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Research Article

EFFECT OF IMMOBILIZED BACTERIAL CONSORTIUM TREATED TANNERY EFFLUENT AND COMPOST MIXTURE ON THE GROWTH, YIELD AND BIOCHEMICAL CONSTITUENTS OF MAIZE Co – 1 (*Zea mays* L.)

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Abstract

Maize is an important cereal crop of India, stands 3rd in area production after rice and wheat. Currently, it is cultivated over an area of 8.49 m ha with a production of 21.28 million tonnes. Maize is one of the most important cereal crops in the world agriculture economy both as food for man and feed for animals. In this present study, tannery effluent was bioremediated and used to irrigation of Maize field and composting mixture of Bagasse and Pressmud used to improve the growth and yield of *Zea mays* Co-1. Seven treatments were designed among the treatments, T_7 recorded highest growth, Yield, Number of Grains, Number of Cobs, grain yield, Stalk yield, and increases starch, protein and chlorophyll content and T_2 g results was on par with treatment seven.

Keywords: Tannery effluent, Maize, Immobilization, Bacterial consortium and Compost mixtures.

Introduction

Tannery wastes are ranked as the highest pollutants among all the industrial wastes (Soyalsan and Karaguzel, 2007; Saranraj *et al*., 2010). In agricultural system, the toxic pollutants reduces light penetration and photosynthesis and also some of toxic elements are mutagenic, carcinogenic and allergenic (Aksu and Cagatay, 2006; Kumar *et al*., 2006; Sadeeshkumar *et al*., 2012). The Tannery industry releases waste water is a serious consequence from the pollution point of view for streams, freshwater and land used for agriculture. The lack of awareness in the modern industrial practice has resulted in the discharge of tannery effluents which exhibit very high value for chromium, sulphide, and chloride, TDS, TSS, BOD and COD in the water stream or land. In the course of the last two decades a wide variety of technologies had been developed for cleanup operations of contaminated sites (Saranraj *et al*., 2010; Aneez Mohamed *et al*., 2011).

Composting is a widely used process to convert organic waste products into valuable soil conditioners that enhance sustainable agricultural production, especially in areas where chemical fertilisers are in short supply (Saranraj and Stella, 2012). Compost has beneficial effect to reduce or eliminate the need for chemical fertilizers and promote higher yields of agricultural crops (Saranraj and Stella, 2014). Hence, the present research was designed to explore the possible effect of low cost, eco-friendly, technique by using tannery industry wastes in rationalizing the nutrients and to under irrigated conditions in Maize (*Zea mays* L.) and composting mixture is used to improve the growth of Maize.

Materials and Methods

Bioremediation of tannery effluent using immobilized efficient bacterial isolates and consortium under aerobic condition

Tannery effluent was collected from Vaniyambadi, Vellore district. Collected effluent was used to isolate the metal resistant bacteria and characterized. The collected tannery effluent was inoculated with immobilized beads containing efficient bacterial consortium (*Bacillus subtilis*, *Serratia marcescens* and *Enterobacter asburiae*), and air was passed continuously using an aerator. After 3 and 6 months, the sample was filtered under aseptic condition and physico - chemical parameters were estimated. The bioremediated effluent was later used for irrigation during field study.

Composting of Pressmud and Bagasse

The pressmud and bagasse to be composted was collected from Mallur, Salem District in Tamil Nadu, India. The collected samples were stored in polythene bags and were analyzed for its physical, chemical and biological properties. From the Collected samples bacteria and fungi were isolated and identified and efficient strains were selected based on the enzyme activity.

Composting technology was carried out at a composting yard, Mallur, Salem District, Tamil Nadu, India. Before composting, the raw material composting substrate (Pressmud and Bagasse) were continuously washed with water for 15 days to remove the excess sulphate content. The composting substrate (Pressmud and Bagasse) were pasteurized by dipping it overnight in 0.1% formalin. Composting of the sterilized substrate (Pressmud and Bagasse) was done in pits (7 feet × 2.5 feet × 1.5 feet). The experiment was conducted with 60 kg of substrates. The selected bacteria (*Cellulomonas composti*) and fungal isolates (*Trichoderma reesei* and *Penicillium expansum*) (50 ml/kg substrate having 10^6 cells per ml) were inoculated after 6 days of pre-decomposition within their combinations:

For aerobic digestion, turning was done manually every 4 days upto 75 days. The composting substrate with different treatments was composted for 90 days. Moisture level of 50 – 60 per cent was maintained throughout the period of composting and the moisture content was determined using a moisture detector and held constant by adding water.

Field experiments were conducted to study the effect of bioremediated tannery effluent and Compost mixture - 8 for the maximization of growth and yield of Maize (*Zea mays* L.) during 2014 at the farmer's field, Vadalur, Cuddalore district, Tamil Nadu, India. The details of materials used and methods adopted during the experimentation are furnished in this chapter.

Location of the Experimental field

The experiment was carried out in Vadalur, Cuddalore district, Tamil Nadu, India. The experimental farm is geographically situated at 11º14'N latitude and 79º18' East longitude.

Crop and Variety

Maize variety Co - 1 (*Zea mays* L.) was selected for this present study. The varietal character of Maize variety Co – 1 was furnished in Table - 5.

Design of the Experiment

The experiments were laid out in Randomized Block Design (RBD) with three replications during 2013. Randomly five plants in each treatment were marked for periodical observation.

Treatment schedule

T_1 – Control
T_2 – 100% RDF
T_3 – 25% Bioremediated tannery effluent alone
T_4 – Cellulosic Compost mixture alone @ 2MT ha^{-1}
T_5 – 25% Bioremediated tannery effluent + 75% RDF
T_6 – Cellulosic Compost mixture @ 2MT ha^{-1} + 75% RDF
T_7 – 25% Bioremediated tannery effluent + Cellulosic Compost mixture @ 2MT ha^{-1} + 75% RDF.

Effect of Bioremediated tannery effluent and Compost mixture - 8 on improvement of growth parameters in Maize CO - 1 (*Zea mays* L.)
Germination percentage

The germination percentage of Maize Co - 1 was observed in the field. The germination percentage was calculated by using the following formula.

$$\text{Germination Percentage} = \frac{\text{No. of seeds germinated}}{\text{Total no. of seeds sown}} \times 100$$

Vigour index

Vigour index was computed at 15 DAS using the procedure suggested by Abdul Baki and Anderson (1973).

Vigour index = Germination % × [shoot length (cm) + root length (cm)]

Plant height

Plant height was measured from the ground level to the tip of the primary branches were recorded on 30 DAS, 60 DAS and at harvest. The mean value was worked out and expressed in cm.

Dry matter production

Randomly, five plants from each plot were uprooted as destructive sampling and the roots were washed thoroughly at 30 DAS, 60 DAS and at harvest. The plants were initially sun-dried followed by oven drying at 80ºC ± 5ºC for 72 hours till a constant weight was attained. The weight of over dried plant samples was recorded and the dry matter production (DMP) was computed to kg ha^{-1}.

Effect of bioremediated tannery effluent and compost mixture-8 on increase in yield and yield attributes of Maize Co - 1 (*Zea mays* L.)

Number of grains per cob and Number of grains per row

Grain number per cob was obtained by manual counting, number of grains after separation of grains from cob. The number of grains per row was counted by manually at randomly selected three rows per cob. Then average number of grains of selected row was taken as number of grains per row.

Length and girth of cob

Length of the cob was measured from the base to the tip of the cob and expressed in cm. The circumference measured at the center of the cob using thread. This was taken as girth of the cob and expressed in cm.

Filled and unfilled ratio

The average ratio of filled to unfilled grain was worked out by counting the number of filled and unfilled grain in each cob of the selected plants.

Grain weight

The weight of grains from each cob of selected five plants in net plot was taken and expressed in g $plant^{-1}$.

Cob weight

The cobs from three randomly selected plants were removed thoroughly, air dried, cleaned and weighed. The average cob weight was taken as weight of cob in g $plant^{-1}$.

Hundred Seed weight

The weight of hundred grains were recorded from the samples drawn from the produce obtained in each of the net plot and is expressed in gram per hundred seeds.

Grain yield

At physiological maturity, cobs were harvested plotwise. The yield per hectare was calculated and expressed in tonnes per hectare on the basis of total weight of the cobs in net plot (kg ha^{-1}).

Stalk yield

After drying of stalk, the stalk yield for each net plot was recorded and yield per hectare was calculated.

Biochemical analysis

Estimation of Total chlorophyll content

One gram of fresh leaf sample taken from each replication was analyzed for total chlorophyll content by following the method of Talling and Driver (1961). The total chlorophyll was calculated using the following formula.

$$\text{Total chlorophyll (mg/g)} = 6.10\,(A_{665}) + 20.04\,(A_{649}) \times V$$

Where,

A_{665} – Absorbance at 665 nm,
A_{649} – Absorbance at 649 nm,
V – volume of ethanol extract

The chlorophyll content of leaf sample was estimated and expressed as mg g^{-1} fresh weight of sample.

Estimation of Starch

The residue left behind after alcoholic of the original material was taken for starch extraction and was estimated according to the method of McCredy *et al*. (1950)

Estimation of Protein

Protein content in the roots and leaves (500 mg) were extracted with buffers used for enzyme assay, grind well the samples with a pestle and mortar in 5-10 ml of buffer and centrifuge, the supernatant for protein was measured at 660 nm by the method of Lowry *et al*. (1951) using bovine serum albumin as the standard protein. Protein content was expressed as mg g^{-1} fresh weight.

Results and Discussion

The effect of bioremediated tannery effluent and Compost mixture - 8 on Germination percentage and Vigour index in Maize Co -1 (*Zea mays* L.) was determined and the results were showed in Table – 1. Maximum Germination percentage (94.05%) and Vigour index (2191.87) was observed in the treatment T_7 (25% Bioremediated tannery effluent + Cellulosic Compost mixture @ 2MT ha^{-1} + 75% RDF). The treatment T_7 was on par with the treatment T_2 (100% RDF) (Germination percentage - 93.90% and Vigour index - 2125.40). Minimum Germination percentage (84.20%) and Vigour index (1380.96) was observed in the treatment T_1 (Control). Sangeetha *et al.* (2012) the germination percentage of *Zea mays* was maximum (95%) in both the control seeds and the seeds treated with 50% diluted Tannery effluent. The germination was delayed by a day in the seeds treated with undiluted Tannery effluent (Saranraj *et al*., 2013; Sivasakthi *et al*., 2013; Sivasakthivelan and Saranraj, 2013; Saranraj and Stella, 2014).

Table – 1: Effect of bioremediated tannery effluent, Compost mixture – 8 on germination percentage and vigour index of Maize Co-1 (*Zea mays*)

Treatments	Germination percentage (%)	Vigour index
T_1 – Control	84.20	1380.96
T_2 – 100% RDF	93.90	2125.40
T_3 – 25% Bioremediated tannery effluent alone	88.25	1670.92
T_4 – Cellulosic Compost mixture alone @ 2MT ha^{-1}	88.25	1670.92
T_5 – 25% Bioremediated tannery effluent + 75%	90.95	1890.25
T_6 – Cellulosic Compost mixture @ 2MT ha^{-1} + 75%	91.38	2075.50
T_7 –25% Bioremediated tannery effluent + Cellulosic Compost mixture @ 2MT ha^{-1} + 75% RDF	94.05	2191.87
SE_D	1.32	112.21
CD (P=0.05)	2.64	224.42

The effect of bioremediated tannery effluent and compost mixture - 8 on plant height of Maize Co – 1 (*Zea mays* L.) was measured in the present research. The observations recorded on plant height at 30 DAS, 60 DAS and at harvest are presented in Table – 2. Maximum plant height was recorded during the harvest and highest plant height (177.21 cm) was recorded in the treatment T_7 (25% Bioremediated tannery effluent + Cellulosic Compost mixture @ 2MT ha^{-1} + 75% RDF). The treatment T_7 was on par with the treatment T_2 (100% RDF) (Plant height – 176.80 cm). Lowest plant height (134.31 cm) was observed in the treatment T_1 (Control).

Table – 2: Effect of bioremediated tannery effluent, Compost mixture 8 –on plant height of Maize Co-1 (*Zea mays*)

Treatments	Plant height (cm)		
	30 DAS	60 DAS	Harvest
T_1 – Control	56.00	83.13	134.31
T_2 – 100% RDF	75.78	126.94	176.80
T_3 – 25% Bioremediated tannery effluent alone	60.35	90.35	142.30
T_4 – Cellulosic Compost mixture alone @ 2MT ha^{-1}	63.30	102.50	150.46
T_5 – 25% Bioremediated tannery effluent + 75%	68.45	110.15	159.70
T_6 – Cellulosic Compost mixture @ 2MT ha^{-1} + 75%	72.18	117.30	166.90
T_7 –25% Bioremediated tannery effluent + Cellulosic Compost mixture @ 2MT ha^{-1} + 75% RDF	76.45	127.12	177.21
SE_D	2.97	6.50	6.30
CD (P=0.05)	5.94	13.0	12.6

The effect of bioremediated tannery effluent and compost mixture - 8 on Dry matter production was investigated. The observations recorded on dry matter production at 30 DAS, 60 DAS and at harvest are presented in Table – 3. Maximum dry matter production was recorded during the harvest and more dry matter production (260.34 t ha^{-1}) was recorded in the treatment T_7 (25% Bioremediated tannery effluent + Cellulosic Compost mixture @ 2MT ha^{-1} + 75% RDF). The treatment T_7 was on par with the treatment T_2 (100% RDF) (Dry matter production – 259.88 t ha^{-1}). Less dry matter production (196.23 t ha^{-1}) was observed in the treatment T_1 (Control).

Table – 3: Effect of bioremediated tannery effluent, compost mixture – 8 on dry matter production of Maize Co-1 (*Zea mays* L.)

Treatments	Dry matter production (t ha^{-1})		
	30 DAS	**60 DAS**	**Harvest**
T_1 – Control	25.12	95.34	196.23
T_2 – 100% RDF	36.05	114.75	259.88
T_3 – 25% Bioremediated tannery effluent alone	27.90	106.62	210.85
T_4 – Cellulosic Compost mixture alone @ 2MT ha^{-1}	30.80	107.75	223.80
T_5 – 25% Bioremediated tannery effluent + 75%	32.40	110.80	230.20
T_6 – Cellulosic Compost mixture @ 2MT ha^{-1} + 75%	34.12	112.30	242.15
T_7 –25% Bioremediated tannery effluent + Cellulosic Compost mixture @ 2MT ha^{-1} + 75% RDF	36.70	115.08	260.34
SE_D	1.60	2.57	9.10
CD (P=0.05)	3.2	5.14	18.2

The effect of bioremediated tannery effluent and compost mixture - 8 on Number of grains per cob and Number of grains per row in Maize Co – 1 (*Zea mays* L.) was tested and the results were presented in figure-1. Maximum number of grains per cob (480.67) and number of grains per row (31.33) was noticed in the treatment T_7 (25% Bioremediated tannery effluent + Cellulosic Compost mixture @ 2MT ha^{-1} + 75% RDF). The treatment T_7 was on par with the treatment T_2 (100% RDF) (Number of grains per cob - 480.05 and Number of grains per row - 30.93). Minimum Number of grains per cob (432.80) and Number of grains per row (15.10) was observed in the treatment T_1 (Control). The results are also in line with Kumar *et al.* (1999) and Anitha *et al*. (2010), Sureshkumar *et al*. (2011), who also reported increase in biological yield of sorghum, maize, wheat, blackgram and rice respectively (Jayanthi *et al*., 2013; Saranraj and Sujitha, 2013; Jayanthi *et al*., 2014; Sivasakthi *et al*., 2014).

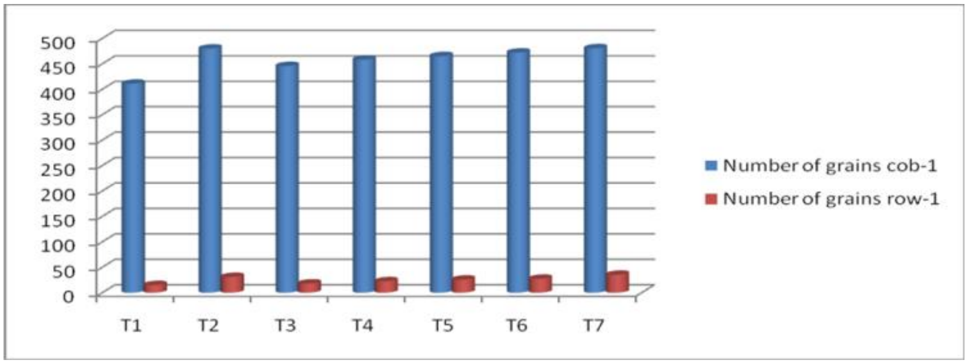


Figure-1: Effect of bioremediated tannery effluent, Compost mixture – 8 on Number of grains per cob and number of grains per row of Maize Co-1(*Zea mays* L.)

The effect of bioremediated tannery effluent and compost mixture-8 on Length of cob, Girth of cob and Filled to unfilled ratio in Maize Co – 1 (*Zea mays* L.) was studied and the results were showed in Table – 4. Maximum length of cob (17.43 cm), Girth of cob (17.65 cm) and Filled to unfilled ratio (25:1) was recorded in the treatment T_7 (25% Bioremediated tannery effluent + Cellulosic Compost mixture @ 2MT ha^{-1} + 75% RDF). The treatment T_7 was on par with the treatment T_2 (100% RDF) (Length of cob – 17.15 cm, Girth of cob – 17.25 cm and Filled to unfilled ratio – 24:1). Minimum length of cob (11.90 cm), Girth of cob (12.35 cm) and Filled to unfilled ratio (12:1) was observed in the treatment T_1 (Control).

Table – 4: Effect of bioremediated tannery effluent, Compost mixture – 8 on Length of cob, Girth of cob and Filled to unfilled ratio in Maize Co-1(*Zea mays* L.)

Treatments	Length of cob (cm)	Girth of cob (cm)	Filled to unfilled ratio
T_1 – Control	11.90	12.35	12:1
T_2 – 100% RDF	17.15	17.25	24:1
T_3 – 25% Bioremediated tannery effluent alone	12.70	13.10	14:1
T_4 – Cellulosic Compost mixture alone @ 2MT ha^{-1}	14.20	14.92	17:1
T_5 – 25% Bioremediated tannery effluent + 75%	15.80	16.02	20:1
T_6 – Cellulosic Compost mixture @ 2MT ha^{-1} + 75%	16.66	16.80	22:1
T_7 –25% Bioremediated tannery effluent + Cellulosic Compost mixture @ 2MT ha^{-1} + 75% RDF	17.43	17.65	25:1
SE_D	0.83	0.78	0.07
CD (P=0.05)	1.66	1.56	0.14

The effect of bioremediated tannery effluent and compost mixture - 8 on Grain weight per plant, Cob weight per plant and 100 seed weight in Maize Co – 1 (*Zea mays* L.) was estimated in the present research and the results were given in figure-2. Maximum Grain weight per plant (145.36 g), Cob weight per plant (276.88 g) and 100 seed weight (27.62 g) was recorded in the treatment T_7 (25% Bioremediated tannery effluent + Cellulosic Compost mixture @ 2 MT ha^{-1} + 75% RDF). The treatment T_7 was on par with the treatment T_2 (100% RDF) (Grain weight per plant – 144.95 g, Cob weight per plant – 276.37 g and 100 seed weight – 27.15 g). Minimum Grain weight per plant (107.61 g), Cob weight per plant (245.36 g) and 100 seed weight (22.18 g) was observed in the treatment T_1 (Control).

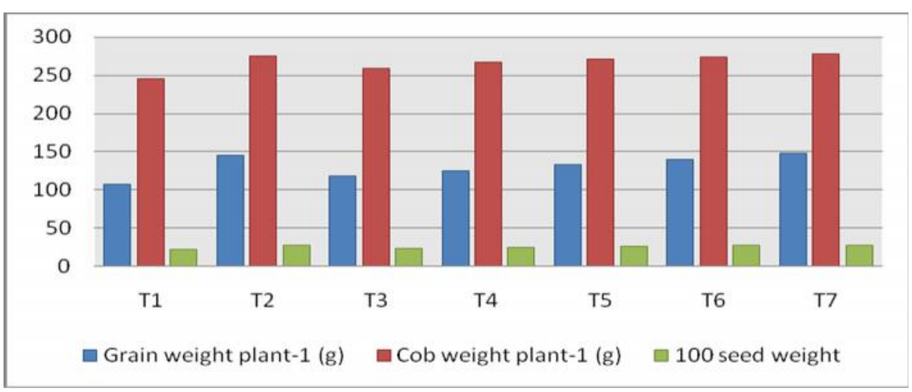


Figure-2: Effect of bioremediated tannery effluent, Compost mixture – 8 on Grain weight per plant, Cob weight per plant and 100 seed weight in Maize Co-1(*Zea mays* L.)

The effect of bioremediated tannery effluent and compost mixture - 8 on Grain yield in Maize Co – 1 (*Zea mays* L.) was studied and the results were presented in Figure - 3. Maximum Grain yield (6.45 t ha^{-1}) was noticed in the treatment T_7 (25% Bioremediated tannery effluent + Cellulosic Compost mixture @ 2MT ha^{-1} + 75% RDF). The treatment T_7 was on par with the treatment T_2 (100% RDF) (Grain yield – 6.03 t ha^{-1}). Minimum Grain yield (3.81 t ha^{-1}) was observed in the treatment T_1 (Control).

The effect of bioremediated tannery effluent and compost mixture - 8 on Stalk yield in Maize Co – 1 (*Zea mays* L.) was assessed and the results were presented in Figure - 3. Maximum Stalk yield (10.40 t ha^{-1}) was noticed in the treatment T_7 (25% Bioremediated tannery effluent + Cellulosic Compost mixture @ 2MT ha^{-1} + 75% RDF). The treatment T_7 was on par with the treatment T_2 (100% RDF) (Stalk yield – 10.33 t ha^{-1}). Minimum Stalk yield (7.16 t ha^{-1}) was recorded in the treatment T_1 (Control).

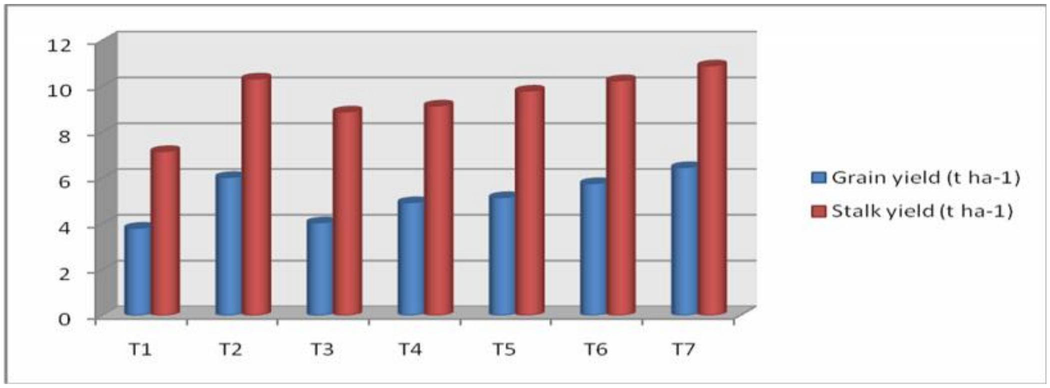


Figure-3: Effect of bioremediated tannery effluent, Compost mixture – 8 on Grain yield and Stalk yield in Maize Co-1(*Zea mays* L.)

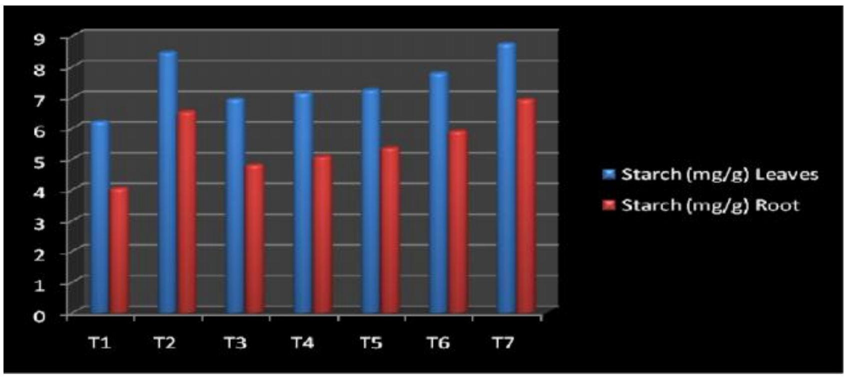
The effect of bioremediated tannery effluent and compost mixture - 8 on chlorophyll content in Maize leaf was estimated in the current study and the results were tabulated in Table - 5. Maximum chlorophyll content (2.67 mg g^{-1}) was recorded in the treatment T_7 (25% Bioremediated tannery effluent + Cellulosic Compost mixture @ 2MT ha^{-1} + 75% RDF). The treatment T_7 was on par with the treatment T_2 (100% RDF) (Chlorophyll content – 2.10 mg g^{-1}). Lowest chlorophyll content (1.80 mg g^{-1}) was observed in the treatment T_1 (Control). Orhue *et al.* (2005) estimated the chlorophyll content of plant treated with 25% brewery effluent concentration had the highest value of 96.37 mg/g^{-1}. This result indicates that brewery effluent stimulates the synthesis of chlorophyll and the synthesis was accelerated at low concentration of the effluent (Saranraj *et al*., 2014; Usharani *et al*., 2014).

Table – 5: Effect of bioremediated tannery effluent, Compost mixture – 8 on Total chlorophyll content in Maize Co - 1(*Zea mays* L.)

Treatments	Chlorophyll content (mg g^{-1})
T_1 – Control	1.80
T_2 – 100% RDF	2.10
T_3 – 25% Bioremediated tannery effluent alone	1.88
T_4 – Cellulosic Compost mixture alone @ 2MT ha^{-1}	1.92
T_5 – 25% Bioremediated tannery effluent + 75%	1.98
T_6 – Cellulosic Compost mixture @ 2MT ha^{-1} + 75%	2.05
T_7 –25% Bioremediated tannery effluent + Cellulosic Compost mixture @ 2MT ha^{-1} + 75% RDF	2.67
SE_D	0.10
CD (P = 0.05)	0.22

The effect of bioremediated tannery effluent and compost mixture - 8 on starch content in leaf and root of maize was determined in the present research (Figure-4). Maximum starch content (Leaf – 8.73 mg g^{-1}; Root – 6.92 mg g^{-1}) was observed in the treatment T_7 (25% Bioremediated tannery effluent + Cellulosic Compost mixture @ 2MT ha^{-1} + 75% RDF). The treatment T_7 was on par with the treatment T_2 (100% RDF) (Leaf – 8.45 mg g^{-1}; Root – 6.52 mg g^{-1}). Minimum starch content (Leaf – 6.20 mg g^{-1}; Root – 4.03 mg g^{-1}) was observed in the treatment T_1 (Control). Sangeetha *et al.* (2012) recorded the starch content was found to increase in the treatment group when compared to the control seeds. Plants have been found to accumulate starch when exposed to environmental stress. The increase in starch content was highly significant in seeds treated with undiluted tannery effluent ($p<0.05$), thus implicating the oxidative stress exerted by the chromium present in the tannery effluent.

Figure-4: Effect of bioremediated tannery effluent and Compost mixture – 8 on starch content in Maize Co - 1(*Zea mays* L.)



The effect of bioremediated tannery effluent and compost mixture - 8 on protein content in leaf and root of maize was estimated and the results were furnished in Table – 6. Maximum protein content (Leaf – 27.64 mg g^{-1}; Root – 14.47 mg g^{-1}) was observed in the treatment T_7 (25% Bioremediated tannery effluent + Cellulosic Compost mixture @ 2MT ha^{-1} + 75% RDF). The treatment T_7 was on par with the treatment T_2 (100% RDF) (Leaf – 27.02 mg g^{-1}; Root – 13.95 mg g^{-1}). Minimum protein (Leaf – 16.40 mg g^{-1}; Root – 9.95 mg g^{-1}) was observed in the treatment T_1.

Table - 6: Effect of bioremediated tannery effluent and compost mixture-8 on Protein content in Maize Co - 1(*Zea mays* L.)

Treatments	Protein (mg/g)	
	Leaves	**Root**
T_1 – Control	16.40	9.95
T_2 – 100% RDF	27.02	13.95
T_3 – 25% Bioremediated tannery effluent alone	18.87	11.96
T_4 – Cellulosic Compost mixture alone @ 2MT ha^{-1}	21.09	12.60
T_5 – 25% Bioremediated tannery effluent + 75%	23.20	13.89
T_6 – Cellulosic Compost mixture @ 2MT ha^{-1} + 75%	24.33	14.08
T_7 –25% Bioremediated tannery effluent + Cellulosic Compost mixture @ 2MT ha^{-1} + 75% RDF	27.64	14.47
SE_D	1.56	0.60
CD (P = 0.05)	3.14	1.22

Conclusion

The study concluded the treated tannery effluent and composting mixture-8 was increase the growth and yield of Maize (*Zea mays* .L). The treatment T_7 recorded highest yield attributes and biochemical constitutes Germination percentage (94.05%) and Vigour index (2191.87) ,plant height (177.21 cm), Dry matter production (260.34 t ha^{-1}), Number of grains per cob (480.67) and number of grains per row (31.33), Grain weight per plant (145.36 g), Cob weight per plant (276.88 g) and 100 seed weight (27.62 g) ,Grain yield (6.45 t ha^{-1}) Stalk yield (10.40 t ha-1).

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