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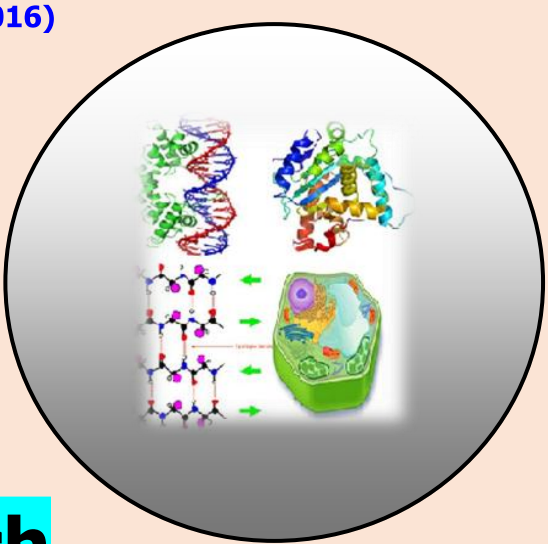

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RESEARCH PAPER

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Assessment and Integrated Management of Salt Affected soil and Impact on Growth, Pigments and Antioxidative Enzymes Activity in Barley (*Hordeum vulgare L.*)

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ABSTRACT

A clay pot experiment was conducted on the salt affected soil which was collected from the Sitapur district (Uttar Pradesh, India). Soil samples were evaluated for their physical and chemical properties (clayey loam texture, soil pH 8.7, EC 3.8 dS per m, ESP 38). The soil was prepared by adding standard doses of N: P: K (60: 30: 30 mg/kg soil). The experiment was Carried out in the controlled conditions (In clay pots) to measure the effectiveness of various amendments viz. farm yard manure (FYM) @ 100 g/kg soil), $CaSO_4$ (@ 100 mg/kg soil), and zinc sulphate (@ 25 mg/kg soil) alone and in combination (FYM + $CaSO_4$ and FYM + Zinc sulphate) in improving growth, pigments and antioxidative enzymes activity of barley (Hordeum vulgare L., var. BH 393). The plants were observed on the regular basis. The growth (height, number of tillers per plant, fresh weight and dry weight) and biochemical parameters (pigments and catalase and peroxidase activity) were analysed after 50 days of growth. The results showed that the use of $CaSO_4$ along with FYM was found to be very effective in supporting growth and determined biochemical constituents in barley as compared to FYM alone or zinc sulphate with FYM application in soil
Key words: Salt affected soil, FYM, Antioxidants, sodicity and barley.

INTRODUCTION

In India, the total geographic area is about 328 million hectares, only 167 million hectares land is used for agriculture and about 2.72 million hectare land is salt affected in the Indo-Gangetic plains (Pandey *et al.,* 2017). Mostly saline sodic soils spread is more prominent in arid and semiarid areas (Pandey, 2012) whereas it is about 62% of total area globally, spread in more than 100 countries (Szabolcs, 1994). The per capita arable land in India (about 0.4 hectare) is very low and total geographic area supports about 17% population globally. Therefore to fulfill the needs of increasing population a proper management of salt affected saline and sodic land is urgent need in present scenario to increase arable area for more production of crops. The conditions in salt affected soils such as alkaline pH reaction, high electrical conductance (> 4 dS/m), high exchangeable sodium percentage (ESP), low availability of nutrients, low organic matter content (< 0.4 %) etc; make the such soils unfavorable for growth and yield of plants. The sodic soils are characterized by a high percentage of sodium carbonate content and high pH (> 8.5) which make a soil poorly fertile (Marschner, 1995). The sodic soils in north Indian plains are highly deficient in sulphur and zinc along with other macro and micro nutrients (Pandey *et al.,* 2008). Use of gypsum and organic compost in reclamation of sodic soils are effective practices (Upadhyay and Pandey, 2011). Less information is available on effectiveness of integrated remedial measures of sodic soil through organic and chemical sources of fertilizers application (alone or in combination) to improve growth and biomolecules content in plants. Therefore, the study was conducted on assessment of sodic soil conditions and use of sources of calcium, sulphur and zinc as calcium sulphate and zinc sulphate and FYM application in sodic soil and their effect on growth, pigments and activity of catalase and peroxidase in a commonly growing salt tolerant plant barley.

MATERIALS AND METHODS

The composite soil samples were collected from Masterbagh area of Sitapur district (Uttar Pradesh, India). The study area is located between 27°27'0"N, 80°50'0"E. The average rain fall is between 105 cm to 150 cm in a semi-arid climatic conditions. The soil samples were collected by random sampling procedure for composite samples after removing surface soil upto 25 cm depth. The composite soil samples were tested for various physico-chemical properties status. The soil pH and EC (electrical conductance) were determined in saturation paste extract (1: 2.5 soil: water extract) as described by Jackson *et al* (1973). The soil organic carbon was estimated by the method of Walkley and Black as described in Piper (1967). The exchangeable sodium percentage was determined by the following formula:

$$E.S.P. = \frac{Exchangeable\ Na\ in\ meq.\ 100\ g\ of\ soil}{Total\ cation\ exchange\ capacity\ in\ meq.\ Na\ per\ 100\ g\ soil} \times 100$$

The DTPA extractable available micronutrients (Zn, Cu, and Fe) were estimated by the method of Lindsay and Norwell (1978).

The above analyzed bulk soil sample was filled in 10 kg size of clay pots (lined with alkathene). The soil in the pots were amended with integrated fertilizers and farm yard manure (FYM) viz. To (without amendment), T1 (FYM), T2 ($CaSO_4$), T3 (FYM + $CaSO_4$), T4 ($ZnSO_4$) and T5 (FYM + $ZnSO_4$). The fertilizers amended in soil were $CasO_4$ @ 100 mg/kg soil, $ZnSO_4$ @ 25 mg/kg soil and FYM @ 100 g/kg soil. The experiment was carried out in triplicate. Each pot top dressed with N: P: K @ 60: 30: 30 mg/kg soil in each pot. Ten seeds of barley (*Hordeum vulgare* L., Var. BH 393) were sown in each pot and were thinned to three after 15 days of growth. The plants were observed regularly for growth (length, tillers, fresh and dry weight yield). The visible symptoms apeared on plants observed at regular interval of times. Plants from each treatment were harvested at day 50 of the growth for analysis of biochemical parameters such as pigments (total chlorophyll, chlorophyll a and b and carotenoids content) and enzymes activity (catalase and peroxidase). Pigments content in plants was determined by the method of Lichtenthaler and Wellburn (1983). The activity of catalase (Euler and Josephson, 1959) and peroxidase (Luck, 1963) was also determined in young barley leaves.

The figures presented in the table are mean ± S.E. value (n=3). Data were statistically analyzed for standard error (S.E.) values with using student `t` test method and their significance tested at $P < 0.05$ and 0.01 levels.

RESULTS

Soil Characteristics

Composite soil sample analyzed and used for experiment was clayey loam in texture, alkaline in pH (> 8.5) with a high exchangeable sodium percentage (38). Organic matter was low (0.25 %) in soil (Table 1). The status of zinc content determined in soil was poor as compared to available iron (4.7 ppm) and copper (0.6 ppm).

Growth of Plants

The amendment of fertilizers (ZnSO4, CaSO4 and FYM) promoted growth of barley, the combined application of $ZnSO_4$ or $CaSO_4$ with FYM was observed most effective as compared to single use. The combined application of FYM and $CaSO_4$ in soil increased maximum length (+ 40%), tillering (+110.7%), fresh weight (+125%) and dry weight (+123%) of barley. The combination of $ZnSO_4$ and FYM application in experimental saline-sodic soil ranked second in promotion of measured growth parameters of barley (*H. vulgare L.*) as compared to application of $CaSO_4$ + FYM in soil.

Pigments content

The application of $ZnSO_4$, either singly or in combination with FYM, enhanced pigment content in barley leaves, particularly in promoting chlorophyll `a' content. But maximum increase in pigments content (chlorophyll a, b and total chlorophyll) was resulted at combined application of $CaSO_4$ with FYM. There was no significant increase in carotenoids content observed in barley leaves with application of above fertilizers and manures amended in saline – alkaline rated soil.

Antioxidative enzymes

The single amendment of fertilizers ($ZnSO_4$, $CaSO_4$, and FYM) in soil was not significantly effective to enhance the activity of catalase while the application of $CaSO_4$ with FYM and $ZnSO_4$ with FYM promoted activity of catalase. In case of peroxidase, the activity increases with the application of FYM alone and $ZnSO_4$ with FYM while least activity of peroxidase was observed in barley leaves in soil treated with $CaSO_4$ with FYM.

DISCUSSION

The composite soil sample analyzed (table 1) indicated characteristic of saline – alkaline soil as described in Brady and Weil (2002). Soil was poorly fertile, rated high electrical conductance, ESP (15 %) and pH in soil along with low organic matter content (< 0.4 %) and available nutrients make the soil unfertile and least productive to a large number of crops (Marschner, 1995; Pandey, 2012). The soil was poor in physical conditions and available zinc content with high percentage of calcium carbonate content, such conditions of soil adversily affects growth and yield of plants (Pandey *et al*., 2009). The soil amended with various fertilizers (FYM, $ZnSO_4$ and $CaSO_4$) to remove above problems in experimental soil resulted positive effects on growth and metabolism of test plant (*H. vulgare* L., var. BH 393). The promotion in growth and biochemical constituents in barley could be attributed due to the amendment of fertilizers were sources of various essential nutrients like zinc, calcium and sulphur (Garg and Malhotra, 2008; Pandey, 2008). The maximum growth and pigments content in barley was observed at soil amended with FYM and $CaSO_4$, which improved soil conditions with lowering sodium and calcium carbonate content and organic matter content in soil (Upadhyay and Pandey, 2011). In addition use of FYM in soil lowered the soil pH and contributed essential elements to the soil through mineralization (Marschner, 1995; Sharma, 2006). Use of $CaSO_4$ might be reduced the effect of Na^+ on availability of zinc to barley roots (Pandey, 2012), supported growth and synthesis of chlorophyll content in leaves (Blumwald, 2000; Pandey, 2008). The increased activity of catalase in barley grown at soil amended with $CaSO_4$ + FYM and $ZnSO_4$ + FYM could be due to the sufficient absorption and translocation of zinc content in barley (Sharma 2006). The reduced activity of peroxidase might be an indication of reduction of highly reactive oxygen species (ROS) (Cakmak, 2000) due to application of $CaSO_4$ alone and $CaSO_4$ with FYM in the salt affected soil (saline-alkaline soil). The increase in barley growth observed could be due to the sufficient synthesis of auxins with sufficient tissue zinc, which increases tryptophan that help in biosynthesis of auxins (Singh *et al.,* 1981). The sufficient zinc level in plants supports normal growth to the plants due to regulating normal biochemical activities by reducing reactive oxygen species in cells (Obata *et al*., 2001; Sharma, 2006).

Table 1. Physico-chemical properties of Soil used in the experiment.

Soil Textture	pH 1:2.5 soil: water	ECe dS/m)	Organic Matter (%)	CaCO3 (%)	ESP	DTPA Extractable Metals (ppm)		
						Zn	Fe	Cu
Clayey loam	8.7	3.8	0.25	1.3	38	0.38	4.7	0.6

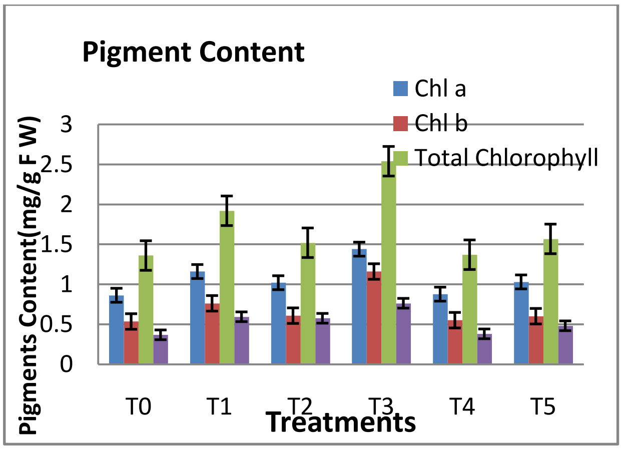

Figure 1. Effect of integrated fertilizers management of soil on pigment content in barley at 50 days of growth. **Amendments**: **To** (No fertilizers), **T1** – FYM, **T2** - **CaSO4, T3** - **FYM** + **CaSO4, T4** - **ZnSO4, T5** - **ZnSO4** + **FYM. FYM @ 100 g/kg soil, $CaSO_4$ @ 100 mg/kg soil, and ZnSO4 @ 25 mg/kg soil.**

Table 2. Effect of integrated fertilizers management in soil on growth and tillers of barley (*H. Vulgare L.*) at 50 days of growth.

Parameters/ Treatments	Height (cm)	Tillers per Plant	Fresh weight per plant (g)	Dry weight per plant(g)
T0	24.2±0.3 (0.00)	2.8±0.4 (0.00)	14.1±0.48 (0.00)	3.5±0.21 (0.00)
T1	29.3±0.6 (+ 21.07)	3.9±0.1 (+39.28)	27.9±0.31 (+97.87)	5.8±0.13 (+65.714)
T2	29.9±0.5 (+23.55)	4.3±0.4 (+53.57)	29.8±0.46 (+102.72)	6.8±0.19 (+94.28)
T3	33.9±0.1 (+40.08)	5.9±0.3 (+110.71)	33.1±0.63 (+125.17)	7.8±0.36 (+122.85)
T4	25.0±0.1 (+3.30)	2.8±0.2 (+0.0)	18.9±0.38 (+28.57)	4.7±0.12 (+34.28)
T5	30.8±0.2 (+27.27)	3.4±0.2 (+21.42)	22.5±0.44 (+53.06)	5.2±0.2 (+48.57)

Amendments: **To** (No fertilizers), **T1** – FYM, **T2** - **CaSO4, T3** - **FYM** + **CaSO4, T4** - **ZnSO4, T5** - **ZnSO4** + **FYM. FYM @ 100 g/kg soil, $CaSO_4$ @ 100 mg/kg soil, and ZnSO4 @ 25 mg/kg soil.**

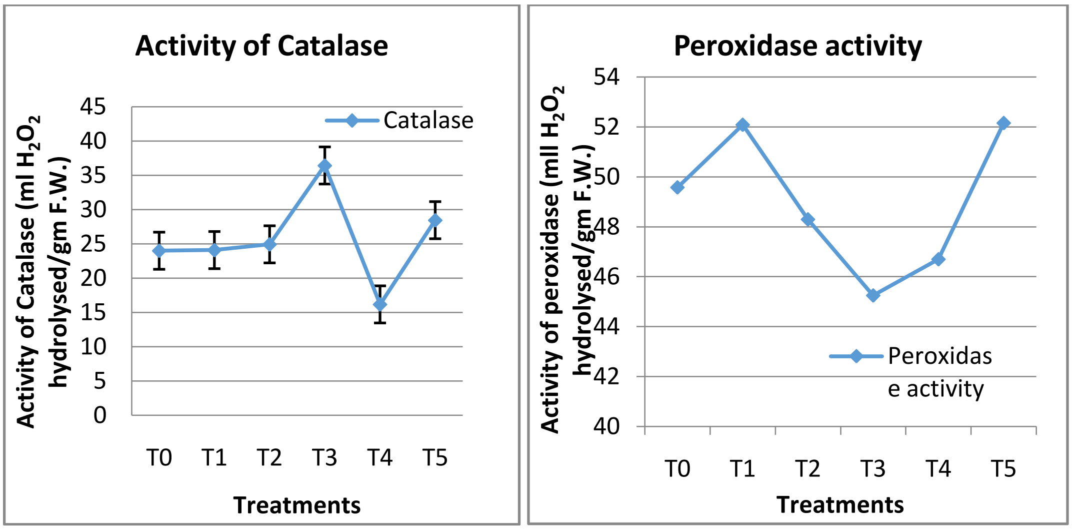

Figure 2. Effect of integrated fertilizers use in soil on (a) - Activity of Catalase and (B) - Activity of Peroxidase in barley at 50 days of growth.

Amendments: **To** (No fertilizers), **T1** – FYM, **T2** - **CaSO4, T3** - **FYM** + **CaSO4, T4** - **ZnSO4, T5** - **ZnSO4** + **FYM. FYM @ 100 g/kg soil, $CaSO_4$ @ 100 mg/kg soil, and ZnSO4 @ 25 mg/kg soil.**

CONCLUSION

The analyzed soil was saline- alkaline in nature and poorly fertile to crops growth. The amendment of FYM with $CaSO_4$ in experimental soil improved maximum growth and biochemical constituents (pigments and activity of catalase and peroxidase) in barley, as compared to FYM and $ZnSO_4$ amendment in soil. The single application of $ZnSO_4$ or $CaSO_4$ was less effective in enhancement of above parameters in barley as compared to in combination with FYM.

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