{*}) \); positively and significantly \( (P = 0.01) \) related with Chl. a \( (r = 0.9859^{**}) \), Chl. b \( (r = 0.8968^{**}) \), Chl. a+b \( (r = 0.9936^{**}) \), ascorbic acid \( (r = 0.9482^{**}) \), tissue Ca \( (r = 0.9986^{**}) \), K \( (r = 0.9867^{**}) \), Mg \( (r = 0.8968^{**}) \); P \( (r = 0.8968^{**}) \); and negatively and significantly \( (P = 0.01) \) related with catalase activity \( (r = -0.8986^{**}) \) and tissue Na \( (r = -0.9837^{**}) \).

Chl. a was found positively and insignificantly related with percentage moisture content in air dry soil \( (r = 0.6438) \) and Ws Cr\(^{+++}\) \( (r = 0.5438) \); negatively and insignificantly elated with soil pH \( (r = -0.4328) \), H\(_2\)O required for saturation \( (r = -0.3216) \), Ws SO\(_4^{2-}\) \( (r = -0.5436^{**}) \), Mg\(^{++}\) \( (r = -0.3896) \), Fe\(^{+++}\)(r = -0.2468) and Mn\(^{++}\) \( (r = -0.5836) \); positively and significantly \( P = 0.05 \) related with \% organic matter \( (r = 0.7648^{*}) \), Ws Ca\(^{++}\) \( (r = 0.7964^{*}) \) and K\(^+\) \( (r = 0.7898^{*}) \); negatively and significantly \( P = 0.05 \) related with Ws Cl\(^-\) \( (r = -0.7884^{*}) \), PO\(_4^{-3-}\) \( (r = -0.7896^{*}) \), and Cu\(^{++}\) \( (r = -0.7749^{*}) \); positively and significantly \( P = 0.01 \) related with
rate of H$_2$O percolation ($r = 0.9348^{**}$) and negatively and significantly ($P = 0.01$) related with Ws soil ESP ($r = -0.9498^{**}$), E.Ce ($r = -0.8987^{**}$), SAR ($r = -0.9841^{**}$), Ws CO$_3^-$ ($r = -0.8659^{**}$), HCO$_3^-$ ($r = -0.8975^{**}$), TSA ($r = -0.8738^{**}$), Ws Na$^+$ ($r = -0.8896^{**}$) and Zn$^{++}$ ($r = -0.9895^{**}$).
3. Chlorophyll b mg/g FM:

F values for *Pedilanthus tithimaloids* L. are T (46.37**), L (648.93**), S (454.29**), T X L (13.65**), T X S (7.86**) And T X L X S (12.15**) interactions were found significant at P = 0.01 probability level while for L X S (0.198**) interactions was found insignificant.

F values for *Calotropis procera* are T (63.73**), L (13.48**), S (398.92**), T X L (11.26**), L X S (13.48**), T X L X S (9.38**) and T X S (18.37**) interaction were found significant at (P = 0.01) probability level.

Over all in all the nine soils with both DE and TE treatments the respective effluent supply was found positively related with chl.b and increase in Chl.b and at L₂ as compared to L₁ was found significant at (P = 0.01) probability level, irrespective of the soil, only exceptions being S₉ in De treatment and S₈ in TE treatment where the chl.b decreased significantly at 0.01 probability level at L₂ as compared to L₁.

As compared to NSNS soils the HSS soils and as compared to HSS soils the LSS soils showed better responses to DE and TE supply for increase in chl.b.

Overall the responses in regard to increase in chl.b were found better in DE treated soils as compared to TE treated soils.

**At Lo level (control):**

Chlorophyll b was found positively and insignificantly related with chlorophyll a/b ratio (r = 0.3686); positively and
significantly (P = 0.05) related with ascorbic acid (r = 0.7523*) and tissue Zn (r = 0.7449*); negatively and significantly (P = 0.05) related with Mn⁺⁺(r = -0.5836*); Fe (r = -0.6771*); positively and significantly (P = 0.01) related with Chl. a+b (r = 0.9957**), tissue Ca (r = 0.9125**), K (r = 0.9271**), Mg (r = 0.9084**) P (r = 0.9160**), S (r = 0.9080**) and Mn (r = 0.8236**) and negatively and significantly (P = 0.01) related with catalase activity (r = -0.8898**), peroxidase activity (r = -0.9100**), tissue Na (r = -0.9026**), Cu (r = -0.9207**) and Cr (r = -0.8679**).

Chlorophyll b was found positively and insignificantly related with Soil Ws Ca⁺⁺ (r = 0.6559), K⁺ (r = 0.6580) and Cr+++ (r = 0.3668); negatively and insignificantly related with Ws PO₄⁻⁻ (r = -0.4146), SO₄⁻⁻ (r = -0.4821), Mg⁺⁺ (r = -0.4066), Fe⁺⁺ (r = -0.4090) and Mn+++ (r = -0.3674); negatively and significantly (P = 0.05) related with Ws Cl⁻ (r = -0.7437*) and Cu⁺⁺(r = -0.7321*); positively and significantly (P = 0.01) related with percentage moisture content in air dry soil (r = 0.8901**), rate of H₂O percolation (r = 0.9727**) and % organic matter (r = 0.9170**) and negatively and significantly (P = 0.01) related with Ws soil ESP (r = -0.9426**), E.Ce (r = -0.9200**), pH (r = -0.9485**), SAR (r = -0.9262**), H₂O for saturation (r = -0.9236**), Ws CO₃⁻⁻ (r = -0.9392**), HCO₃⁻ (r = -0.9412**), TSA (r = -0.9410**), Ws Na⁺ (r = -0.8997**) and Zn⁺⁺ (r = -0.9375**).
In DE treated soils at L3 Level:

Chlorophyll b was found positively and insignificantly related with chlorophyll a/b ratio ($r = 0.2758$) and tissue Cu ($r = 0.1683$); negatively and insignificantly related with peroxidase activity ($r = -0.1489$), tissue Na ($r = -0.6219$), S ($r = -0.5357$) and Fe ($r = -0.3310$); positively and significantly ($P = 0.05$) related with ascorbic acid ($r = 0.6829^*$); positively and significantly ($P = 0.01$) related with Chl. a+b ($r = 0.9965^{**}$), tissue Ca ($r = 0.8699^{**}$), K ($r = 0.8855^{**}$), Mg ($r = 0.8700^{**}$) P ($r = 0.8945^{**}$), Mn ($r = 0.8413^{**}$) and Zn ($r = 0.8001^{**}$) and negatively and significantly ($P = 0.01$) related with catalase activity ($r = -0.8577^{**}$) and Cr ($r = -0.8826^{**}$).

Chlorophyll b was found positively and insignificantly related with Soil $Ws$ Ca$^{++}$ ($r = 0.6536$); negatively and insignificantly related with $H_2O$ required for saturation of soil ($r = -0.3059$), $Ws$ SO$_4^{--}$ ($r = -0.6152$), Mg$^{++}$ ($r = -0.3054$), Fe$^{++}$ ($r = -0.2395$), Mn$^{++}$ ($r = -0.5898$) and and Cu$^{++}$(r = -0.5556); positively and significantly ($P = 0.05$) related with $Ws$ Cr$^{+++}$ ($r = 0.6845^*$); negatively and significantly ($P = 0.01$) related with Cl$^-$ ($r = -0.7154^*$) positively and significantly ($P = 0.01$) related with percentage moisture content ($r = 0.8197^{**}$), rate of $H_2O$ percolation ($r = 0.8307^{**}$) and % organic matter ($r = 0.8137^{**}$) and $Ws$ K$^+$(r = 0.9098**)) and negatively and significantly ($P = 0.01$) related with $Ws$ soil ESP ($r = -0.9475^{**}$), E.Ce ($r = -0.9333^{**}$), pH ($r = -0.9122^{**}$), SAR ($r = -0.9403^{**}$), $Ws$ CO$_3^{--}$ ($r = -0.8845^{**}$), HCO$_3^-$ ($r = -0.9295^{**}$), TSA ($r = -0.9334^{**}$), PO$_4^{-}^{--}$ ($r = -0.8409^{**}$), $Ws$ Na$^+$ ($r = -0.9321^{**}$) and Zn$^{++}$ ($r = -0.8686^{**}$).
In TE treated soils at L3 levels:

Chl. b was found positively and insignificantly related with tissue S (r = 0.6078), negatively and insignificantly related with chlorophyll a/b ratio (r = -0.2975), peroxidase activity (r = -0.5812), tissue Fe (r = -0.4471), Cu (r = -0.0721) and Cr (r = -0.5134); positively and significantly (P = 0.05) related with tissue Mn (r = 0.7974*) and Zn (r = 0.7994*), positively and significantly (P = 0.01) related with Chl. a+b (r = 0.9941**), ascorbic acid (r = 0.8611**), tissue Ca (r = 0.9526**), K (r = 0.9096**), Mg (r = 0.9296**) and P (r = 0.8894**); and negatively and significantly (P = 0.01) related with catalase activity (r = -0.8579**) and tissue Na (r = -0.9700**).

Chl. b was found positively and insignificantly related with percentage moisture content in air dry soil (r = 0.6355); negatively and insignificantly related with soil pH (r = -0.5589), H2O required for saturation (r = -0.1788), Ws SO4−− (r = -0.5994**), Mg++ (r = -0.5429), Fe+++ (r = -0.1805) and Mn++ (r = -0.5316); positively and significantly (P = 0.05) related with % organic matter (r = 0.7878*), Ws Ca++ (r = 0.7558*) and Cr+++ (r = 0.7103*); negatively and significantly (P = 0.05) related with Ws Cu++ (r = -0.7524*); positively and significantly (P = 0.01) related with rate of H2O percolation (r = 0.9140**) and Ws K+ (r = 0.8649**) and negatively and significantly (P = 0.01) related with Ws soil ESP (r = -0.9431**), E.Ce (r = -0.9348**), SAR (r = -0.9288**), Ws CO3−− (r = -0.9343**), HCO3−− (r = -0.9372**), TSA (r = -0.9362**), Ws Cl− (r = -0.8195**), PO4−−−− (r = -0.8356**), Ws Na+ (r = -0.9128**) and Zn++ (r = -0.8992**).
Fig. 3.3: Mean value of Chlorophyll b mg/g FM

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Soils Nos.

Soils Nos.

Soils Nos.

Soils Nos.

L0  L1  L2  L3
4. Chlorophyll a+b mg/g F.M.:

F values for *Pedilanthus tithimaloids* L. are T (43.86**), L (468.93**), S (263.19**), T x L (13.59**), T x S (21.13**) And T x L x S (12.93**) interactions were found significant at P = 0.01 probability level.

F values for *Calotropis procera* L. are T (43.73**), L (586.38**), S (468.36**), T x L (17.64**), L x S (11.94**), T x L x S (19.84**) and T x S (13.88**) interactions were found significant at (P = 0.01) probability level.

Both in DE and TE treatments in all nine soils at L₁ as compared to L₀ a significant (P = 0.01) increase was found in chl. a+b. At L₂ level as compared to L₁ level to except in S₇ and S₉ of DE treatment and S₈ of TE treatment where chl. a+b showed a significant (P = 0.01) decrease and in S₆ of the TE treatment the decrease in chl. a+b was not significant; in rest of the soils at L₂ as compared to L₁ in both DE and TE treatments the chl. a+b increased significantly at (P = 0.01) probability level.

As compared to NSNS soils the HSS soils and as compared to HSS soils the LSS soils showed better responses to De supply while as compared to NSNS soils the LSS soils and as compared to LSS soils the HSS soils showed better responses to TE supply for increase in chlorophyll a+b.

Over all the responses in regard to increase in chl. a+b were found better in DE treated soils as compared to TE treated soils.
At Lo level (control):

Chlorophyll a+b was found positively and insignificantly related with chlorophyll a/b ratio (r = 0.4516); negatively and insignificantly related with tissue Fe (r = -0.6617); positively and significantly (P = 0.05) related with ascorbic acid (r = 0.7270*) and tissue Zn (r = 0.7402*); positively and significantly (P = 0.01) related with tissue Ca (r = 0.8969**), K (r = 0.9263**), Mg (r = 0.8997**) P (r = 0.8931**), S (r = 0.9136**) and Mn (r = 0.8213**) and negatively and significantly (P = 0.01) related with catalase activity (r = -0.8937**), peroxidase activity (r = -0.9200**), tissue Na (r = -0.8887**), Cu (r = -0.8943**) and Cr (r = -0.8761**).

Chlorophyll a+b was found positively and insignificantly related with Soil Ws Ca++ (r = 0.6572), K+ (r = 0.6862) and Cr+++ (r = 0.4344); negatively and insignificantly related with Ws PO₄³⁻ (r = -0.3857), SO₄²⁻ (r = -0.4863), Mg++ (r = -0.4119), Fe++ (r = -0.1257) and Mn++(r = -0.4102); negatively and significantly (P = 0.05) related with Ws Cl⁻ (r = -0.7115*) and Cu++(r = -0.7047*); positively and significantly (P = 0.01) related with percentage moisture content in air dry soil (r = 0.8629**), rate of H₂O percolation (r = 0.9730**) and % organic matter (r = 0.9055**) and negatively and significantly (P = 0.01) related with Ws soil ESP (r = -0.9293**), E.Ce (r = -0.9233**), pH (r = -0.9451**), SAR (r = -0.9112**), H₂O for saturation (r = -0.9730**), Ws CO₃⁻ (r = -0.9501**), HCO₃⁻ (r = -0.9506**),
TSA \( (r = -0.9509^{**}) \), Ws Na\(^+\) \( (r = -0.8887^{**}) \) and Zn\(^{++}\) \( (r = -0.9132^{**}) \).

**In DE treated soils at L\(_3\) Levels:**

Chlorophyll a+b was found positively and insignificantly related with chlorophyll a/b ratio \( (r = 0.3527) \) and tissue Cu \( (r = 0.2139) \); negatively and insignificantly related with peroxidase activity \( (r = -0.1490) \), tissue Na \( (r = -0.5565) \), S \( (r = -0.5033) \) and Fe \( (r = -0.2940) \); positively and significantly \( (P = 0.05) \) related with ascorbic acid \( (r = 0.6798^{*}) \); positively and significantly \( (P = 0.01) \) related with tissue Ca \( (r = 0.8537^{**}) \), K \( (r = 0.8728^{**}) \), Mg \( (r = 0.8884^{**}) \) P \( (r = 0.8972^{**}) \), Mn \( (r = 0.8456^{**}) \) and Zn \( (r = 0.8130^{**}) \) and negatively and significantly \( (P = 0.01) \) related with catalase activity \( (r = -0.8449^{**}) \) and Cr \( (r = -0.8688^{**}) \).

Chlorophyll a+b was found positively and insignificantly related with Soil Ws Ca\(^{++}\) \( (r = 0.6247) \); negatively and insignificantly related with H\(_2\)O required for saturation of soil \( (r = -0.3072) \), Ws SO\(_4^{--}\) \( (r = -0.5963) \), Mg\(^{++}\) \( (r = -0.3365) \), Fe\(^{++}\) \( (r = -0.2495) \), Mn\(^{++}\) \( (r = -0.5832) \) and and Cu\(^{++}\)(\(r = -0.5304\)) positively and significantly \( (P = 0.05) \) related with Ws Cr\(^{+++}\)(\(r = 0.6977^{*}\)); negatively and significantly \( (P = 0.01) \) related with Cl\(^-\) \( (r = -0.6803^{*}) \) positively and significantly \( (P = 0.01) \) related with percentage moisture content \( (r = 0.8530^{**}) \), rate of H\(_2\)O percolation \( (r = 0.8825^{**}) \) and % organic matter \( (r = 0.8012^{**}) \) and Ws K\(^+\)(\(r = 0.9066^{**}\)) and negatively and significantly \( (P = 0.01) \) related with Ws soil ESP \( (r = -0.9366^{**}) \), E.Ce
(r = -0.9291**), pH (r = -0.8954**), SAR (r = -0.9292**), Ws CO$_3$$^-$ (r = -0.8929**), HCO$_3$- (r = -0.9270**), TSA (r = -0.9290**), PO$_4$$^{3-}$ (r = -0.8485**), Ws Na$^+$ (r = -0.9232**) and Zn$^{2+}$ (r = -0.8587**).

**In TE treated soils at L$3$ level:**

Chl. a+b was found positively and insignificantly related with tissue $S$ (r = 0.6226), negatively and significantly related with chlorophyll a/b ratio (r = -0.1637), peroxidase activity (r = -0.6285), tissue Fe (r = -0.4703), Cu (r = -0.0901) and Cr (r = -0.4676); positively and significantly (P = 0.05) related with tissue Mn (r = 0.7971*) and Zn (r = 0.7972*), positively and significantly (P = 0.01) related with ascorbic acid (r = 0.8918**), tissue Ca (r = 0.9398**), $K$ (r = 0.9316**), Mg (r = 0.8994**) and P (r = 0.8860**); and negatively and significantly (P = 0.01) related with catalase activity (r = -0.8637**) and tissue Na (r = -0.9659**).

Chl. a+b was found positively and insignificantly related with percentage moisture content in air dry soil (r = 0.6226); negatively and insignificantly related with soil pH (r = -0.5291), H$_2$O required for saturation (r = -0.1556), Ws SO$_4$$^-$ (r = -0.6319**), Mg$^{2+}$ (r = -0.5353), Fe$^{3+}$ (r = -0.2419) and Mn$^{2+}$ (r = -0.5667); positively and significantly (P = 0.05) related with % organic matter (r = 0.7596*), Ws Ca$^{2+}$ (r = 0.7792*) and Cr$^{3+}$ (r = 0.6818*); negatively and significantly (P = 0.05) related with Ws Cu$^{2+}$ (r = -0.7544*); positively and significantly (P = 0.01) related with rate of H$_2$O percolation (r = 0.9125*) and Ws K$^+$ (r = 0.8289**) and negatively and significantly (P = 0.01)
related with Ws soil ESP \( (r = -0.9444^{**}) \), E.Ce \( (r = -0.9217^{**}) \), SAR \( (r = -0.9272^{**}) \), Ws \( \text{CO}_3^- \) \( (r = -0.9050^{**}) \), HCO\(_3\)\(^-\) \( (r = -0.9090^{**}) \), TSA \( (r = -0.9076^{**}) \), Ws \( \text{Cl}^- \) \( (r = -0.7980^{**}) \), PO\(_4\)\(^{3-}\) \( (r = -0.8253^{**}) \), Ws Na\(^+\) \( (r = -0.8988^{**}) \) and Zn\(^{++}\) \( (r = -0.9028^{**}) \).
Fig. 3.4: Mean value of Total Chlorophyll (a+b) mg/g. FM

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Soils Nos.

Treatments

Soils Nos.

Soils Nos.

Soils Nos.

L0 L1 L2 L3

Treatments
5. Chlorophyll a/b ratio:

F values for *Pedilanthus tithimaloids* L. are T (19.44**), L (38.47**), S (14.16**), L × S (11.46**), T × L (16.53**), T × S (11.38**) And T × L × S (17.98**) interactions were found significant at P = 0.01 probability level.

F values for *Calotropis procera* are T (21.46**), L (18.83**), S (11.84**), L × S (17.83**), T × L (13.63**), T × S (12.81**) And T × L × S (18.94**) interactions were found significant at P = 0.01 probability level.

In DE treatment in S₁, S₃, S₄, S₇ and S₉ at L₁ as compared to L₀ chl. a/b at (P = 0.01) probability level, in S₈ showed a significant increase at (P = 0.05) probability level, in S₂ and S₆ showed a significantly decrease at (P = 0.05) probability level and in S₅ showed an insignificant decrease while in TE treatment in S₃, S₄, S₇, S₈ and S₉ it showed a significant increase at (P = 0.01) level, in S₆ showed a significant increase at (P = 0.05) level, in S₂ showed a significant decrease at (P = 0.01) level and S₁ and S₅ it showed an insignificant increase at L₁ as compared to L₀ except in S₁, S₃ and S₄ of DE treatment where increase in chl. a/b ratio was found insignificant and in TE treatment the decrease in chl. a/b ratio in S₃, S₄ and S₆ was found significant at (P = 0.05) level and more; under the same treatment in S₇ chl. a/b ratio did not differ in rest of the soils L₂ as compared to L₁ both in DE and TE treatment it showed a significant increase at (P = 0.01) level.

As compared to NSNS soils the HS soils and as compared to HSS soils the LSS soils showed better responses to DE supply.
while as compared to NSNS soils and as compared to LSS soils showed better responses to TE supply for increase on chl. a/b ratio.

Over all the responses in regard to increase in chl. a/b ratio were better in DE treated soils as compared to TE treated soils.

**At Lo level (control):**

Chlorophyll a/b ratio was found positively and insignificantly related with ascorbic acid (r = 0.0053), tissue Ca (r = 0.1978), K (r = 0.3523), Mg (r = 0.3204); P (r = 0.1577), S (r = 0.4151), Mn (r = 0.3233) and Zn (r = 0.2620) and negatively and insignificantly (P = 0.01) related with catalase activity (r = -0.3875), peroxidase activity (r = -0.4700), tissue Na (r = -0.2385), Fe (r = -0.1111), Cu (r = -0.1059) and Cr (r = -0.4698).

Chl. a/b was found positively and insignificantly related with percentage moisture content in air dry soil (r = 0.1123), rate of H2O percolation (r = 0.3934), % organic matter (r = 0.2484) Ws PO4 – (r = 0.1418) Ca++ (r = 0.2486), K+ (r = 0.3424) and Cu++ (r = 0.0093) and negatively and significantly related with Ws soil ESP (r = -0.2537**), E.Ce (r = -0.4342**), pH (r = -0.3506**), SAR (r = -0.2346), Ws CO3– (r = -0.5162), HCO3– (r = -0.5048), TSA (r = -0.5094), Ws Cl– (r = -0.0227), SO4– (r = -0.1886), Na+ (r = -0.2692), Mg++ (r = -0.4522), Fe++ (r = -0.1932), Mn+ (r = -0.5736) and Zn++ (r = -0.1265) and positively and significantly (P = 0.01) related with Ws Cr+++ (r = -0.8617).
In DE treated soils at L3 level:

Chlorophyll a/b ratio was found positively and insignificantly related with ascorbic acid \( (r = 0.1463) \), peroxidase activity \( (r = 0.0139) \), tissue Ca \( (r = 0.0518) \), K \( (r = 0.0249) \), Mg \( (r = 0.4991) \); S \( (r = 0.1881) \), Fe \( (r = 0.4062) \), Mn \( (r = 0.3015) \) and Zn \( (r = 0.3996) \); negatively and insignificantly related with catalase activity \( (r = -0.1256) \), tissue Na \( (r = -0.6349) \), P \( (r = -0.0620) \) and Cr \( (r = -0.1239) \). positively and significantly \((P = 0.05)\) related with tissue Cu \( (r = -0.7282^*) \).

Chl. a/b ratio was found positively and insignificantly related with percentage moisture content in air dry soil \( (r = 0.6607) \), rate of H2O percolation \( (r = 0.1195) \), % organic matter \( (r = 0.1793) \) Ws Cl\(^-\) \( (r = 0.2260) \) SO\(_4^{--}\) \( (r = 0.1406) \), K\(^+\) \( (r = 0.2475) \), Cr\(^{+++}\) \( (r = 0.3690) \) and Cu\(^{++}\) \( (r = 0.1560) \) and negatively and significantly related with Ws soil ESP \( (r = -0.1381) \), E.Ce \( (r = -0.2053) \), pH \( (r = -0.1054) \), SAR \( (r = -0.1369) \), H\(_2\)O required for saturation \( (r = -0.0628) \) Ws CO\(_3^{--}\) \( (r = -0.3464) \), HCO\(_3^-\) \( (r = -0.2648) \), TSA \( (r = -0.2399) \), PO\(_4^{--}\) \( (r = -0.3611) \), Na\(^+\) \( (r = -0.1661) \), Ca\(^++\) \( (r = -0.0593) \), Mg\(^++\) \( (r = -0.4857) \), Fe\(^++\) \( (r = -0.1508) \), Mn\(^+\) \( (r = -0.1421) \) and Zn\(^++\) \( (r = -0.1159) \).

In TE treated soils at L3 level:

Chlorophyll a/b ratio was found positively and insignificantly related with ascorbic acid \( (r = 0.0499) \), catalase activity \( (r = 0.1370) \), tissue Na \( (r = 0.2652) \), and Cr \( (r = 0.5989) \). and negatively and insignificantly related with peroxidase activity \( (r = -0.2856) \), tissue Ca \( (r = -0.3697) \), K \( (r = -0.0523) \), Mg
(r = -0.5270); P (r = -0.2457), S (r = -0.0752), Fe (r = -0.1648), 
Mn (r = -0.1834), Cu (r = -0.1840) and Zn (r = -0.2148).

Chl. a/b ratio was found positively and insignificantly related with soil ESP (r = 0.2286), E.Ce (r = 0.3419), pH 
(r = 0.4641), SAR (r = 0.2498), H2O required or saturation 
(r = 0.2274), Ws CO3− (r = 0.4903), HCO3− (r = 0.4790), TSA 
(r = 0.4833), Ws Cl− (r = 0.3846), PO4− (r = 0.4282), Na⁺ 
(r = 0.2646), Ca++ (r = 0.0379), Mg++ (r = 0.1564), Cu++ 
(r = 0.1426) and Zn++ (r = -0.1542) and negatively and insignificantly related with percentage moisture content 
(r = -0.3019), rate of H2O percolation (r = -0.2739), % organic matter (r = -0.4344) Ws SO4− (r = -0.1554), K⁺ (r = -0.5274) and 
Fe+++ (r = -0.5189), Mn++ (r = -0.2066) and Cr+++ (r = -0.3949).
Fig. 3.5: Mean value of Chlorophyll a/b.

**Distillery effluent treatment: Soils after Pedilanthus**

**Distillery effluent treatment: Soils after Calotropis**

**Tannery effluent treatment: Soils after Pedilanthus**

**Tannery effluent treatment: Soils after Calotropis**

![Graphs showing mean value of Chlorophyll a/b for different treatments and soil samples.](image)
6. Ascorbic acid mg/g FM:

F values for Pedilanthus tithimaloids L. are T (186.27**), L (714.68**), S (348.48**), T X L (57.21**), T X S (14.97**), L X S (29.83**) and T X L X S (12.76**) interactions were found significant at P = 0.01 probability level.

F values for Calotropis procera are T (84.79**), L (638.41**), S (293.84**), T X L (53.72**), T X S (11.79**), L X S (26.48**) and T X L X S (9.83**) interactions were found significant at (P = 0.01) probability level.

Over all in the nine soils with both DE and TE treatment the respective effluent supply was found directly related with ascorbic acid and the increase in ascorbic acid with the increase in DE or TE treatment at L1 as compared to L0, L2 as compared to L1 and L2 as compared to L2 was fond significant at (P = 0.01) probability level in both the crops.

As compared to HSS soils the LSS soils and as compared to LSS soils the NSNS soils showed better responses to DE and TE supply for increase in ascorbic acid content.

Over all the responses in regard to increase in ascorbic acid content were found better in DE treated soils as compared to TE.

Table 3.14: F values in case of tissue sulphur for L1, S and L X S in reactions in Paddy and Barley at I, II and III stages of growth respectively.
At L₀ level (control):

Ascorbic acid content was found positively and insignificantly related with Mg (r = 0.4991), Mn (r = 0.6286), Mn (r = 0.5656) and Zn (r = 0.4321); negatively and insignificantly related with peroxidase activity (r = 0.5397), tissue Na (r = 0.5837), Fe (r = -0.5107), and Cr (r = -0.6511); positively and significantly (P = 0.05) related with tissue tissue Ca (r = 0.6993*), K (r = 0.7295*), P (r = 0.6677*) and S(r = 0.6923*); negatively and insignificantly (P = 0.05) related with catalase activity (r = -0.6826*) and negatively and significantly (P = 0.01) related with tissue Cu (r = -0.8106**).

Ascorbic acid content was found positively and insignificantly related with percentage moisture content in air dry soil (r = 0.6405), % organic matter (r = 0.6268) Ws Ca++ (r = 0.6110), Mg++ (r = 0.2819), Fe++ (r = 0.0671) and Cr+++ (r = 0.1328); negatively and significantly related with Ws soil ESP (r = -0.6197), E.Ce (r = -0.5295), pH (r = -0.6650), SAR (r = -0.5786), Ws CO₃⁻⁻ (r = -0.5852), HCO₃⁻ (r = -0.5932), TSA (r = -0.5905), Cl⁻ (r = -0.4575), PO₄⁻⁻⁻ (r = -0.4520), SO₄²⁻ (r = -0.5557), Na⁺ (r = -0.5060), Mn⁺ (r = -0.4198); positively and significantly (P = 0.05) related with rate of H₂O percolation (r = 0.6915*) and negatively and significantly (P = 0.01) related with Cu++ (r = -0.8166) and Zn++ (r = -0.8928).

In DE treated soils at L₃ level:

Ascorbic acid content was found positively and insignificantly related with peroxidase activity (r = 0.2088), Mg
Ascorbic acid content was found positively and insignificantly related with percentage moisture content in air dry soil \((r = 0.4370)\), % organic matter \((r = 0.4809)\) Ws K\(^+\) \((r = 0.4543)\), Mg\(^{++}\) \((r = 0.1394)\) and Cr\(^{+++}\) \((r = 0.6299)\); negatively and significantly related with Ws soil ESP \((r = -0.6239)\), E.Ce \((r = -0.4949)\), pH \((r = -0.4533)\), SAR \((r = -0.5873)\), H\(_2\)O require for saturation of soil \((r = -0.2125)\), Ws CO\(_3\)\(^{-}\) \((r = -0.5038)\), HCO\(_3\)\(^{-}\) \((r = -0.5330)\), TSA \((r = -0.5540)\), Cl\(^-\) \((r = -0.5283)\), PO\(_4\)\(^{3-}\) \((r = -0.5491)\), SO\(_4\)\(^{2-}\) \((r = -0.5303)\), Na\(^+\) \((r = -0.5393)\), Fe\(^{++}\) \((r = -0.3234)\), Mn\(^+\) \((r = -0.2160)\) and Cu\(^{++}\) \((r = -0.5742)\) positively and significantly \((P = 0.05)\) related with Ws Ca\(^{++}\) \((r = -0.6956^*)\); positively and significantly \((P = 0.05)\) related with rate of H\(_2\)O percolation \((r = 0.8543^{**})\) and negatively and significantly \((P = 0.01)\) related with Ws Zn\(^{++}\) \((r = -0.8281^{**})\).

**In TE treated soils at L\(_3\) levels:**

Ascorbic acid was found positively and insignificantly related with tissue S \((r = 0.5138)\) and Zn \((r = 0.6899)\); negatively and insignificantly related with peroxidase activity \((r = -0.5195)\), tissue Fe \((r = -0.2391)\), Cu \((r = -0.1322)\) and Cr \((r = -0.2719)\);
positively and significantly (P = 0.05) related with tissue Mg 
(r = 0.7294*), P (r = 0.7625*) and Mn (r = 0.7084*); negatively 
and significantly (P = 0.05) related with catalase activity 
(r = -0.7672*) and tissue Na (r = -0.7805) positively and 
significantly (P = 0.01) related with tissue tissue Ca 
(r = 0.8155**).

Ascorbic acid was found positively and insignificantly 
related with percentage moisture content in air dry soil 
(r = 0.2627), H2O required for saturation (r = 0.0683), % organic 
matter (r = 0.5713) Ws K+ (r = 0.5287) and Cr+++ (r = 0.3640); 
negatively and insignificantly related with Ws soil pH 
(r = -0.3255), Cl− (r = -0.6410), PO4−− (r = -0.5810), SO4−−−− 
(r = -0.5515), Mg+ (r = -0.2254), Fe+++ (r = -0.1738), Mn+ 
(r = -0.5573); positively and significantly (P = 0.05) related with 
H2O percolation (r = 0.7557*) and Ws Ca++ (r = 0.7930*); 
negatively and significantly (P = 0.05) related with soil ESP 
(r = -0.7476*), E.Ce (r = -0.6919*), SAR (r = -0.7127*), Ws CO3−−− 
(r = -0.7318*), HCO3− (r = -0.7344*), TSA (r = -0.7335*), Ws Na+ 
(r = -0.6670*) and Cu+++ (r = -0.7451*) and negatively and 
significantly (P = 0.01) related with Ws Zn+++ (r = -0.9007**).
Fig. 3.6: Mean value of Ascorbic acid mg/g. FM.

Distillery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Calotropis

- L0
- L1
- L2
- L3
7. Catalase activity µL O₂ evolved:

F values for *Pedilanthus tithimaloids* L. are T (637.65**), L (783.51**), S (658.75**), T X L (178.27**), T X S (53.84**), L X S (28.18**) and T X L X S (14.74**) interactions were found significant at (P = 0.01) probability level.

F values for *Calotropis procera* are T (738.56**), L (1738.15**), S (2863.57**), T X L (138.72**), T X S (31.58**), L X S (26.18**) and T X L X S (14.74**) interactions were found significant at (P = 0.01) probability level.

Except in S₉ of DE treatment and S₄ and S₈ treatment where catalase activity showed a significant at (P = 0.01) decrease.

At L₂ as compared to L₁ in all the nine soils in both DE and TE treatments at L₁ as compared to L₀ and at L₂ as compared to L₁ catalase activity showed a significant increase at (P = 0.01) probability level.

As compared to LSS soils and as compared to HSS soils the NSNS soils showed better responses to DE and TE supply for increase in catalase activity.

Over all the responses in regard to increase in catalase activity were found better in DE treated soils as compared to TE treated soils.

**At L₀ level (control):**

Catalase activity was found positively and insignificantly related with Fe (r = 0.5142); positively and significantly
(P = 0.05) related with tissue tissue Cu (r = 0.7902*) and Cr (r = 0.6990*); negatively and insignificantly (P = 0.05) related with Tissue Ca (r = -0.7939*), K (r = -0.7753*), Mg (r = 0.7250*), P (r = -0.7847*) and Mn (r = -0.7821*); positively and significantly (P = 0.01) related with peroxidase activity (r = 0.7788**) and Tissue Na (r = 0.8810**)) and negatively and significantly (P = 0.01) related with tissue S (r = 0.9930**) and Zn (r = -0.8175**).

Catalase activity was found positively and insignificantly related with Ws Cl− (r = 0.5356), PO4−−− (r = 0.2315), SO4−−− (r = 0.3636), Mg++ (r = 0.2033), Fe++ (r = 0.0133) (r = 0.4198), Mn++ (r = 0.1733) and Cu++ (r = 0.5799); negatively and insignificantly related with Tissue Ca++ (r = -0.5155) and Cr (r = -0.4318); positively and significantly (P = 0.05) related with water required for saturation (r = 0.7547*); negatively and significantly (P = 0.05) related with percentage moisture content in air dry soil (r = 0.7766*); positively and significantly (P = 0.05) related with ESP (r = 0.8702**), E.Ce (r = 0.8771**), pH (r = 0.9280**), SAR (r = 0.8702**), Ws CO3−− (r = 0.8145**), HCO3− (r = 0.8290**), TSA (r = 0.8240**), Ws Na++ (r = 0.8670**) and Zn++ (r = 0.8315**) and negatively and significantly (P = 0.01) related with H2O percolation (r = -0.8922**), % organic matter (r = -0.9373**) and Ws K+ (r = -0.8240**).

**In DE treated soil at L3 level:**

Catalase activity was found positively and insignificantly related with peroxidase activity (r = 0.2339), Tissue Na
(r = 0.65.9), S (r = 0.2364. 74), Fe (r = 0.2222) and Cu
(r = 0.1138); negatively and insignificantly (P = 0.05) related with
Tissue Mg (r = 0.7502*), Ca (r = -0.6668*), Mn (r = -0.7301*) and
Zn (r = -0.7906*); positively and significantly (P = 0.05) related
with tissue tissue Cr (r = 0.6727*) and negatively and
significantly (P = 0.01) related with Tissue K (r = -0.8022**),
P (r = -0.8335**).

Catalase activity was found positively and insignificantly
related with H2O required for saturation of soil (r = 0.3252),
HCO3¯ (r = 0.6625), Ws Cl¯ (r = 0.4602), SO4²¯ (r = 0.4103), Mg++
(r = 0.4334), Fe++ (r = 0.2743) (r = 0.4198), Mn++ (r = 0.3569)
and Cu++ (r = 0.2945); negatively and significantly related with
H2O percolation (r = -0.6616**), Ca++ (r = -0.4515) and Cr
(r = -0.5675); positively and significantly (P = 0.05) related with
soil pH (r = 0.7903*), Ws CO3-- (r = 0.7082*), TSA (r = 0.6795*),
and Zn++ (r = 0.6997*); negatively and significantly (P = 0.05)
related with percentage moisture content in air dry soil
(r = 0.7141*); positively and significantly (P = 0.05) related with
ESP (r = 0.8850**), E.Ce (r = 0.8840**), SAR (r = 0.8909**), PO4--
(r = 0.8810**) and Na+ (r = 0.8925**) and negatively and
significantly related with % organic matter (r = -0.8666**) and
Ws K+ (r = -0.8690**).

In TE treated soil at L3 level:

Catalase activity was found positively and insignificantly
related with peroxidase activity (r = 0.4703), Tissue Fe
(r = 0.3798) and Cr (r = 0.1725); negatively and insignificantly
related with Tissue Mn ($r = 0.6526^*$) and Cu ($r = -0.1875^*$); negatively and insignificantly ($P = 0.05$) related with Tissue Ca ($r = 0.7905^*$), K ($r = -0.6752^*$), Mg ($r = -0.6932^*$), P ($r = -0.6829^*$) and S ($r = -0.7395^*$); positively and significantly ($P = 0.05$) related with tissue tissue Na ($r = 0.9068^{**}$) and Zn ($r = -0.8601^{**}$).

Catalase activity was found positively and insignificantly related with soil pH ($r = 0.3771$), $H_2O$ required for saturation of soil ($r = 0.0548$), $Ws \text{Cl}^{-}$ ($r = 0.4794$), $SO_4^{2-}$ ($r = 0.4090$), $Fe^{++}$ ($r = 0.0447$) ($r = 0.4198$), $Mn^{++}$ ($r = 0.4752$), $Cu^{++}$ ($r = 0.4897$) and $Zn^{++}$ ($r = 0.6436$); negatively and significantly related with percentage moisture content in air dry soil ($r = 0.5673^*$) and $Ws \text{Ca}^{++}$ ($r = -0.5540$); positively and significantly ($P = 0.05$) related with $Ws \text{CO}_3^{-}$ ($r = 0.7148^*$), $HCO_3^{-}$ ($r = 0.7282^*$), TSA ($r = 0.7243^*$) $Ws \text{PO}_4^{3-}$ ($r = 0.6910^*$) and $Mg^{++}$ ($r = 0.6940^*$); negatively and significantly ($P = 0.01$) related with rate of water percolation ($r = 0.7720^*$), % organic matter ($r = -0.7876^*$) and $Cr^{+++}$ ($r = 0.7241^*$); positively and significantly ($P = 0.01$) related with ESP ($r = 0.8853^{**}$), E.Ce ($r = 0.8553^{**}$), SAR ($r = 0.8488^{**}$), and $Na^+$ ($r = 0.8390^{**}$) and negatively and significantly related with $Ws \text{K}^+$ ($r = -0.8234^{**}$).
Fig. 3.7: Mean value of Catalase µL O2 / evolved 5 minutes

Distillery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Calotropis

Legend:
- L0
- L1
- L2
- L3
8. Peroxidase activity λ OD:

F values for *Pedilanthus tithimaloids* L. are T (83.26**), L (3056.56**), S (342.91**), T X L (26.83**), T X S (15.74**), L X S (63.68**) and T X L X S (19.17**) interactions were found significant at (P = 0.01) probability level.

F values for *Calotropis procera* L. are T (75.63**), L (2648.93**), S (436.27**), T X L (23.38**), T X S (12.47**), L X S (64.73**) and T X L X S (13.17**) interactions were found significant at (P = 0.01) probability level.

In all the nine soils with both DE and TE treatments the respective effluent supply was found positively related with peroxidase activity with the increase in DE or TE treatment at L1 as compared to L0 and at L2 as compared to L1 was found significant at 0.01 probability level, irrespective of the soil.

As compared to HSS soils the LSS soils and as compared to LSS soils the NSNS soils showed better responses to DE and TE supply for increase in peroxidase activity.

Over all the responses in regard to increase in peroxidase activity were found better in DE treated soils as compared to TE treated soils.

**At L0 level (control):**

Peroxidase activity was found positively and insignificantly (P = 0.05) related with Tissue Fe (r = 0.7343*) and Cr (r = 0.6976*); negatively and significantly related with Tissue Mg (r = 0.7145*); positively and significantly (P = 0.01) related with
tissue tissue Na (r = 0.9267**) and Cu (r = -0.8336**) and negatively and significantly (P = 0.01) related with Tissue Ca (r = 0.8303**), K (r = -0.8894**), P (r = -0.8510**), S (r = -0.9055**), Mn (r = 0.8824**) and Zn (r = -0.7982**).

Peroxidase activity was found positively and insignificantly related with Ws Cl− (r = 0.6203), PO4−−−− (r = 0.1086), SO4−−−− (r = 0.5473), Mg++ (r = 0.1318), Fe+++ (r = 0.3781), Mn+++ (r = 0.2147); negatively and insignificantly related with Cr+++ (r = -0.3543); positively and significantly (P = 0.05) related with Cu+++ (r = 0.6744*) and Zn+++ (r = 0.7967*); negatively and significantly (P = 0.05) related with percentage moisture content in air dry soil (r = 0.7922*) and Ws Ca+++ (r = -0.6743*) and K+ (r = -0.7105*); positively and significantly (P = 0.01) related with ESP (r = 0.9548**), E.Ce (r = 0.8951**), pH (r = 0.9209**), SAR (r = 0.9418**), H2O required for saturation of soil (r = 0.8525**), Ws CO3−−−− (r = 0.8659**), HCO3−−−− (r = 0.8537**), TSA (r = 0.8588**) Ws Na+ (r = 0.9214**) and negatively and significantly (P = 0.01) related with rate of H2O percolation (r = -0.9743**), % organic matter (r = -0.9280**).

**In DE treated soils at L3 level:**

Peroxidase activity was found positively and insignificantly related with tissue Na (r = 0.1470), Fe (r = 0.4480), Cu (r = 0.4142) and Cr (r = 0.2438); negatively and insignificantly related with Tissue Ca (r = 0.1703), K (r = -0.2267), Mg (r = -0.3770), P (r = -0.2796) and S (r = -0.1615), Mn (r = 0.4211) and Zn (r = -0.5089**).
Peroxidase activity was found positively and insignificantly related with ESP \((r = 0.3954)\), E.Ce \((r = 0.3252)\), pH \((r = 0.3179)\), SAR \((r = 0.4149)\) H\(_2\)O required for saturation of soil \((r = 0.4945)\), Ws CO\(_3\)\(^{--}\) \((r = 0.4867)\), HCO\(_3\)\(^{--}\) \((r = 0.2483)\), TSA \((r = 0.2203)\), Ws Cl\(^{-}\) \((r = 0.0491)\), PO\(_4\)\(^{3--}\) \((r = 0.3770)\), SO\(_4\)\(^{--}\) \((r = 0.2856)\), Na\(^+\) \((r = 0.4094)\) Mg\(^{++}\) \((r = 0.3599)\), Fe\(^{++}\) \((r = 0.1316)\), Mn\(^{++}\) \((r = 0.0629)\), Zn\(^{++}\) \((r = 0.1259)\) and Cr\(^{+++}\) \((r = 0.0765)\); negatively and insignificantly related with percentage moisture content in air dry soil \((r = -0.3079^*)\), rate of water percolation \((r = 0.0097)\), % organic matter \((r = -0.0250)\), Ws Ca\(^{++}\) \((r = -0.0989)\), K\(^+\) \((r = 0.5035)\) and Cu\(^{++}\) \((r = -0.0186)\).

**In TE treated soils at L\(_3\) level:**

Peroxidase activity was found positively and insignificantly related with tissue Na \((r = 0.5742)\), Fe \((r = 0.6467)\), Cu \((r = 0.2399)\) and Cr \((r = 0.2399)\); negatively and insignificantly related with Tissue Ca \((r = 0.5650)\), Mg \((r = -0.3613)\), P \((r = -0.5672)\) and S \((r = -0.2900)\), and Zn \((r = -0.5516)\); negatively and insignificantly \((P = 0.05)\) related with Tissue Tissue K \((r = -0.6721^*)\), and Mn \((r = 0.7603^*)\).

Peroxidase activity was found positively and insignificantly related with ESP \((r = 0.5944)\), E.Ce \((r = 0.4586)\), pH \((r = 0.2396)\), SAR \((r = 0.5631)\), H\(_2\)O required for saturation of soil \((r = 0.5747)\), Ws CO\(_3\)\(^{--}\) \((r = 0.5594)\), HCO\(_3\)\(^{--}\) \((r = 0.5640)\), TSA \((r = 0.5620)\), Ws Cl\(^{-}\) \((r = 0.5315)\), PO\(_4\)\(^{3--}\) \((r = 0.3377)\), Na\(^+\) \((r = 0.5982)\) Mg\(^{++}\) \((r = 0.3628)\), Fe\(^{++}\) \((r = 0.4716)\) and Mn\(^{++}\) \((r = 0.3780)\); negatively and insignificantly related with percentage moisture content in
air dry soil ($r = -0.5460$), % organic matter ($r = -0.1974$), Ws K$^+$ ($r = 0.4293$) and Cr$^{+++}$ ($r = -0.6144$); positively and insignificantly ($P = 0.05$ related with Cu$^{++}$ ($r = 0.6877^*$) and Zn$^{++}$ ($r = 0.6733^*$); negatively and significantly ($P = 0.05$) related with rate of water percolation ($r = 0.6877^*$); positively and insignificantly ($P = 0.05$ related with SO$_4^{--}$ ($r = 0.8388^{**}$) and negatively and significantly ($p = 0.01$) related with Ca$^{++}$ ($r = -0.8123^{**}$).
Fig. 3.8: Mean value of Peroxidase λ OD

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis
9. Tissue sodium (Na) percent DM:

F values for *Pedilanthus tithimaloides* L. are T (380.53**), L (1768.83**), S (158.12**), T × L (93.12**), T × S (17.54**), L × S (13.78**) and T × L × S (16.56**) interactions were found significant at (P = 0.01) probability level.

F values for *Calotropis procera* L. are T (396.35**), L (1378.67**), S (176.32**), T × L (97.33**), T × S (27.45**), L × S (17.87**) and T × L × S (6.65**) interactions were found significant at P = 0.01 probability level.

Except in S6 in DE treatment at L2 as compared to L1 where tissue sodium content decreased significantly at (P = 0.01) probability level. In all the nine soils at L1 as compared to L0, L2 as compared to L1 and L3 as compared to L2, it increased significant at (P = 0.01) probability level in both the crops and in both DE and TE treatments. As compared to HSS soils the LSS soils and as compared to LSS soils the NSNS soils showed higher responses to DE and TE supply for increase in tissue sodium content in plants.

Over all the responses in regard to increase in tissue Na content in plants were found better in DE treated soils as compared to TE treated soils.
At L₀ level (control):

Tissue Na content was found positively and insignificantly (P = 0.05) related with tissue Cr (r = 0.6901*); negatively and significantly (P = 0.05) related with Tissue Mg (r = -0.7902*); positively and significantly (P = 0.01) related with tissue Fe (r = 0.8404**) and Cu (r = 0.8952**) and negatively and significantly (P = 0.05) related with Tissue Ca (r = -0.8100**), K (r = 0.8388**), P (r = 0.9006**), S (r = 0.8984**), Mn++ (r = 0.8615**) and Zn++ (r = 0.8133**)

Tissue Na content was found positively and insignificantly related with Ws Cl⁻ (r = 0.6348), PO₄³⁻ (r = 0.2423), SO₄²⁻ (r = 0.3307), Mg++ (r = 0.0788), Fe++ (r = 0.3007), Mn++ (r = 0.0803), Cu++ (r = 0.6367) and negatively and insignificantly related with Ws Ca++ (r = -0.5026) and Cr+++ (r = -0.2621); negatively and significantly (P = 0.05) related with Ws K⁺ (r = -0.7386); positively and significantly (P = 0.01) related with soil ESP (r = 0.9570**), E.Ce (r = 0.9409**), pH (r = 0.9039**), SAR (r = 0.9642**) H₂O required for saturation of soil (r = 0.8204**), Ws CO₃⁻ (r = 0.8048**), HCO₃⁻ (r = 0.8126**), TSA (r = 0.8101**), Na⁺ (r = 0.9567**) and Zn++ (r = 0.8322**); negatively and significantly (P = 0.01) related with percentage moisture content in air dry soil (r = -0.9398**), rate of water percolation (r = 0.9242**), % organic matter in soil (r = -0.9302**).

In De treated soils at L₃ level:
Tissue Na content was found positively and insignificantly related with tissue S \((r = 0.1384)\), Fe \((r = 0.0153)\), Cr \((r = 0.5015)\); negatively and insignificantly related with Tissue Ca \((r = 0.2662)\), K \((r = -0.4751)\), P \((r = -0.3804)\) and Cu \((r = -0.4103)\); negatively and significantly \((P = 0.05)\) related with Tissue Mg \((r = -0.7344^*)\), and Mn \((r = 0.6862^*)\); and negatively and significantly \((P = 0.05)\) related with Tissue Tissue Zn \((r = -0.8134^{**})\)

Tissue Na content was found positively and insignificantly related with ESP \((r = 0.5631)\), pH \((r = 0.6398)\), SAR \((r = 0.5742)\), \(H_2O\) required for saturation of soil \((r = 0.5110)\), Ws \(CO_3^-\) \((r = 0.6231)\), \(HCO_3^-\) \((r = 0.5761)\), TSA \((r = 0.5695)\), Ws \(SO_4^-\) \((r = 0.0207)\), \(Na^+\) \((r = 0.6108)\), Fe\(^{++}\) \((r = 0.4913)\), Mn\(^{++}\) \((r = 0.5726)\), Cu\(^{++}\) \((r = 0.0890)\) and Zn\(^{++}\) \((r = 0.3219)\); negatively and insignificantly related with rate of \(H_2O\) percolation \((r = -0.3560)\), % organic matter \((r = -0.6489)\) Ws \(Cl^-\) \((r = 0.0890)\), Ca\(^{++}\) \((r = 0.1881)\); positively and significantly \((P = 0.05)\) related with soil E.Ce. \((r = 0.7079^*)\) Ws \(PO_4^{---}\) \((r = 0.7024^*)\) and Mg\(^{++}\) \((r = 0.7433)\); negatively and significantly \((P = 0.05)\) related with Ws K\(^+\) \((r = 0.6796^*)\) and Cr\(^{+++}\) \((r = 0.6946^*)\) and negatively and significantly \((p = 0.01)\) related with % moisture content in air dry soil \((r = -0.8913^{**})\).

**In TE treated soils at L3 level:**

Tissue Na content was found positively and insignificantly related with tissue Fe \((r = 0.5434)\), Cr \((r = 0.4426)\); negatively and insignificantly related with Tissue S \((r = -0.6550)\) and Cu
(r = -0.0728); negatively and significantly (P = 0.05) related with Tissue Mn (r = 0.7690*); and negatively and significantly (P = 0.01) related with Tissue Ca (r = -0.8822**), K (r = -0.8790**), Mg (r = -0.8762**), P (r = -0.8062**) and Zn (r = -0.8893**).

Tissue Na content was found positively and insignificantly related with content soil pH (r = 0.5943), H2O required for saturation of soil (r = 0.1661), Ws SO₄²⁻ (r = 0.5852), Fe⁺⁺ (r = 0.2270), Mn⁺⁺ (r = 0.6116), and Cu⁺⁺ (r = 0.6537); negatively and insignificantly related with Ws Ca⁺⁺ (r = -0.6454); positively and significantly (P = 0.05) related with Ws Cl⁻ (r = 0.7173*), Mg⁺⁺ (r = 0.7003*) and Zn⁺⁺ (r = 0.7805*); negatively and significantly (P = 0.05) related with % moisture content in air dry soil (r = -0.7202*) and Cr⁺⁺⁺ (r = 0.7707*); positively and significantly (P = 0.01) related with soil ESP (r = 0.9628**), E.Ce. (r = 0.9669**), SAR (r = 0.9578**), Ws CO₃⁻⁻ (r = 0.8901**), HCO₃⁻ (r = 0.8972**), TSA (r = 0.8946**), Ws PO₄⁻⁻⁻ (r = 0.8341**) and Na⁺ (r = 0.9696**); negatively and significantly (P = 0.01) related with rate of water percolation (r = 0.9496**), % organic matter (r = 0.7974**), Ws K⁺ (r = 0.246**)
Fig. 3.9: Mean value of Sodium (Na) % DM

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis
10. Tissue calcium (Ca) percent DM:

F values for *Pedilanthus tithimaloids* L. are T (47.52**), L (548.36**), S (43.38**), T X L (12.39**), T X S (12.28**), L X S (7.26**) and T X L X S (12.39**) interactions were found significant at (P = 0.01) probability level.

F values for *Calotropis procera* L. are T (57.63**), L (1498.63**), S (68.83**), T X L (31.39**), T X S (17.28**), L X S (17.62**) and T X L X S (9.83**) interactions were found significant at (P = 0.01) probability level.

In all nine soils with both DE and TE treatments, the respective effluent supply was found positively related with tissue Ca content and the increase in tissue Ca content with the increase in DE or TE treatment at L1 as compared to L0, L2 as compared to L1 and L3 as compared to L2 was found significant at (P = 0.01) probability level, irrespective of the soil.

As compared to LSS the HSS soils and as compared to HSS soils the NSNS soils the NSNS soils showed better responses to TE supply for increase in tissue Ca content.

Over all the responses in regard to increase in tissue Ca content in plants were found better in DE treated soils as compared to TE treated soils.

**At Lo level (control):**

Tissue Ca content was found positively and insignificantly related with tissue Mn (r = 0.6533); negatively and insignificantly related with Tissue Cr (r = 0.6324); positively and significantly
related with tissue S ($r = 0.7794^*$) and Zn ($r = 0.7270^*$); negatively and significantly ($P = 0.05$) related with Tissue Fe ($r = -0.6662^*$); positively and significantly ($P = 0.01$) related with tissue K ($r = 0.9269^{**}$), Mg ($r = 0.7970^{**}$) and P ($r = 0.8008^{**}$) and negatively and significantly ($P = 0.01$) related with Tissue Cu ($r = 0.8092^{**}$).

Tissue Ca content was found positively and insignificantly related with Ws Ca$^{++}$ ($r = 0.5327$), K$^+$ ($r = 0.4901$) and Cr$^{+++}$ ($r = 0.0695$); negatively and insignificantly related with Cl$^-$ ($r = -0.6552$), PO$_4^{--}$ ($r = -0.5107$), SO$_4^{--}$ ($r = -0.4547$), Mg$^{++}$ ($r = -0.2476$), Fe$^{++}$ ($r = -0.1488$), Mn$^{++}$ ($r = -0.2693$) and Cu$^{++}$ ($r = -0.6439$); positively and significantly ($P = 0.01$) related with % moisture content in air dry soil ($r = 0.8158^{**}$), rate of water percolation ($r = 0.9023^{**}$), % organic matter ($r = 0.9103^{**}$), negatively and significantly ($P = 0.01$) related with soil ESP ($r = -0.9085^{**}$), E.Ce ($r = -0.8142^{**}$), pH ($r = -0.9010^{**}$), SAR ($r = -0.8898^{**}$), H$_2$O required for saturation of soil ($r = -0.9189^{**}$), Ws CO$_3^{--}$ ($r = -0.8534^{**}$), HCO$_3^{-}$ ($r = -0.8389^{**}$), TSA ($r = -0.8448^{**}$), Ws Na$^+$ ($r = 0.8579^{**}$) and Cr$^{+++}$ ($r = 0.8526^{**}$).

**In DE treated soils at L$_3$ level:**

Tissue Ca content was found positively and insignificantly related with tissue Zn ($r = 0.5365$); negatively and insignificantly related with Tissue S ($r = 0.6151$), Cu ($r = 0.0721$) and Fe ($r = 0.3608$); positively and significantly ($P = 0.01$) related with tissue Mg ($r = 0.7760^*$) and Mn ($r = 0.7487^{**}$); positively and
significantly (P = 0.01) related with tissue K (r = 0.9381**) and P (r = 0.9267**); and negatively and significantly (P = 0.01) related with Tissue Cr (r = -0.8854**).

Tissue Ca content was found positively and insignificantly related with % moisture content in air dry soil (r = 0.6015), % organic matter (r = 0.5958), Ws Mg (r = 0.1288), Cr+++ (r = 0.4294); negatively and insignificantly related with H2O required for saturation of soil (r= -0.2238), Ws Fe++ (r = -0.2952) and Mn++ (r = -0.5780); positively and significantly (P = 0.05) related with Ca++ (r = 0.7773*) and K+ (r = 0.7357*); negatively and significantly (P = 0.05) related with soil E.Ce (r = -0.7641*), pH (r = -0.7305*), PO4-- (r = -0.7297*), and Cu+++ (r = -0.7420*); positively and significantly (P = 0.01) related with rate of H2O percolation (r = -0.8383**) and negatively and significantly (P = 0.01) related with soil ESP (r = -0.8629**), SAR (r = -0.8427**), Ws CO3-- (r = -0.8322**), HCO3-- (r = -0.8617**), TSA (r = -0.8714**), Cl– (r = -0.8560), SO4-- (r = -0.7979), Ws Na+ (r = 0.8041**) and Zn++ (r = 0.9411**).

In TE treated soils at L3 level:

Tissue Ca content was found positively and insignificantly related with tissue S (r = 0.6477); negatively and insignificantly related with Tissue Fe (r = 0.2822), Cu (r = 0.1116) and Cr (r = 0.6472) positively and significantly (P = 0.05) related with tissue Mn (r = 0.7656*) and Zn (r = 0.7085*); positively and
significantly (P = 0.01) related with tissue K (r = 0.8497**) and Mg (r = 0.9911**) and P (r = 0.9090**).

Tissue Ca content was found positively and insignificantly related with % moisture content in air dry soil (r = 0.6167) and Ws Fe++ (r = 0.0233); negatively and insignificantly related with pH (r = -0.5912), H2O required for saturation of soil (r = -0.2087), Ws SO4 -- (r = -0.5889), Mg++ (r = -0.3717) and Mn++ (r = -0.3108); positively and significantly (P = 0.05) related with % organic matter (r = 0.7887*), Ca++ (r = 0.7545*) and Cr+++ (r = 0.6724*); negatively and significantly (P = 0.05) related with Cu++ (r = -0.7158*); positively and significantly (P = 0.01) related with rate of H2O percolation (r = -0.9357**) and Ws K+ (r = 0.8130**) and negatively and significantly (P = 0.01) related with soil ESP (r = -0.9158**), E.Ce. (r = -0.8950**), SAR (r = -0.8971**), Ws CO3-- (r = -0.9876**), HCO3-- (r = -0.9182**), TSA (r = -0.9145**), Cl- (r = -0.8475**), PO4---- (r = -0.8658**), Ws Na+ (r = 0.8649**) and Zn++ (r = 0.9456**).
Fig. 3.10: Mean value of Calcium (Ca) % DM

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Legend:
- L0
- L1
- L2
- L3
11. Tissue potassium (K) percent D.M.:

F values for *Pedilanthus tithimaloids* L. are T (136.92**), L (1248.78**), S (312.31**), T X L (38.36**), L X S (7.86**), T X S (11.52**) and T X L X S (21.48**) interactions were found significant at (P = 0.01) probability level.

F values for *Calotropis procera* L. are T (126.29**), L (1343.36**), S (348.36**), T X L (33.83**), L X S (17.86**), T X S (32.25**) and T X L X S (41.36**) interactions were found significant at (P = 0.01) probability level.

**Tissue potassium (K):**

F values for T (129.29**), L (1340.87**), S (307.13**), T X L (32.36**), L X S (7.74**), interactions were found significant at (P = 0.01) probability level while for the T X S (1.25) and T X L X S (1.21) interactions were found insignificant.

In all the nine soils in both DE and TE treatments L1 as compared to L0 and L2 as compared to L1 showed significant (P = 0.01) increase in tissue K content, only exception being S5 in TE treatment where L2 as compared to L1 showed a significant decrease in tissue K content at 0.01 probability level.

As compared to NSNS soils the LSS soils and as compared to LSS soils the HSS soils showed better responses to DE and TE supply for increase in tissue potassium content.

Over all the responses in regard to increase in tissue K content in plants were found better in DE treated soils as compared to TE treated soils.
At L₀ level (control):

Tissue K content was found positively and significantly (P = 0.05) related with tissue Mg (r = 0.7935*), P (r = 0.7917*), S (r = 0.7916*), Mn (r = 0.7921*) and Zn (r = 0.7309*); negatively and significantly (P = 0.05) related with Tissue Fe (r = -0.7780*), Cr (r = -0.6953*); and negatively and significantly (P = 0.01) related with Tissue Cu (r = -0.8551**).

Tissue K content was found positively and insignificantly related with Ws Ca++ (r = 0.6502), K⁺ (r = 0.4341) and Cr+++ (r = 0.2453); negatively and insignificantly related with Cl⁻ (r = -0.5720), PO₄⁻⁻⁻ (r = -0.4227), SO₄⁻⁻ (r = -0.6041), Mg++ (r = -0.1102), Fe⁺⁺ (r = -0.3810), Mn++ (r = -0.4806); negatively and significantly (P = 0.05) related with Cu++ (r = -0.7425*); positively and significantly (P = 0.01) related with % moisture content in air dry soil (r = 0.8273**), rate of water percolation (r = 0.9460**), % organic matter (r = 0.8447**) and negatively and significantly (P = 0.01) related with soil ESP (r = -0.9130**), E.Ce (r = -0.8440**), pH (r = -0.9010**), SAR (r = -0.8898**), H₂O required for saturation of soil (r = -0.9189**), Ws CO₃⁻⁻ (r = -0.8534**), HCO₃⁻ (r = -0.8389**), TSA (r = -0.8448**), Ws Na⁺ (r = 0.8579**) and Zn++ (r = 0.8526**).

In DE treated soils at L₃ levels:

Tissue K content was found positively and insignificantly related with tissue Zn (r = 0.6535); negatively and insignificantly related with Tissue S (r = 0.5352), Fe (r = 0.4016) and Cu
(r = 0.1365); positively and significantly (P = 0.01) related with tissue Mg (r = 0.8316*) , P (r = 0.9339**) and Mn (r = 0.8113**) and negatively and significantly (P = 0.01) related with Tissue Cr (r = -0.8590**). 

Tissue K content was found positively and insignificantly related with Cr+++ (r = 0.5097); negatively and insignificantly related with H2O required for saturation of soil (r = -0.3938), Ws Mg (r = -0.0689), Fe++ (r = -0.5313) and Mn++ (r = -0.6545); positively and significantly (P = 0.05) related with % moisture content in air dry soil (r = 0.7131*), % organic matter (r = 0.6814*) and Ws Ca++ (r = 0.7150*); negatively and significantly (P = 0.05) related with soil pH (r = -0.7700*), Cl− (r = -0.6691*), SO4 −− (r = -0.7516*), and Cu++ (r = -0.6664*); positively and significantly (P = 0.01) related with rate of H2O percolation (r = -0.8090**) and Ws K+ (r = -0.8027*); and negatively and significantly (P = 0.01) related with soil ESP (r = -0.9219**), E.Ce. (r = -0.8648**), SAR (r = -0.9091**), Ws CO3− − (r = -0.8595**), HCO3 −− (r = -0.8342**), TSA (r = -0.8501**), PO4 −−− (r = -0.8448), Ws Na+ (r = 0.8854**) and Zn+++ (r = 0.8919**).

In TE treated soils at L3 level:

Tissue K content was found positively and insignificantly related with tissue S (r = 0.5660); negatively and insignificantly related with Tissue Fe (r = 0.5431), Cu (r = 0.1750) and Cr (r = 0.5483) positively and significantly (P = 0.05) related with tissue Mn (r = 0.7322*) and Zn (r = 0.6781*) and positively and
significantly \((P = 0.01)\) related with tissue and \(\text{Mg} \ (r = 0.8391^{**})\) and \(\text{P} \ (r = 0.8518^{**})\).

Tissue K content was found positively and insignificantly related with % moisture content in air dry soil \((r = 0.6468)\) % organic matter \((r = 0.6451)\) and \(\text{Cr}^{+++} \ (r = 0.5245^{*})\); negatively and insignificantly related with pH \((r = -0.5933)\), \(\text{H}_{2}\text{O} \) required for saturation of soil \((r = -0.0936)\), \(\text{Ws} \ \text{Mg}^{++} \ (r = -0.4352)\), \(\text{Fe} \ (r = -0.4436)\) and \(\text{Mn}^{++} \ (r = -0.6260)\); positively and significantly \((P = 0.05)\) related with \(\text{Ca}^{++} \ (r = 0.7182^{*})\) and \(\text{K}^{+} \ (r = 0.7129^{*})\); negatively and significantly \((P = 0.05)\) related with \(\text{SO}_4^{--} \ (r = -0.7138^{*})\), \(\text{Cu}^{++} \ (r = -0.6942^{*})\); positively and significantly \((P = 0.01)\) related with rate of \(\text{H}_2\text{O} \) percolation \((r = -0.8640^{**})\) and negatively and significantly \((P = 0.01)\) related with soil ESP \((r = -0.9110^{**})\), E.Ce. \((r = -0.8463^{**})\), SAR \((r = -0.8959^{**})\), \(\text{Ws} \ \text{CO}_3^{--} \ (r = -0.8053^{**})\), \(\text{HCO}_3^{--} \ (r = -0.8076^{**})\), TSA \((r = -0.8068^{**})\), \(\text{Cl}^{-} \ (r = -0.8044^{**})\), \(\text{PO}_4^{--} \ (r = -0.8088^{**})\), \(\text{Ws} \ \text{Na}^{+} \ (r = 0.8727^{**})\) and \(\text{Zn}^{++} \ (r = 0.8665^{**})\).
Fig. 3.11: Mean value of Potassium (K) % DM

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Legend:
- L0
- L1
- L2
- L3
12. Tissue magnesium (mg) percent D.M:

F values for *Pedilanthus tithimaloids* L. are T (98.63**), L (963.26**), S (276.69**), T X L (52.67**), T X S (13.63**), L X S (11.78**) and T X L X S (12.56**) interactions were found significant at (P = 0.01) probability level.

F values for *Calotropis procera* L. are T (93.36**), L (869.63**), S (364.86**), T X L (36.74**), T X S (23.63**), L X S (12.64**) and T X L X S (9.68**) interactions were found significant at (P = 0.01) probability level.

In all the nine soils with both DE and TE treatments the respective effluent supply was found directly related with tissue mg content and the increase in tissue Mg content with the increase in De of TE treatment at L2 as compared to L1 found significant at 0.01 probability level, respective of the soil.

Over all the responses in regard to increase in tissue Mg content in plants were found better in DE treated soils.

**At Lo level (control):**

Tissue Mg content was found positively and insignificantly related with tissue Zn (r = 0.6514); negatively and insignificantly related with Tissue Fe (r = 0.5038); positively and significantly (P = 0.05) related with tissue S (r = 0.7361*) and Mn (r = 0.6784*); negatively and significantly (P = 0.05) related with Tissue Cu (r = 0.7976*); positively and significantly (P = 0.01) related with tissue P (r = 0.8144**) and negatively and significantly (P = 0.01) related with Tissue Cr (r = 0.8903**).
Tissue Mg content was found positively and insignificantly related with Ws Ca\(^{++}\) \((r = 0.4174)\), K\(^{+}\) \((r = 0.5873)\), Fe\(^{++}\) \((r = 0.0609)\), and Cr\(^{+++}\) \((r = 0.4260)\); negatively and insignificantly related with PO\(_4\)\(^{-2-}\) \(-r = -0.6443\), SO\(_4\)\(^{-2-}\) \((-r = -0.1937)\), Mg\(^{++}\) \((-r = -0.2274)\), Mn\(^{++}\) \((-r = -0.4375)\), and Cu\(^{++}\) \((-r = -0.5180)\); positively and significantly \((P = 0.05)\) related with % organic matter \((r = 0.7448*)\), negatively and significantly \((P = 0.05)\) related with Ws Cl\(^{-}\) \((-r = -0.7459*)\); positively and significantly \((P = 0.01)\) related with % moisture content in air dry soil \((r = 0.8972**)) and rate of water percolation \((r = 0.8068**))\), negatively and significantly \((P = 0.01)\) related with soil ESP \((r = -0.8049**))\), E.Ce \((r = -0.8953**))\), pH \((r = -0.8294**))\), SAR \((r = -0.8060**))\), H\(_2\)O required for saturation of soil \((r = -0.8131**))\), Ws CO\(_3\)\(^{-}\) \((-r = -0.9028**))\), HCO\(_3\) \(-r = -0.9199**))\), TSA \((r = -0.9139**))\), Ws Na\(^{+}\) \((r = 0.8060**))\) and Cr\(^{+++}\) \((r = 0.8206**))\).

**In DE treated soils at L\(_3\) level:**

Tissue Mg content was found positively and insignificantly related with tissue Cu \((r = 0.1470)\); negatively and insignificantly related with Tissue S \((r = 0.3057)\) and Fe \((r = 0.1534)\) positively and significantly \((P = 0.05)\) related with tissue P \((r = 0.7608*)\); positively and significantly \((P = 0.01)\) related with tissue Mn \((r = 0.8678**))\); and negatively and significantly \((P = 0.01)\) related with Tissue Cr \((r = -0.8300**))\).

Tissue Mg content was found positively and insignificantly related with H\(_2\)O percolation \((r = 0.6164)\), Ca\(^{++}\) \((r = 0.5004)\) and Cr\(^{+++}\) \((r = 0.5152)\); negatively and insignificantly related with
H₂O required for saturation of soil (r = -0.3744), Ws Cl⁻ (r = -0.0607), SO₄⁻⁻ (r = -0.4386), Ws Mg²⁺ (r = 0.3949), Fe³⁺ (r = -0.3986), Mn³⁺ (r = -0.6450) and Cu²⁺ (r = -0.4036); positively and significantly (P = 0.05) related with % organic matter (r = 0.7400*); negatively and significantly (P = 0.05) related with soil pH (r = 0.7850*) and Ws Zn⁺ (r = 0.7269*); positively and significantly (P = 0.01) related with % moisture content in air dry soil (r = 0.9483**) and K⁺ (r = 0.8958*) and negatively and significantly (P = 0.01) related with soil ESP (r = -0.8517**), E.Ce. (r = -0.8789**), SAR (r = -0.8538**), Ws CO₃⁻⁻ (r = -0.9289**), HCO₃⁻⁻ (r = -0.8539**), TSA (r = -0.8503**), PO₄⁻⁻ (r = -0.9364*) and Na⁺ (r = 0.8554**).

In TE treated soils at L₃ level:

Tissue Mg content was found positively and insignificantly related with tissue S (r = 0.5656); negatively and insignificantly related with Tissue Fe (r = 0.2461), Cu (r = 0.0055) and Cr (r = -0.6246) positively and significantly (P = 0.05) related with tissue Mn (r = 0.7392*) and Zn (r = 0.6885*); positively and significantly (P = 0.01) related with tissue P (r = 0.8171**).

Tissue Mg content was found positively and insignificantly related with % moisture content in air dry soil (r = 0.6490), Ca²⁺ (r = 0.6052) and Cr⁶⁺⁺ (r = 0.6394*); negatively and insignificantly related with pH (r = -0.6100), H₂O required for saturation of soil (r = -0.1777), Ws SO₄⁻⁻ (r = -0.3863), Mg²⁺ (r = -0.4778), Fe³⁺ (r = -0.1230), Mn³⁺ (r = -0.3862) and Cu²⁺ (r = -0.6420); positively and significantly (P = 0.05) related with
% organic matter \( (r = 0.7482^*) \), positively and significantly (\( P = 0.01 \)) related with rate of \( \text{H}_2\text{O} \) percolation \( (r = -0.8520^{**}) \) and
Ws \( \text{K}^+ \ (r = 0.8506^{**}) \) and negatively and significantly (\( P = 0.01 \)) related with soil ESP \( (r = -0.8453^{**}) \), E.Ce. \( (r = -0.8959^{**}) \), SAR
\( (r = -0.8394^{**}) \), Ws \( \text{CO}_3^{-} \ (r = -0.9227^{**}) \), \( \text{HCO}_3^- \ (r = -0.9229^{**}) \),
TSA \( (r = -0.9229^{**}) \), \( \text{Cl}^- \ (r = -0.8050^{**}) \), \( \text{PO}_4^{3-} \ (r = -0.9014^{**}) \),
Ws \( \text{Na}^+ \ (r = 0.8262^{**}) \) and \( \text{Zn}^{++} \ (r = 0.8161^{**}) \).
Fig. 3.12: Mean value of Magnesium (Mg) % DM

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

[Graphs showing magnesium concentration in different soils treated with distillery and tannery effluents]
13. Tissue phosphorus (P) percent D.M.:

F values for *Pedilanthus tithimaloids* L. are $T (293.75^{**})$, $L (432.75^{**})$, $S (1983.48^{**})$, $T \times L (136.43^{**})$, $T \times S (19.56^{**})$, $L \times S (36.78^{**})$ and $T \times L \times S (15.29^{**})$ interactions were found significant at $(P = 0.01)$ probability level.

F values for *Calotropis procera* L. are $T (306.83^{**})$, $L (463.48^{**})$, $S (1784.93^{**})$, $T \times L (126.38^{**})$, $T \times S (9.68^{**})$, $L \times S (39.87^{**})$ and $T \times L \times S (13.26^{**})$ interactions were found significant at $(P = 0.01)$ probability level.

In all the nine soils with both DE and TE treatments, the respective effluent supply was found positively related with tissue phosphorus content and the increase in tissue phosphorus content with the increase in DE or TE treatment at $L_1$ as compared to $L_0$, $L_2$ as compared to $L_1$ and $L_3$ as compared to $L_2$ was found significant at $(P = 0.01)$ level of probability irrespective of the soil.

As compared to NSNS soils the HSS soils and as compared to HSS soils the LSS soils showed better responses to DE and TE supply for the increase in tissue phosphorus content.

Over all the responses in regard to increase in tissue P content in plants were found better in DE treated soils as compared to TE treated soils.

Tissue P content was found positively and insignificantly related with tissue Zn ($r = 0.5763$); negatively and insignificantly related with Tissue Fe ($r = 0.6054$); positively and significantly ($P = 0.05$) related with tissue Mn ($r = 0.6784^{*}$); positively and
significantly (P = 0.05) related with tissue S (r = 0.8241**) and negatively and significantly (P = 0.01) related with Tissue Cu (r = 0.9617**) and Cr (r = 0.8240**).

Tissue P content was found positively and insignificantly related with Ws Ca++ (r = 0.6544), K+ (r = 0.6206), Mg++ (r = 0.1419), and Cr+++ (r = 0.1688); negatively and insignificantly related with PO4−−−− (r = -0.2177), SO4−−−− (r = -0.4140), Fe++ (r = 0.1351) and Mn++ (r = -0.0683); negatively and insignificantly (P = 0.05) related with Ws CO3−−−− (r = -0.7961*) and Cu++ (r = 0.7681*); positively and significantly (P = 0.01) related with % moisture content in air dry soil (r = 0.8761**), rate of water percolation (r = 0.8969**) and % organic matter (r = 0.8692**); negatively and significantly (P = 0.01) related with soil ESP (r = -0.8903**), E.Ce (r = -0.8155**), pH (r = -0.8092**), SAR (r = -0.8767**), H2O required for saturation of soil (r = -0.8372**), HCO3−− (r = -0.7990**), TSA (r = -0.7980**), Ws Cl−− (r = -0.8188**), Ws Na+ (r = 0.8368**) and Zn++ (r = 0.9066**).

**In DE treated soils at L3 level:**

Tissue P content was found negatively and insignificantly related with Tissue S (r = 0.6144), Fe (r = 0.4167) and Cu (r = 0.1467); positively and significantly (P = 0.05) related with tissue Zn (r = 0.7010*); positively and significantly (P = 0.01) related with tissue Mn (r = 0.8439*); and negatively and significantly (P = 0.01) related with Tissue Cr (r = -0.9085**).
Tissue P content was found positively and insignificantly related with % moisture content in air dry soil \( (r = 0.6146) \) and Cr\(^{+++} \) \( (r = 0.5606) \); negatively and insignificantly related with H\(_2\)O required for saturation of soil \( (r = -0.4128) \), Ws Mg\(^{++} \) \( (r = -0.0132) \), Fe\(^{++} \) \( (r = -0.3197) \) and Mn\(^{++} \) \( (r = -0.5396) \); positively and significantly \( (P = 0.05) \) related with % organic matter \( (r = 0.6684^*) \); negatively and significantly \( (P = 0.05) \) related with PO\(_4^{--} \) \( (r = -0.7702^*) \), SO\(_4^{--} \) \( (r = -0.7505^*) \) and Cu\(^{++} \) \( (r = -0.7217^*) \); positively and significantly \( (P = 0.01) \) related with rate of H\(_2\)O percolation \( (r = 0.8720^{**}) \), Ws Ca\(^{++} \) \( (r = -0.8110^{**}) \) and K\(^+ \) \( (r = -0.8341^{**}) \); and negatively and significantly \( (P = 0.01) \) related with soil ESP \( (r = -0.9302^{**}) \), E.Ce. \( (r = -0.8341^{**}) \), pH \( (r = -0.8432^{**}) \) SAR \( (r = -0.9130^{**}) \), Ws CO\(_3^{--} \) \( (r = -0.8460^{**}) \), HCO\(_3^{-} \) \( (r = -0.8508^{**}) \), TSA \( (r = -0.8698^{**}) \), Ws Cl\(^- \) \( (r = -0.8077^{**}) \), Na\(^+ \) \( (r = -0.8722^{**}) \) and Zn\(^{++} \) \( (r = -0.9354^{**}) \).

**In TE treated soils at L\(_3\) level:**

Tissue P content was found negatively and insignificantly related with Tissue S \( (r = 0.4915) \), and Zn \( (r = 0.4851) \); negatively and insignificantly related with tissue Fe \( (r = -0.4588^*) \), Cu \( (r = -0.4470) \) and Cr \( (r = -0.5531) \); positively and significantly \( (P = 0.05) \) related with tissue Mn \( (r = 0.7570^*) \).

Tissue P content was found positively and insignificantly related with % moisture content in air dry soil \( (r = 0.4955) \) and Ws Cr\(^{+++} \) \( (r = 0.5590) \); negatively and insignificantly related with soil pH \( (r = 0.3905) \), H\(_2\)O required for saturation of soil.
(r = -0.1153), SO$_4$\(^{--}\) (r = -0.5980), Ws Mg\(^{++}\) (r = 0.3283), Fe\(^{++}\) (r = -0.1578) and Mn\(^{++}\) (r = -0.2962); positively and significantly (P = 0.05) related with H$_2$O percolation (r = 0.7656\(*)\), Ws Ca\(^{++}\) (r = -0.7482) and K\(^{+}\) (r = -0.6812\*)\); negatively and significantly (P = 0.05) related with Ws CO$_3$\(^{-}\)\(\sim\) (r = -0.7789\(**\)), HCO$_3$\(^{-}\)\(\sim\) (r = -0.7749\(**\)), TSA (r = -0.7765\(**\)), PO$_4$\(^{-}\)\(\sim\) (r = -0.7683\(**\)), and Cu\(^{++}\) (r = -0.6813\(**\)); positively and significantly (P = 0.01) related with \% organic matter and negatively and significantly (P = 0.01) related with soil ESP (r = -0.8976\(**\)), E.Ce. (r = -0.8624\(**\)), SAR (r = -0.8698\(**\)), Ws Cl\(^{-}\) (r = -0.9843\(**\)), Na\(^{+}\) (r = 0.8439\(**\)) and Zn\(^{++}\) (r = 0.8496\(**\)).
Fig. 3.13: Mean value of Phosphorus (P) % DM

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Soils Nos.

Distilleries

Soils Nos.

Tanneries

Soils Nos.

Tannery effluent treatment: Soils after Calotropis

Soils Nos.

L0  L1  L2  L3
14. **Tissue sulphur (S) percent DM:**

F values for *Pedilanthus tithimaloids* L. are T (543.84**), L (2346.70**), S (749.70**), T X L (136.84**), T X S (11.96**), L X S (87.46**) and T X L X S (15.36**) interactions were found significant at (P = 0.01) probability level.

F values for *Calotropis procera* L. are T (493.68**), L (2186.68**), S (769.43**), T X L (196.38**), T X S (21.53**), L X S (63.84**) and T X L X S (26.38**) interactions were found significant at (P = 0.01) probability level.

Except in S₂ at L₁ a compared to L₀ in TE treatment where tissue S content did not differ, in rest of the soils L₁ showed significant increase at (P = 0.01) probability level in tissue S content over L₀ in both DE and TE treatments.

At L₂ compared to L₁ in DE treatment in S₁, S₂ and S₃ a significant decrease at (P = 0.01) level of probability was found while in rest of the soils in both DE and TE treatments the increase in tissue S content at L₂ as compared to L₁ was found to be significant at (P = 0.01) probability level.

As compared to NSNS soils the LSS soils and as compared to LSS soils the HSS soils showed better responses to DE and TE supply for increase in tissue S content.

Over all the responses in regard to increase in tissue S content in plants were found better in DE treated soils as compared to TE treated soils.
At L₀ level (control):

Tissue S content was found negatively and insignificantly related with Ws Fe ($r = -0.5510$); negatively and significantly ($P = 0.05$) related with tissue Zn ($r = -0.7949^*$) and Cr ($r = -0.744741^*$); positively and significantly ($P = 0.01$) related with tissue Mn ($r = -0.8250^*$); negatively and significantly ($P = 0.01$) related with tissue Cu ($r = -0.8300^{**}$).

Tissue S content was found positively and insignificantly related with Ws Ca$^{++}$ ($r = 0.5822$) and Cr$^{+++}$ ($r = 0.4603$); negatively and insignificantly related with Cl$^-$ ($r = -0.5660$), PO$_4^{3-}$ ($r = -0.1838$), SO$_4^{2-}$ ($r = -0.4163$), Mg$^{++}$ ($r = -0.1252$), Fe$^{++}$ ($r = -0.0608$), Mn$^{++}$ ($r = -0.1968$) and Cu$^{++}$ ($r = -0.6357$); positively and significantly ($P = 0.05$) related with % moisture content in air dry soil ($r = 0.7869^*$); negatively and significantly ($P = 0.05$) related with H$_2$O required for saturation of soil ($r = -0.7782^*$); positively and significantly ($P = 0.01$) related with Rate of H$_2$O percolation ($r = 0.9160^*$), % organic matter ($r = 0.9308^{**}$) and Ws K$^+$ ($r = 0.8188^{**}$); and negatively and significantly ($P = 0.01$) related with soil ESP ($r = -0.8842^{**}$), E.Ce. ($r = -0.8829^{**}$), pH ($r = -0.8453^{**}$) SAR ($r = -0.8756^{**}$), Ws CO$_3^{--}$ ($r = -0.8342^{**}$), HCO$_3^-$ ($r = -0.8453^{**}$), TSA ($r = -0.8415^{**}$), Na$^+$ ($r = 0.8618^{**}$) and Zn$^{++}$ ($r = 0.8571^{**}$).

In DE treated soils at L₃ level:

Tissue S content was found negatively and insignificantly related with Tissue Fe ($r = 0.4580$); negatively and significantly
related with tissue Mn \( (r = -0.5890) \), Cu \( (r = -0.2386) \) and Zn \( (r = -0.3234) \) and positively and significantly \( (P = 0.05) \) related with tissue Tissue Cr \( (r = 0.7552^*) \).

Tissue S content was found positively and insignificantly related with ESP \( (r = 0.4585) \), E.Ce. \( (r = 0.3964) \), pH \( (r = 0.6139) \), SAR \( (r = 0.5742) \), H\(_2\)O required for saturation of soil \( (r = 0.4651) \), Ws CO\(_3^-\) \( (r = 0.5107) \), PO\(_4^{--}\) \( (r = 0.1236) \), SO\(_4^{--}\) \( (r = 0.6423) \), Na\(^+\) \( (r = 0.3627) \) and Fe\(^{++}\) \( (r = 0.3224) \); negatively and insignificantly related with % moisture content in air dry soil \( (r = -0.2462) \), % organic matter \( (r = -0.1751) \), Ws K\(^+\) \( (r = -0.3293) \) Mg\(^{++}\) \( (r = -0.3232) \), and Cr\(^{+++}\) \( (r = -0.6486) \); positively and significantly \( (P = 0.05) \) related with HCO\(_3^-\) \( (r = 0.7194^*) \), TSA \( (r = 0.7265^*) \), Ws Cl\(^-\) \( (r = 0.7120^*) \), Mn\(^{++}\) \( (r = 0.6716^*) \) and Zn\(^{++}\) \( (r = 0.6716^*) \); negatively and significantly \( (P = 0.05) \) related with rate of H\(_2\)O percolation \( (r = 0.7510^*) \); positively and significantly \( (P = 0.01) \) related with Ws Cu\(^{++}\) \( (r = 0.9347^{**}) \); and negatively and significantly \( (p = 0.01) \) related with Ws Ca\(^{++}\) \( (r = -0.8679^{**}) \).

**In TE treated soils at L\(_3\) level:**

Tissue S content was found positively and insignificantly related with tissue Mn \( (r = 0.4775) \) and Cu \( (r = 0.3883) \); negatively and insignificantly related with Tissue Fe \( (r = -0.0053) \) and Cr \( (r = -0.2882) \); positively and significantly \( (P = 0.05) \) related with Tissue Zn \( (r = 0.6621^*) \).

Tissue S content was found positively and insignificantly related with H\(_2\)O required for saturation of soil \( (r = 0.0847) \), Ws Ca\(^{++}\) \( (r = 0.2061) \), K\(^+\) \( (r = -0.6607) \) and Cr\(^{+++}\) \( (r = -0.4944) \);
negatively and insignificantly related with Soil pH ($r = -0.4634$), Ws CO$_3^{--}$ ($r = -0.4268$), HCO$_3^-$ ($r = -0.4326$), TSA ($r = -0.4305$), Ws Cl$^-$ ($r = -0.2172$), Ws SO$_4^{--}$ ($r = 0.1451$), Mg$^{++}$ ($r = 0.5241$), Fe$^{++}$ ($r = 0.0040$), Mn$^{++}$ ($r = 0.1231$), Cu$^{++}$ ($r = 0.0280^{**}$) and Zn$^{++}$ ($r = 0.4279$); positively and significantly ($P = 0.05$) related with % moisture content in air dry soil ($r = 0.7038^{*}$), rate of H$_2$O percolation ($r = 0.6978^{*}$) and % organic matter ($r = 0.6679^{*}$); negatively and significantly ($P = 0.05$) related with soil ESP ($r = -0.7208^{*}$), E.Ce. ($r = -0.7214^{*}$), SAR ($r = -0.7250^{*}$), Na$^+$ ($r = 0.7338^{*}$) and negatively and significantly ($P = 0.05$) related with PO$_4^{--}$ ($r = 0.7989$).
Fig. 3.14: Mean value of Sulphur (S) % DM

Distillery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis
15. **Tissue nitrogen (N) percent DM:**

F values for *Pedilanthus tithimaloids* L. are T (464.38**), L (2643.78**), S (852.98**), T X L (132.48**), T X S (27.94**), L X S (68.92**) and T X L X S (32.68**) interactions were found significant at (P = 0.01) probability level.

F values for *Calotropis procera* L. are T (363.49**), L (2684.96**), S (867.49**), T X L (129.36**), T X S (38.56**), L X S (73.42**) and T X L X S (9.48**) interactions were found significant at (P = 0.01) probability level.

In all the nine soils with both De and TE treatments, the respective effluent supply was found positively related with tissue N\textsubscript{2} content with the increase in DE or TE treatments at L\textsubscript{1} as compared to L\textsubscript{0}, L\textsubscript{2} as compared to L\textsubscript{1} and L\textsubscript{3} as compared to L\textsubscript{2} was found significantly at (P = 0.01) probability level, irrespective of the soil.

As compared to LSS soils the HSS soils the NSNS soils showed better responses to DE supply while as compared to HSS soils the LSS soils and as compared to LSS soils at the NSNS soils showed better responses to TE supply for increase in tissue N\textsubscript{2} content.

Over all the responses in regard to increase in tissue N\textsubscript{2} content in plants were found better in DE treated soils as compared to TE treated soils.
At L₀ level (control):

Tissue N₂ content was found positively and insignificantly related with Ws Mn (r = 0.6543); negatively and insignificantly related with chl. a/b ratio tissue (r = -0.3317), tissue Fe (r = -0.6114), Cu (r = -0.3477) and Cr (r = -0.6414); positively and significantly (P = 0.05) related with tissue ascorbic acid (r = 0.7754*), Ca (r = 0.6867*), K (r = 0.6705*), P (r = 0.6832*), S (r = 0.7431*) and Zn (r = 0.6959*); negatively and significantly (P = 0.05) related with catalase activity (r = -0.7580*), peroxidase activity (r = -0.6690*); positively and significantly (P = 0.01) related with chl. a (r = 0.9449**), chl. b (r = 0.9583**), chl. a+b (r = 0.9845**) and tissue Mg (r = -0.8647**) and negatively and significantly (P = 0.01) related with tissue Na (r = -0.9176**)

Tissue N₂ content was found positively and insignificantly related with Ws Ca⁺⁺ (r = 0.5988) and Cr⁺⁺⁺ (r = 0.4863); negatively and insignificantly related with H₂O required for saturation of soil (r = -0.2488) Cl⁻ (r = -0.6464), Fe⁺⁺ (r = -0.2618), and Cu⁺⁺ (r = -0.6026); positively and significantly (P = 0.05) related with K⁺ (r = 0.7095*); negatively and significantly (P = 0.05) related with PO₄⁻⁻⁻ (r = -0.7023*), SO₄⁻⁻ (r = -0.6670*) and Mn⁺⁺ (r = -0.7557); positively and significantly (P = 0.01) related with % moisture content in air dry soil (r = 0.8378**) and rate of H₂O percolation (r = 0.9543**); and negatively and significantly (P = 0.01) related—with soil ESP (r = -0.8940**), E.Ce. (r = -0.8827**), pH (r = -0.8258**) SAR (r = -0.8964**), Ws CO₃⁻⁻ (r = -0.9386**), HCO₃⁻ (r = -0.9846**),
TSA (r = -0.9684**), Ws Na⁺ (r = -0.8968**), Mg²⁺ (r = -0.8893**) and Zn²⁺ (r = 0.8694**).

**In DE treated soils at L₃ level:**

Tissue N₂ content was found positively and insignificantly related with Tissue K (r = 0.6180), Mg (r = 0.6025), P (r = 0.5604), S (r = 0.5577), Mn (r = 0.5835), and Zn (r = 0.3467); negatively and insignificantly related with peroxidase activity (r = -0.6556*), tissue Na (r = -0.6458), Fe (r = -0.0528), Cu (r = -0.4360) and Cr (r = -0.4068); positively and insignificantly (P = 0.05) related with Ca (r = 0.7901*); and negatively and significantly (P = 0.05) related with catalase activity (r = -0.7408*).

Tissue N₂ content was found positively and insignificantly related with % moisture content in air dry soil (r = 0.5770), % organic matter (r = 0.6252*), Ca++ (r = 0.5053) and K⁺ (r = 0.3361); and negatively and insignificantly related with soil E.Ce. (r = -0.6303), pH (r = -0.5157). SAR (r = -0.6504), H₂O required for saturation (r = -0.0719), Ws CO₃⁻⁻ (r = -0.6078), HCO₃⁻ (r = -0.6078) TSA (r = -0.6266), Ws Cl⁻ (r = -0.3695), SO₄²⁻⁻ (r = -0.4131), Na⁺ (r = -0.6098), Mg⁺⁺ (r = 0.2789), Fe⁺⁺ (r = 0.2114), Mn⁺⁺ (r = 0.4793) and Cu⁺⁺ (r = 0.5704); positively and significantly (P = 0.05) related with Cr⁺⁺⁺ (r = 0.7523*); and negatively and significantly (P = 0.01) related with soil ESP (r = -0.6875**), and PO₄⁻⁻⁻ (r = -0.6741*); positively and significantly (P = 0.01) related with rate of H₂O percolation (r = 0.8590**) and negatively and significantly (P = 0.01) related with Zn⁺⁺ (r = -0.8621**).
In TE treated soils at L3 level:

Tissue N₂ content was found positively and insignificantly related with Tissue Mn (r = 0.6590), and Zn (r = 0.6590); negatively and significantly related with Chl. a/b ratio tissue (r = 0.5846), tissue Fe (r = -0.6245), Cu (r = -0.3298) and Cr (r = -0.6039); positively and significantly (P = 0.05) related with tissue Ca (r = 0.7773*), K (r = 0.7513*), P (r = 0.7313*) and S (r = 0.7780*); negatively and insignificantly (P = 0.05) related with peroxidase activity (r = -0.7205*); positively and significantly (P = 0.01) related with tissue chl. a+b (r = 0.9935**), ascorbic acid (r = 0.8033**) and tissue Mg (r = 0.8385**); negatively and significantly (P = 0.01) related with catalase activity (r = -0.8451**) and tissue Na (r = 0.8540).

Tissue N₂ content was found positively and insignificantly related with % organic matter in soil (r = 0.6575), Ca⁺⁺⁺ (r = 0.6232), K⁺ (r = 0.5871) and and Cr⁺⁺⁺⁺ (r = 0.4789); negatively and insignificantly related with H₂O required for saturation of soil (r = -0.2060), PO₄⁻⁻⁻ (r = -0.6450), SO₄⁻⁻ (r = -0.6449), Fe⁺⁺ (r = -0.0889) and Mn⁺⁺ (r = -0.6557); positively and significantly (P = 0.05) related with % moisture content in air dry soil (r = 0.6905*); negatively and significantly (P = 0.05) related with pH(r = -0.07381*), Cl⁻ (r = -0.7456*) and Cu⁺⁺ (r = -0.7456*) positively and significantly (P = 0.01) related with rate of H₂O percolation (r = 0.9420**) and negatively and significantly (P = 0.01) related with soil ESP (r = -0.8784**), E.Ce. (r = -0.8425**), SAR (r = -0.8598**), Ws CO₃⁻⁻ (r = -0.9249**), HCO₃⁻⁻ (r = -0.9206**), TSA (r = 0.8439**).
Fig. 3.15: Mean value of Nitrogen (N$_2$) % DM

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis
16. Tissue iron (Fe) ppm D.M.:

F values for *Pedilanthus tithimaloids* L. are T (38.94*), L (268.91**), S (86.78**), T X L (13.54**), T X S (12.30**), L X S (17.74**) and T X L X S (21.27**) interactions were found significant at (P = 0.01) probability level.

F values for *Calotropis procera* L. are T (33.46**), L (236.83**), S (68.73**), T X L (17.63**), T X S (26.94**), L X S (21.38**) and T X L X S (11.48**) interactions were found significant at (P = 0.01) probability level.

In all the nine soils at L₁ as compared to L₀ except in S₇ of DE treatment where decrease in tissue iron content was found significant at (P = 0.01) probability level and in TE treatment in S₅ and S₇ was found insignificant while in rest of the soils both in DE and TE. Treatment tissue iron content showed a significant increase at 0.01 probability level. In both DE and TE treatments in all the nine soils the increase in tissue iron content at L₂ as compared to L₁ was found significant at 0.01 probability level except in S₈ where increase was insignificant and in S₆ where increase was insignificant and in S₆ of the TE treatment where insignificant decrease between L₂ and L₁ was found.

As compared to HSS soils the LSS soils and as compared to LSS soils the NSNS soils showed better responses to DE and TE supply for increase in tissue iron content.
Over all the responses in regard to increase in tissue Fe content in plants were found better in DE treated soils as compared to TE treated soils.

**At Lo level (control):**

Tissue Fe content was found positively and insignificantly related with tissue Cr ($r = 0.4711^*$); positively and insignificantly ($P = 0.05$) related with tissue Cu ($r = 0.6783^*$); negatively and insignificantly ($P = 0.05$) related with Tissue Zn ($r = -0.7058^*$); and negatively and insignificantly ($P = 0.01$) related with Tissue Mn ($r = -0.8537^{**}$).

Tissue Fe content was found positively and insignificantly related with soil E.Ce. ($r = 0.5829$), Ws Cl$^-$ ($r = 0.6403$), PO$_4^{--}$ ($r = 0.2884$), Na$^+$ ($r = 0.6562$), Fe$^{++}$ ($r = 0.3959^{**}$) and Mn$^{++}$ ($r = 0.3284^{**}$); negatively and significantly related with percentage moisture content in air dry soil ($r = -0.5704$), % organic matter in soil ($r = -0.6291$), K$^+$ ($r = -0.3966$), Mg$^{++}$ ($r = -0.1676$) and Cr$^{+++}$ ($r = -0.0204$); positively and significantly ($P = 0.05$) related with soil ESP ($r = 0.7825^*$), pH ($r = 0.7305^*$), SAR ($r = 0.7453^*$), Ws CO$_3^{--}$ ($r = 0.7057^*$), HCO$_3^-$ ($r = 0.6709^*$), TSA ($r = 0.6844^*$), and Ws Zn$^{++}$ ($r = 0.6980^*$); negatively and significantly ($P = 0.01$) related with rate of water percolation ($r = 0.8660^*$), Ws SO$_4^{--}$ ($r = 0.8247^{**}$), Cu$^{++}$ ($r = 0.8198^{**}$).

**In De treated soils at L3 level:**

Tissue Fe content was found positively and insignificantly related with tissue Cu ($r = 0.3781$) and Cr ($r = 0.3683$);
negatively and insignificantly related with Tissue Mn ($r = 0.3392$) and Zn ($r = -0.3276$);

Tissue Fe content was found positively and insignificantly related with ESP ($r = 0.5071$), E.Ce. ($r = 0.4573$), pH ($r = 0.5320$), SAR ($r = 0.5120$), $H_2O$ required for saturation of soil ($r = 0.4934$), Ws $CO_3^-$ ($r = 0.4176$), $HCO_3^-$ ($r = 0.4154$), TSA ($r = 0.4340$), $Cl^-$ ($r = 0.4037$), Ws $PO_4^{3-}$ ($r = 0.1395$), $Na^+$ ($r = 0.5097$), $Mg^{++}$ ($r = 0.1576$), $Fe^{+++}$ ($r = 0.2547$), $Mn^{++}$ ($r = 0.4141$) and $Zn^{++}$ ($r = 0.2824$); negatively and insignificantly related with % moisture content in soil ($r = -0.1254$), rate of $H_2O$ percolation ($r = -0.3065$), % organic matter ($r = -0.0863$) Ws $Ca^{++}$ ($r = 0.3537$), $K^+$ ($r = 0.4185$) and $Cr^{+++}$ ($r = 0.2063$); positively and insignificantly ($P = 0.05$ related with soil $SO_4^{--}$($r = 0.6968^*$).

In TE treated soils at $L_3$ level:

Tissue Fe content was found positively and insignificantly related with Cu ($r = 0.3234$) and Cr ($r = 0.1259$); negatively and insignificantly related with Tissue Mn ($r = 0.4670$) and Zn ($r = -0.4310^*$).

Tissue Fe content was found positively and insignificantly related with soil tissue ESP ($r = 0.5476$), E.Ce. ($r = 0.4796$), pH ($r = 0.2359$), SAR ($r = 0.5547$), $H_2O$ required for saturation of soil ($r = 0.2265$), Ws $CO_3^-$ ($r = 0.3831$), $HCO_3^-$ ($r = 0.3917$), TSA ($r = 0.3885$), $Cl^-$ ($r = 0.5054$), Ws $PO_4^{3-}$ ($r = 0.2354$), $Na^+$ ($r = 0.5569$), $Mg^{++}$ ($r = 0.5437$), $Fe^{+++}$ ($r = 0.5684$), $Mn^{++}$ ($r = 0.6580$), Cu$^{++}$ ($r = 0.4625$) and Zn$^{++}$ ($r = 0.2945$); negatively and insignificantly related with % moisture content in air dry
soil \( r = -0.4136 \), rate of \( \text{H}_2\text{O} \) percolation \( r = -0.3365 \), \% organic matter \( r = -0.3370 \) Ws \( \text{Ca}^{++} \) \( r = 0.4107 \), \( \text{K}^{+} \) \( r = 0.4387 \) and \( \text{Cr}^{+++} \) \( r = 0.4784 \); positively and insignificantly \( \text{P} = 0.05 \) related with soil \( \text{SO}_4^{--} \) \( r = 0.7167^{*} \).
Fig. 3.16: Mean value of Iron (Fe) ppm DM

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Legend:
- L0
- L1
- L2
- L3
17. Tissue manganese (Mn) ppm D.M.:

F values for *Pedilanthus tithimaloids* L. are T (2015.32*), L (687.94**), S (946.68**), T X L (586.34**), T X S (21.49**), L X S (128.93**) and T X L X S (53.86**) interactions were found significant at (P = 0.01) probability level.

F values for *Calotropis procera* L. are T (983.64**), L (584.87**), S (876.93**), T X L (487.43**), T X S (37.89**), L X S (136.39**) and T X L X S (49.36**) interactions were found significant at (P = 0.01) probability level.

In all the nine soils with both DE and TE treatments the respective effluent supply was found positively related with tissue manganese content and the increase in respective tissue manganese content with the increase in DE or TE treatment at L₁ as compared to L₀ and at L₂ as compared to L₁ was found significant at 0.01 probability level, irrespective of the soils, only exceptions being S₉ in DE treatment and S₂ and S₈ of the TE treatment where a significant decrease at 0.01 probability level was found between L₂ and L₁.

As compared to NSNS soils the LSS soils and as compared to LSS soils the HSS soils showed better responses to DE and TE supply for increase in tissue manganese content.

Over all the responses in regard to increase in tissue Mn content in plants were found better in DE treated soils as compared to TE treated soils.
At L₀ level (control):

Tissue Mn content was found negatively and significantly \((P = 0.05)\) related with tissue Cr \((r = -0.6972^*)\); positively and significantly \((P = 0.01)\) related with tissue Zn \((r = 0.8333^{**})\) and negatively and significantly \((P = 0.01)\) related with tissue Cu \((r = -0.8109^{**})\).

Tissue Fe content was found positively and insignificantly related with Ws Mg\(^{++}\) \((r = 0.0969)\) and Cr\(^{+++}\) \((r = 0.3842)\); negatively and insignificantly related with Cl\(^-\) \((r = -0.6520)\), PO\(_4\)^{---} \((r = -0.1993)\), SO\(_4\)^{---} \((r = -0.6277)\), Fe\(^{++}\) \((r = -0.3062)\) and Mn\(^{++}\) \((r = -0.2959)\); positively and significantly \((P = 0.05)\) related with % moisture content in air dry soil \((r = 0.7601^*)\), % organic matter \((r = 0.7770^*)\), Ws Ca\(^{++}\) \((r = 0.7501^*)\) and K\(^+\) \((r = 0.7245^*)\); negatively and insignificantly \((P = 0.05)\) related Ws Cu\(^{++}\) \((r = -0.7592^*)\); positively and significantly \((P = 0.01)\) related with Rate of H\(_2\)O percolation \((r = 0.8814^*)\), and negatively and significantly \((P = 0.01)\) related with soil ESP \((r = -0.8833^{**})\), E.Ce. \((r = -0.8258^{**})\), pH \((r = -0.8602^{**})\) SAR \((r = -0.8612^{**})\), H\(_2\)O required for saturation of soil \((r = -0.8773^*)\), Ws CO\(_3\)^{---} \((r = -0.8381^{**})\), HCO\(_3\)^{---} \((r = -0.8293^{**})\), TSA \((r = -0.8331^{**})\), Na\(^+\) \((r = 0.8015^{**})\) and Zn\(^{++}\) \((r = 0.8089^{**})\).

In DE treated soils at L₃ level:

Tissue Mn content was found positively and insignificantly related with Tissue Cu \((r = 0.1934)\); positively and significantly
(P = 0.01) related with tissue Zn (r = 0.9100**); and negatively and significantly (P = 0.01) related with tissue Cr (r = -0.9237**).

Tissue Mn content was found positively and insignificantly related with % organic matter in soil (r = 0.5467*); negatively and insignificantly related with Ws Cl− (r = -0.5417), SO4 −− (r = -0.6024), Mg+++ (r = 0.2755) and Fe+++ (r = 0.4809); positively and significantly (P = 0.05) related with Ca+++ (r = 0.7806*) and Cr+++ (r = 0.7626*); negatively and insignificantly (P = 0.05) related with H2O required for saturation (r = -0.7099*), PO4−−− (r = -0.7599*), Mn++ (r = -0.6818*) and Cu++ (r = -0.6716*); positively and significantly (P = 0.01) related with % moisture content in air dry soil (r = 0.8388**), rate of H2O percolation (r = 0.8030**) and K+ (r = -0.8645**); and negatively and significantly (P = 0.01) related with soil ESP (r = -0.8592**), E.Ce. (r = -0.8145**), pH (r = -0.8723**), SAR (r = -0.8411**), Ws CO3−− (r = -0.9529**), HCO3− (r = -0.9021**), TSA (r = -0.9111**), Na+ (r = -0.8094**) and Zn++ (r = -0.8207**).

** In TE treated soils at L3 level:**

Tissue Mn content was found positively and insignificantly related with Tissue Zn (r = 0.6487); and negatively and insignificantly related with tissue Cu (r = -0.2619) and Cr (r = -0.3013).

Tissue Mn content was found positively and insignificantly related with % organic matter in soil (r = 0.5159); negatively and significantly related with pH (r = -0.2286), H2O required for
saturation of soil \( (r = -0.6336) \), \( \text{SO}_4^{2-} \) \( (r = -0.4883) \), \( \text{Mg}^{++} \) \( (r = -0.6326) \), \( \text{Fe}^{++} \) \( (r = -0.3988) \), \( \text{Mn}^{++} \) \( (r = -0.2053) \) and \( \text{Cu}^{++} \) \( (r = -0.6642) \); positively and significantly \( (P = 0.05) \) related with % moisture content in air dry soil \( (r = 0.7266^*) \), rate of \( \text{H}_2\text{O} \) percolation \( (r = 0.7935^{**}) \), \( \text{Ws \ Ca}^{++} \) \( (r = 0.7917) \) and \( \text{K}^+ \) \( (r = 0.7309^*) \); and negatively and significantly \( (P = 0.05) \) related with soil ESP \( (r = -0.7675^*) \), \( \text{E.Ce.} \) \( (r = -0.7675^*) \), SAR \( (r = -0.7147^*) \), \( \text{Ws \ CO}_3^{--} \) \( (r = -0.7919^*) \), \( \text{Ws \ Cl}^- \) \( (r = -0.6984^*) \), \( \text{PO}_4^{3--} \) \( (r = -0.6918^*) \), \( \text{Na}^+ \) \( (r = -0.6777^*) \) and \( \text{Zn}^{++} \) \( (r = -0.7313) \); and negatively and significantly \( (P = 0.05) \) related with \( \text{HCO}_3^- \) \( (r = -0.8003^*) \) and TSA \( (r = 0.7979^{**}) \).
Fig. 3.17: Mean value of Manganese (Mn) ppm DM

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis
18. Tissue copper (Cu) ppm D.M.:

F values for *Pedilanthus tithimaloids* L. are T (364.27**), L (4863.68**), S (278.41**), T X L (138.26**), T X S (37.94**), L X S (43.75**) and T X L X S (21.70**) interactions were found significant at (P = 0.01) probability level.

F values for *Calotropis procera* L. are T (331.48**), L (5136.94**), S (302.14**), T X L (121.62**), T X S (47.63**), L X S (36.84**) and T X L X S (19.89**) interactions were found significant at (P = 0.01) probability level.

In all the nine soils with both DE and TE treatments the respective effluent supply was found directly related with tissue Cu content and the increase in respective tissue copper copper content with increase in DE and TE treatment at L₁ as compared to L₀ and at L₂ as compared to L₁ was found significant at 0.01 probability level. Only exceptions being S₇ of DE treatment and S₈ of the TE treatment where it showed a significant (P = 0.01) decrease at L₂ as compared to L₁ and in S₈ of the DE treatment the increase between L₂ and L₁ was found insignificant.

As compared to HSS soils the LSS soils and as compared to LSS soils the NSNS soils showed better responses to DE and TE supply for increase in tissue copper content.

Over all the responses in regard to increase in tissue Cu content in plants were found better, in DE treated soils as compared to TE treated soils.
At L₀ level (control):

Tissue Cu content was found positively and insignificantly related with $\text{PO}_4^{3-}$ ($r = 0.2883$), $\text{SO}_4^{2-}$ ($r = 0.5220$), $\text{Fe}^{++}$ ($r = 0.2033$) and $\text{Mn}^{++}$ ($r = 0.2007$); negatively and insignificantly related with $\text{K}^+$ ($r = -0.5314$), $\text{Mg}^{++}$ ($r = -0.2466$) and $\text{Cr}^{+++}$ ($r = -0.1585$); positively and insignificantly ($P = 0.05$) related with E.Ce. ($r = 0.7969^*$), $\text{Ws CO}_3^{--}$ ($r = 0.7736^*$), $\text{HCO}_3^-$ ($r = 0.7754^*$), TSA ($r = 0.7751^*$), and $\text{Ws Cl}^-$ ($r = 0.7291^*$); positively and significantly ($P = 0.05$) related with $\text{Ca}^{++}$ ($r = 0.6980^*$); negatively and significantly ($P = 0.01$) related with ESP ($r = -0.8862^{**}$) pH ($r = -0.8203^{**}$), SAR ($r = -0.8625^{**}$), $\text{H}_2\text{O}$ required for saturation of soil ($r = -0.8782^{**}$), $\text{Na}^+$ ($r = -0.8042^{**}$), $\text{Cu}^{++}$ ($r = -0.8668^{**}$) and $\text{Zn}^{++}$ ($r = -0.9621^{**}$); positively and significantly ($P = 0.01$) related with percentage moisture content in air dry soil ($r = 0.8911^{**}$), rate of water percolation ($r = 0.9062^{**}$) and % organic matter in soil ($r = 0.8423^{**}$).

In De treated soils at L₃ level:

Tissue Cu content was found positively and insignificantly related with ESP ($r = 0.0873$), E.Ce. ($r = 0.8419$), SAR ($r = 0.1134$), % moisture content in soil ($r = 0.3363$), rate of $\text{H}_2\text{O}$ percolation ($r = 0.2373$), $\text{Cl}^-$ ($r = 0.0480$), $\text{PO}_4^{3-}$ ($r = 0.0903$), $\text{SO}_4^{2-}$ ($r = 0.1602$) $\text{Na}^+$ ($r = 0.1139$), $\text{Ca}^{++}$ ($r = 0.1538$), $\text{Fe}^{++}$ ($r = 0.0525$) and $\text{Cr}^{+++}$ ($r = 0.5843$); negatively and insignificantly related with soil pH ($r = -0.0661$), $\text{H}_2\text{O}$ required for saturation of soil ($r = -0.0404$), % organic matter in soil.
(r = -0.0404), Ws CO$_3^{--}$ (r = -0.1229), HCO$_3^-$ (r = -0.2565), TSA (r = -0.2300), K$^+$ (r = -0.0198), Mg$^{++}$ (r = -0.1682), Mn$^{++}$ (r = -0.1520), Cu$^{++}$ (r = -0.1179) and Zn$^{++}$ (r = -0.0986).

**In TE treated soils at L$_3$ level:**

Tissue Cu content was found positively and insignificantly related with soil tissue % moisture content in air dry soil (r = 0.2565), rate of H$_2$O percolation (r = 0.0849), H$_2$O required for saturation of soil (r = 0.1497), Ws CO$_3^{--}$ (r = 0.0295), HCO$_3^-$ (r = 0.0217), TSA (r = 0.0246), Cl$^-$ (r = 0.5237), SO$_4^{--}$ (r = 0.3103), K$^+$ (r = 0.2420), Fe$^{++}$ (r = 0.2839), Cu$^{++}$ (r = 0.3755), Zn$^{++}$ (r = 0.2562) and Cr$^{++}$ (r = 0.0919) and negatively and insignificantly related with soil E.Ce. (r = -0.0611), pH (r = -0.3846), SAR % (r = -0.0118), % organic matter (r = -0.0373), Ws PO$_4^{--}$ (r = -0.1106), Na$^+$ (r = -0.0684), Ca$^{++}$ (r = -0.4647), Mg$^{++}$ (r = -0.3059) and Mn$^{++}$ (r = -0.1315).
Fig. 3.18: Mean value of Tissue Copper (Cu) ppm DM

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Legend:
- L0
- L1
- L2
- L3
19. Tissue zinc (Zn) ppm D.M.:

F values for *Pedilanthus tithimaloids* L. are T (798.41**), L (684.35**), T x L (438.71**), T x S (47.46**), L x S (64.31**) and T x L x S (41.98**) interactions were found significant at (P = 0.01) probability level.

F values for *Calotropis procera* L. are T (684.14**), L (486.37**), S (436.64**), T x L (389.17**), T x S (37.83**), L x S (63.13**) and T x L x S (27.84**) interactions were found significant at (P = 0.01) probability level.

Except in S3 of the TE treatment between L2 and L1 where the result was found reversed and significant at (P = 0.01) probability level, in all the nine soils with both DE and TE treatments the respective effluent supply was found positively related the respective effluent supply was found positively related with tissue zinc content and the increase in DE or TE treatment at L1 as compared to L0 and at L2 as compared to L1 was found significant at 0.01 probability level, irrespective of the soils.

As compared to LSS soils the NSNS soils and as compared to NSNS soils the HSS soils showed better responses to DE supply while as compared to NSNS soils the LSS soils and as compared to LSS soils the HSS soils showed better responses to TE supply for increase in tissue Zn content,

Over all the responses in regard to increase Zn content in plants were found better in DE treated soils as compared to TE treated soils.
At L0 level (control):

Tissue Zn content was found negatively and insignificantly related with tissue Cr ($r = -0.4671^*$);

Tissue Zn content was found positively and insignificantly related with Ws Ca$$^{++}$$ ($r = 0.4056$) and Cr$$^{+++}$$ ($r = 0.2963$); negatively and insignificantly related with Cl$$^-$$ ($r = -0.5057$), PO$$^-_-$$ ($r = -0.4220$), SO$$^-_-$$ ($r = -0.3454$), Mg$$^{++}$$ ($r = 0.3653$), Fe$$^{++}$$ ($r = -0.1470$) and Mn$$^{++}$$ ($r = -0.1891$) Cu$$^{++}$$ ($r = -0.4402$) and Zn$$^{++}$$ ($r = 0.6504$); positively and significantly ($P = 0.05$) related with % moisture content in air dry soil ($r = 0.7364^*$), rate of H$$_2$$O percolation ($r = 0.7880^*$) and Ws K$$^+$$ ($r = -0.7961^*$); negatively and insignificantly ($P = 0.05$) related H$$_2$$O required for saturation of soil ($r = -0.7740^*$), Ws CO$$^-_-$$ ($r = -0.7849^*$), HCO$$^-_-$$ ($r = -0.7894^*$), TSA ($r = -0.7881^*$); positively and significantly ($P = 0.01$) related with % organic matter in soil ($r = 0.8236^{**}$); and negatively and significantly ($P = 0.01$) related with soil ESP ($r = -0.8597^{**}$), E.Ce. ($r = -0.8258^{**}$), pH ($r = -0.9090^{**}$) SAR ($r = -0.8753^{**}$) and Ws Na$$^+$$ ($r = -0.8788^{**}$).

In DE treated soils at L3 level:

Tissue Zn content was found negatively and significantly ($P = 0.05$) related with tissue Cr ($r = -0.7451^*$).

Tissue Zn content was found positively and insignificantly related with rate of H$$_2$$O percolation ($r = 0.6249$), % organic matter in soil ($r = 0.6228$) and Ws Ca$$^{++}$$ ($r = 0.5102$); negatively and insignificantly ($P = 0.05$) related with H$$_2$$O required for
saturation of soil ($r = -0.6600$), Cl$^-$ ($r = -0.3416$), SO$_4^{2-}$ ($r = -0.4035$), Mg$^{++}$ ($r = 0.6240$), Fe$^{++}$ ($r = 0.3316$), Mn$^{++}$ ($r = 0.5021$), Cu$^{++}$ ($r = -0.3463$) and Zn$^{++}$ ($r = -0.6211$); positively and significantly ($P = 0.01$) related with Cr$^{+++}$ ($r = 0.7438^*$); negatively and significantly ($P = 0.05$) related with HCO$_3^-$ ($r = -0.7817^*$), TSA ($r = -0.7876^*$) and Ws PO$_4^{3-}$ ($r = -0.7759^*$); positively and significantly ($P = 0.01$) related with % moisture content in air dry soil ($r = 0.8749^{**}$) and K$^+$ ($r = -0.9175^{**}$); and negatively and significantly ($P = 0.01$) related with soil ESP ($r = -0.8335^{**}$), E.Ce. ($r = -0.8403$), pH ($r = 0.8712^{**}$), SAR ($r = -0.8349^{**}$), Ws CO$_3^{2-}$ ($r = -0.8727^{**}$) and Na$^+$ ($r = 0.8342^{**}$).

**In TE treated soils at L3 level:**

Tissue Zn content was found negatively and insignificantly related with tissue Cr ($r = -0.3238$).

Tissue Zn content was found positively and insignificantly related with % organic matter in soil ($r = 0.5609$) and Ws Ca$^{++}$ ($r = 0.4886$); negatively and insignificantly ($P = 0.05$) related with soil pH ($r = -0.6321$), H$_2$O required for saturation of soil ($r = -0.2931$), Ws Cl$^-$ ($r = -0.3921$), SO$_4^{2-}$ ($r = -0.5080$), Fe$^{++}$ ($r = 0.1328$), Mn$^{++}$ ($r = 0.5878$) and Zn$^{++}$ ($r = -0.6057$); positively and significantly ($P = 0.05$) related with % moisture content in air dry soil ($r = 0.7653^*$); negatively and significantly ($P = 0.05$) related with Ws CO$_3^{2-}$ ($r = -0.7843^*$), HCO$_3^-$ ($r = -0.7949^*$), TSA ($r = -0.7910$) and Ws PO$_4^{3-}$
(r = -0.6774*) and Mg$$^{++}$$ (r = 0.7584*); positively and significantly (P = 0.01) related with rate of H$_2$O percolation (r = 0.8491**), WS % K$$^{+}$$ (r = -0.8887**) and Cr$$^{+++}$$ (r = 0.8082**); and negatively and significantly (P = 0.01) related with soil ESP (r = -0.8092**), E.Ce. (r = -0.8118), SAR (r = -0.8036**) and Ws Na$$^{+}$$ (r = -0.8691**).
Fig. 3.19: Mean value of Tissue Zinc (Zn) ppm DM

Distillery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Calotropis

Soils Nos.

Treatments

Soils Nos.
20. Tissue chromium (Cr) ppm D.M.:

F values for Pedilanthus tithimaloids L. are T (738.23**), L (738.46**), S (136.84**), T X L (1876.48**), T X S (27.86**), L X S (16.94**) and T X L X S (9.83**) interactions were found significant at (P = 0.01) probability level.

F values for Calotropis procera L. are T (689.68**), L (463.38**), S (127.48**), T X L (1348.84**), T X S (37.89**), L X S (28.36**) and T X L X S (28.36**) interactions were found significant at (P = 0.01) probability level.

In all the nine soils with both DE and TE treatments the respective effluent supply was found directly related with tissue chromium content and the increase in respective tissue chromium content with increase in DE or TE treatment at L1 as compared to L0 and at l2 as compared to L1 was found significant at 0.01 probability level, irrespective of the soil.

As compared to HSS soils the NSNS soils and as compared to NSNS soils the LSS soils showed greater responses to DE supply while as compared to HSS soils the LSS soils and as compared to LSS soils the NSNS soils showed greater responses to TE supply for increase in tissue chromium content.

Over all the responses in regard to increase in tissue Cr content were found higher in TE treated soils as compared to DE treated soils.

At L0 Level (control):

Tissue Cr content was found positively and insignificantly related with PO$_4^{--}$ (r = 0.3582), SO$_4^{--}$ (r = 0.3660), Na$^{++}$
(r = 0.6317), Mn++ (r = 0.4841) and Cu++ (r = 0.6317); negatively and significantly related with % organic matter in soil (r = -0.6472), Ca++ (r = -0.6328), K+ (r = -0.5828), Mg++ (r = -0.8330), Fe++ (r = -0.1132) and Cr+++ (r = -0.5889); positively and significantly (P = 0.05) related with ESP (r = 0.6983*), E.Ce. (r = 0.7676*), pH (r = 0.7228*), SAR (r = 0.6696*), H2O required for saturation of soil (r = 0.7549*), and Ws Cl− (r = 0.7564*); negatively and significantly (P = 0.01) related with percentage moisture content in air dry soil (r = -0.7266*), rate of water percolation (r = 0.7789*) and positively and insignificantly (P = 0.01) related with Ws CO3−− (r = 0.8776**), HCO3− (r = 0.8874**), TSA (r = 0.8841**) and Ws Zn++ (r = 0.8313**).

**In De treated soils at L3 level:**

Tissue Cr content was found positively and insignificantly related with H2O required for saturation of soil (r = 0.5041), Ws SO4−− (r = 0.6630), Mg++ (r = 0.0416) and Fe++ (r = -0.3683); negatively and insignificantly related with % organic matter in soil (r = 0.6040) and Cr+++ (r = -0.6642) positively and significantly (P = 0.05 related with Ws Cl− (r = -0.7718*), Ws PO4−−− (r = 0.7059*), Na+ (r = 0.7914*) and Mn++ (r = 0.7567*); negatively and significantly (P = 0.05) related with % moisture content in air dry soil (r = -0.7146*); positively and significantly (P = 0.05) related with soil ESP (r = 0.85023**), E.Ce. (r = 0.8097**), pH (r = 0.8890**), SAR (r = 0.8295**), Ws CO3−− (r = 0.9119**), HCO3− (r = 0.9657**), TSA (r = 0.9706**), Cu++
(r = 0.8024**) and \( \text{Zn}^{++} \) (r = 0.8891**); negatively and significantly related with rate of H\(_2\)O percolation (r = -0.8425**), 
Ws \( \text{Ca}^{++} \) (r = -0.8475**) and \( \text{K}^{+} \) (r = -0.8150**).

**In TE treated soils at L\(_3\) level:**

Tissue Cr content was found positively and insignificantly related with ESP (r = 0.5611), E.Ce. (r = 0.4495), SAR (r = 0.5609), rate of H\(_2\)O required for saturation of soil (r = 0.1436), Ws \( \text{CO}_3^{--} \) (r = 0.6152), \( \text{HCO}_3^{-} \) (r = 0.5953), TSA (r = 0.6028), Ws \( \text{PO}_4^{--} \) (r = 0.6181), \( \text{SO}_4^{--} \) (r = 0.5057), \( \text{Na}^{+} \) (r = 0.5440), \( \text{Mn}^{++} \) (r = 0.0940), \( \text{Cu}^{++} \) (r = 0.4027) and \( \text{Zn}^{++} \) (r = 0.5567); negatively and insignificantly related with % moisture content in air dry soil (r = -0.50953363), rate of H\(_2\)O percolation (r = -0.6312), % organic matter in soil (r = -0.4759), Ws \( \text{Ca}^{++} \) (r = 0.2857), \( \text{K}^{+} \) (r = 0.5345), \( \text{Mg}^{++} \) (r = 0.0428), \( \text{Fe}^{++} \) (r = 0.2440) and \( \text{Cr}^{+++} \) (r = 0.3033); positively and significantly (P = 0.01) related with \( \text{Cl}^{-} \) (r = 0.6780*); positively and significantly (P = 0.01) related with soil pH (r = 0.8491**).
Fig. 3.20: Mean value of Tissue Chromium (Cr) ppm DM

Distillery effluent treatment: Soils after Pedilanthus

Tannery effluent treatment: Soils after Pedilanthus

Distillery effluent treatment: Soils after Calotropis

Tannery effluent treatment: Soils after Calotropis

Soils Nos.

Soils Nos.

Soils Nos.

Soils Nos.

Legend:
- L0
- L1
- L2
- L3