

MODULATION OF MORPHO-PHYSIOLOGICAL AND BIOCHEMICAL ATTRIBUTES OF *SOLANUM MELONGENA* L. (BRINJAL) BY EXOGENOUS APPLICATION OF THIOUREA UNDER SALINITY STRESS

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Abstract

Salinity is a major stress that lowers the plant production globally. The main purpose of present study was to overcome the adverse effects of salinity stress by foliar application of Thiourea. In this experiment Thiourea (0, 500, 1000 mM) was applied on four varieties (Bemissal, Verab, Black Round and Purple Pearl Long) of Brinjal as foliar spray to alleviate the inhibitory effects of salt stress (0mM, 200 mM). There were three replicates for each treatment. Completely Randomized Desig (CRD) was used for this experiment. The morphological and biochemical attributes of Brinjal were noted. The salinity stress caused reduction in plants fresh and dry biomass, photosynthetic pigments, total free amino acids. However, foliar spray of thiourea improved these growth attributes and activities of antioxidant enzymes i.e POD, SOD& CAT under salt stress.

Key words: Brinjal, Thiourea, Salt stress, Proline, Glycine betaine.

Introduction

Salinity is serious environmental threat as it hampers plant growth and crop yield is limited when irrigated with saline water as their roots are in direct contents to high soil salts (Qadir *et al.*, 2014; Ashraf & Ashraf, 2015). World salt affected area is increasing, where as in Pakistan the saline affected area is 10 million hector which is salinized when irrigated with canal water (Hussain *et al.*, 2013). In most of vital plant crops, overall production decrease ranges from 20% to 50% when irrigated with saline water (Shrivastava & Kumar, 2015). The abiotic climate stress for drought, salinity and high temperature impede plant yields as result of decline in organic soil contents, physical appearance of biosphere and soil texture ruins hence blocks the soil porosity which ultimately hinder normal plant growth (Ahmad *et al.*, 2013).

Salinity stress, hamper pant yields as it is concerned with alteration of various plant internal bio-physiological processes, macromolecules chemical functions, and molecular mechanism when exposed to salt stress (Perveen *et al.*, 2013; Ashraf & Ashraf, 2015). The significant physio biochemical functions of plants that are altered due to salinity in various crops showed variations (Noreen *et al.*, 2010). The physio-chemical traits overstated in plants when exposed to salinization conditions caused deterioration in synthesis of protein, hormone release (Ashraf *et al.*, 2010), plant respiration regulation (Moud & Maghsoudi, 2008), photosynthesis capacity and stomatal conductance (Saleem *et al.*, 2011), electron transport management (Perveen *et al.*, 2013), water holding capacity (Akram *et al.*, 2009), antioxidants role of enzyme (Ashraf and Akram, 2009) and plants mineral nutrition (Flowers *et al.*, 2010; Akram & Ashraf, 2011).

Vegetable crops are vital source for human food and fulfil their basic nutritional needs (Noreen & Ashraf, 2009; Mukherjee *et al.*, 2014) as many of vegetable crop shows decrease in production when cultivated in salt stress. Therefore, it needs to understand salt stress

tolerance mechanism in vital food crops in order to achieve the goal of high yield of vegetable crops. There is a basic human necessity to discover advance means to increase the tolerance mechanism of salt stress in order to increase production of food crops (Shahbaz *et al.*, 2012).

Brinjal (*Solanum melongena* L.) is well known plant of Solanaceae family and is a common poor person's vegetable crop in subcontinent. It is mostly cultivated by small peasants and consumed by low income persons. It is popular food dish of household of all societies of Indian subcontinent (Choudhary & Gaur, 2009). It is a low calories food and good in fiber contents, rich in Ca, PO₄, high in iron and possesses both Vitamins B and C (Collonnier *et al.*, 2001). Its medicinal value is high in *ayurvedic* medicine. This medicine is common in curing diabetes patient, relief in hypertension and helps to overcome obesity (Choudhary & Gaur, 2009). There is a contradictory point of view regarding Eggplant sensitivity to saline soil situation; some considered it as a temperately sensitive crop (Heuer *et al.*, 1986; Savvas and Lenz, 1996; Unlukara *et al.*, 2010) whereas other noticed Egg plant as sensitive to salinity at germination seedling stage depending upon crop variety (Akinci *et al.*, 2004).

Exogenous application of inorganic salt and organic hormones have power to overcome salt stress, that depend on the action mechanism and their property to develop plant propagation to enhance cultivation in saline soil (Wahid *et al.*, 2007; Farooq *et al.*, 2009; Srivastava *et al.*, 2009; Nawaz & Ashraf, 2010). Thiourea improved salt stress tolerance in plants, it serves as vital growth regulator and it helps plants to overcome salt stress. It can enter plant very conveniently as it can be dissolved in water. The structural formula of Thiourea consists of "thiol sulfhydryl (-SH) group", "functional amino group and carboxyl imino groups. The salts stress in plants can be overcome with thiol group and Nitrogen deficiency can be provided to crop by imino and amino groups under salt stress. Thiourea increased yields of crop depending upon plant sowing seasons, climatic conditions and soil salinity levels (Kumawat, 2004; Anjum *et al.*, 2011; Perveen *et al.*, 2015).

So, this research was conducted to evaluate the effectiveness of foliar spray of Thiourea under salt stress on morphological, physiological and biochemical attributes of this important vegetable crop i.e. Egg plant.

Materials and Methods

This pot experiment was conducted in Botanical Garden, University of Gujrat, Gujrat. Four Brinjal varieties namely Bemissal, Verab, Black Round and Purple Pearl Long, were used in this experiment. The seeds of these varieties were obtained from Ayub Agricultural Research Institute Faisalabad. There were two levels of NaCl (0, 200 mM) which were applied in soil media and three concentrations (0, 500, 1000 mM) of Thiourea were applied as spray on leaves of Brinjal. There were three replicated in this experiment. Experimental layout was Completely Randomized Design (CRD). Data for following the morpho-physiological and biochemical attributes were collected at maturity.

Morphological growth parameters: Single plant from each pot was pulled up from soil and cleaned with distilled water and carefully separated into roots and shoots and dry with tissue paper.

Biomass determination: Fresh weights of both root and shoot were determined with an electronic weight balance machine after cleaning an uprooted plant. After fresh weight calculation the samples of plant fresh root and shoot were placed in an oven at temperature of 60°C for 3 days and finally dried biomass were noted on electronic balance. Root and shoot lengths were measured manually with a scale carefully.

Measurement of chlorophyll contents: Chlorophyll contents of plants were determined by Arnon (1949) method. Green tissues (0.5 g) of leaves were cut into small pieces with scissor and sample was ground in 10 ml of 80% with pestle and mortar. After grinding the samples were filtered with filter paper and placed in refrigerator at -4°C for an overnight. The absorbance for Chlorophyll and Carotenoids pigments were noted at 645, 663 and 470 nm wave lengths on spectrophotometer. Davies (1976) procedure was used for Carotenoid contents determination.

Proline contents measurement: Bates *et al.*, (1973) procedure was followed in to measure the proline contents. Fresh leaves (0.5g) were taken and grinded in pestle and mortar. 10 ml of % solution of sulphosalicylic acid was mixed and sieved with help of filter paper. Then two ml of filtrate were mixed with 20ml 6M orthophosphoric acid, two ml of acid ninhydrin and two ml of Glacial acetic acid in a test tube. Then samples mixture was boiled at 100°C in water bath. After boiling ice bath was used to cool the test tubes and finally 4ml of toluene were added. The chromophore contain toluene was removed from aqueous phase and absorbance was noted at 520 nm by using spectrophotometer.

Enzyme assay: Green tissues (.5 g) of leaves were crushed in 5ml of buffer solution of Phosphate (50 mM). The mixed crushed sample was placed in centrifuged machine adjusted with speed of 12,000×g at temperature of -4°C for time twenty minutes. The supernatant was utilized for finding enzyme activities. The sample mixture was again centrifuged at speed of 15,000×g, at -20°C and for ten minutes. The SOD enzyme activity was determined by following Giannopolitis and Ries (1977) procedure. SOD activity was noted on spectrophotometer at 560 nm wave length. Similarly, the activity of CAT was measured by Kar & Mishra (1976) method and absorbance was noted at 240 nm. By following Chance & Maehly (1955) protocol POD activity was measured at 470 nm. The antioxidant enzymes activities were noted on their protein enzyme action bases.

Total free amino acids: Hamilton & Van Slyke (1943) method was used for total free amino acid determination. According to this method green leaves (.25g) were crushed in 10 ml of Potassium Phosphate buffer (50 mM with pH 7.8). Then added .5ml of plant buffer sample along with .5ml of 10% pyridine solutions in cultural tubes and finally added 0.5 ml of 2% Ninhydrin then centrifuged. Then mixture was heated in water bath for 30 minutes. Absorbance was noted on spectrophotometer at 570 nm.

Determination of glycine betaine: Grieve & Grattan (1983) protocol was used for determination of Glycine betaine.

Results and Discussion

In the current research, the adverse effects of saline conditions were overcome by foliar spray of Thiourea on plants by improving morphological, physiological and biochemical attributes.

In Fig. 1 elaborated that Thiourea treatment as foliar spray had overcome the adverse effects of salt stress in four varieties of Brinjal. It was observed that higher plant stem length was noted in T₄ (200 mM NaCl+500 ppm Thiourea) treatment. The highest root length was observed in T₅ (200mM NaCl +1000 ppm Thiourea). Similarly, it was found that fresh weight of shoot was observed in T₅ (200mM NaCl +1000 ppm Thiourea) treatment than other treatments. The measurement regarding root fresh weight was highest in T₄ (200 mM NaCl+ 500 ppm Thiourea) treatment. At T₅ (200mM NaCl +1000 ppm Thiourea) shoot dry weight was higher than at other treatments. While the highest root dry weight values were recorded at T₄ (200 mM NaCl+500 ppm Thiourea).

It was observed that V₃ (Black Round) Variety had highest values for most of the growth biomass attributes i.e shoot length, root length, fresh & dry shoot biomass and dry weight of root. Similarly, in V₄ (Purple Pearl Long) variety a gain in fresh weight of root was noted.

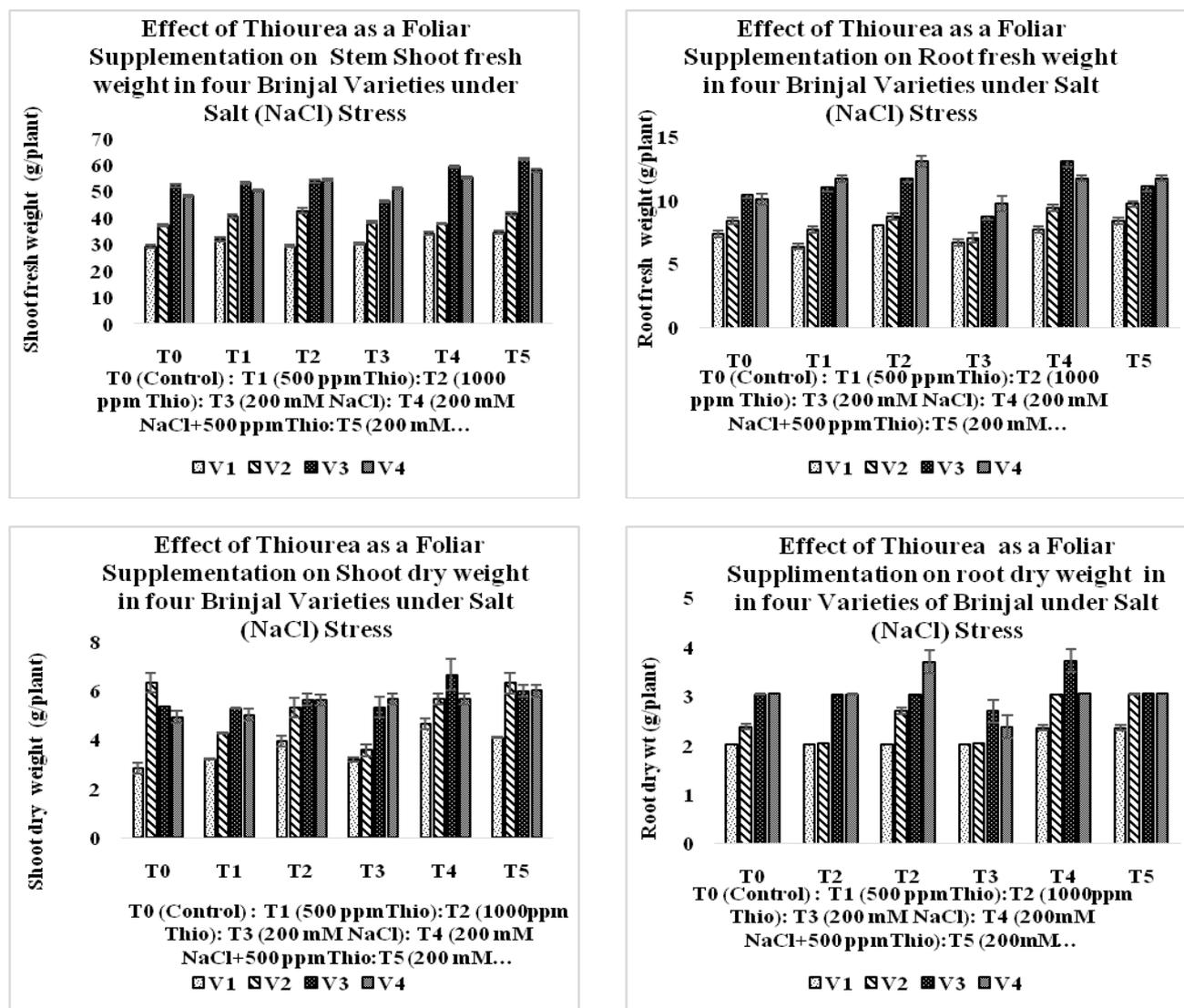


Fig. 1. Shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight of four varieties of brinjal when thiourea was used as foliar spray under salinity stress.

Analysis of Variance Table 1 showed that thiourea treatments significantly increased these morphological parameters under salt stress except root length. All four varieties differ significantly for these parameters under normal conditions. However, varieties showed non significant behavior for shoot fresh weight and root dry weight. The interaction (Thio x salt) was significant for all parameters except root length. Salt stress significantly reduced the shoot length, shoot fresh weight and shoot dry weight. Thio x salt x Var interaction was non significant for root fresh weight and root dry weight.

Similar results were found by Abou-Bakar and Sitta, 1995. They observed that Thiourea improved morphological attributes i.e maize seeds germination, fresh biomass and dry weight of stem and root in maize.

High salt concentration in soil adversely affect the regular growth in plant shoot, root and leaves due to less uptake of nutrients (Munns & Tester, 2008; Nawaz & Ashraf, 2010; Shaheen *et al.*, 2012). Plants adopt different mechanisms to avoid damage by compartmentation of Na ions inside vacuole or by excluding salt through specific ions channel mechanism response to salt stress

(Yamaguchi & Blumwald, 2005). It was revealed that reduction in plant biomass was the maximum in plants against saline conditions (Ashraf & Akram, 2009).

Improvement in biomass of shoot and root was observed when thiourea was applied under salt stress in maize This improvement was observed due to increase in capacity of root nutrients uptake (Sanaullah, *et al.*, 2016).

Similar results were noticed for study on application of Thiourea to seed of corn crop sown in saline conditions (Kaya *et al.*, 2015). Similar results were also found when Thiourea was applied to wheat crop by agronomist researchers. They found shoot and root biomass increase noted in wheat variety by (Sahu *et al.*, 2006), *Vigna radiata* plants (Mathur *et al.*, 2006), *Solanum tuberosum* (Mani *et al.*, 2012) and in *Brassica* (Pandey *et al.*, 2013). Thiourea was considered to improve in plant biomass due to its better penetration inside plant tissues and thought to be source of Carbon and Nitrogen (Mitoi *et al.*, 2009; Anjum *et al.*, 2011).

Effect of Thiourea Treatments on all Chlorophyll Contents and Carotenoids When thiourea was applied to Brinjal plants through Foliar Spray under Salt stress.

Table 1. Analysis of variance (ANOVA) data for shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight of four varieties of brinjal when thiourea was supplemented as foliar spray under salt stress.

Source	df	Mean squares values when thiourea foliar treated under salt stress					
		Shoot length (cm/plant)	Root length (cm/plant)	Shoot fresh wt. (g/plant)	Root fresh wt. (g/plant)	Shoot dry wt. (g/plant)	Root dry wt. (g/plant)
Thio	2	9.4305 ***	7.199***	183.067***	19.771 ***	3.0614 **	1.711***
Salt	1	4.351 **	.499 ns	86.054 ***	.0171ns	3.172 *	2.107 ns
Var	3	154.462 ***	18.150 ***	2172.173***	65.487***	15.444 ***	3.270***
Thio x Salt	2	4.081 ***	.223 ns	28.004***	7.831***	3.991***	1.534 ***
Thio x Var	6	5.088 ***	1.733**	18.115***	2.168 **	.467 ns	.245 *
Salt x Var	3	21.580 ***	3.219***	21.393***	.9123 ns	.585 ns	.536 **
Thio x Salt x Var	6	4.538 ***	3.195***	24.342***	1.186 ns	1.789 **	.167ns
Error	48	0.451	.494	1.709	.568	.442	.0969
Total	71						

ns = Non-significant; *, **, ***, Significant at 0.05, 0.01, .001 levels, Thio = Thiourea and Var = Varieties respectively

Fig. 2 showed that there were higher Chlorophyll 'a' contents in T₄ (200mM NaCl+500 ppmThiourea), Chlorophyll 'b' contents in T₂ (1000ppm Thiourea) and Chlorophyll 'a'/b ratio values in T₅ (200mM NaCl +1000 ppm Thiourea) when thiourea was applied as foliar spray. Carotenoids contents were highest in T₂ (500 ppm Thiourea) in four Brinjal varieties under salt stress in plants.

Among all four varieties the highest values for Chlorophyll 'a' contents were noted in V₁ (Bemissal) when Thiourea was applied as foliar spray on plants leaves to mitigate adverse effects of salt. The highest values for Chlorophyll 'b' contents were observed in V₂ (Verab) variety for foliar Thiourea application. The maximum chlorophyll contents ratio was detected in leaves of V₄ (Purple Pearl Long) variety when 1000 ppm Thiourea was applied on plant as foliar spray under saline conditions. V₁ (Bemissal) variety had highest values of Carotenoids content than other three varieties under saline conditions.

Analysis of Variance (ANOVA) table 2 elaborated that interactions were highly significant when Thiourea was applied in foliar form for Chlorophyll 'a' contents to alleviate salt stress. However, the interactions between Salt and Variety did not differ from each other significantly. Data in table 02 regarding Chlorophyll 'b' contents also revealed that values significantly differ except for Salt and Thiourea interactions. Statistical data regarding Chlorophyll 'a'/'b' ratio cleared that values of treatments were highly significant. It was established that all values for interactions found non-significant for Carotenoids contents. The varieties and treatments interactions did not differ from each other significantly.

Previously, it was reported that adverse conditions due high salt conc causes direct damage to green pigment by rupturing chlorophyll thylakoid membrane that is pigment site, decrease photosynthesis activity and ultimately plant yield (Noreen *et al.*, 2010). In view of various scientific researches a direct link occurs between green pigments of Chlorophyll contents and photosynthesis in plants propagated under saline conditions (Liu & Shi, 2010; Gupta & Huang, 2014). For instant when working with safflower, Siddiqui & Ashraf, (2008) stated that salinity causes decline in photosynthesis rate of crop. Similar results were noted for decrease in Chlorophyll pigment in Pistachio (Hajiboland *et*

al., 2014) and sunflower (Akram & Ashraf, 2011). However, opposite results were noted by Saleem *et al.*, (2011) in Okra sown in saline soil only eminent decline in Chlorophyll 'b' but no any changes observed in Chlorophyll 'a' contents. However, while working with maize (Nawaz & Ashraf., 2010) found a considerable reduction in crop biomass as result of salinity. In *Solanum melongena* L. salt stress lowered plants photosynthesis rate under saline stress (Shaheen *et al.*, 2012).

In view of various findings organic chemicals compounds exogenously applied to alleviate the salt injurious consequence on leaf are associated with decline in chlorophyll pigments and number of studies conducted by various researches (Nawaz & Ashraf, 2010; Ashraf and Harris, 2013; Yıldızgüç *et al.*, 2014). In the same way, a study was conducted by Anjum *et al.*, (2011) where they applied foliar spray of 10 mMThiourea and noted enhance growth in wheat cultivars under salinity (120 mMNaCl) stress. In Phragmites karka alleviating salinity effect was observed by application of Thiourea (Zehra *et al.*, 2013). In latest research Kaya *et al.*, (2019) noted alleviation of salinity by combined foliage spray of nitric oxide and thiourea organic compound on maize sown in saline conditions.

Our present research was supported out to appraise that foliarly supplemented Thiourea enhanced the pigments of leaf and carotenoids contents of egg plants.

Effect of Thiourea Treatments on Amino acid, Proline and Glycine betainecontents When thiourea was applied to Brinjal plants through Foliar Spray under Salt stress.

From Fig. 3 showed that there was a high Amino acid contents at T₄ (200 mM NaCl+500 ppmThio) in four varieties under saline conditions when Thiourea was foliar supplied to plants. In contrast least Amino acids conc was noted in T₃(200 mMNaCl) treatments. The V₁ (Bemissal) variety had high concentration of Amino acids contents under salt stress when compared with other three varieties (Fig. 4.03). In similar conditions increase in proline contents was observed in T₃(200 mMNaCl) treatments and variety V₁ (Bemissal) leaves had higher proline contents when Thiourea was applied as foliar spray. It was demonstrated that salt (NaCl) induced remark increase in GB contents at T₃ level in all four varieties. However, highest GB contents was observed in V₃(Black Round) variety.

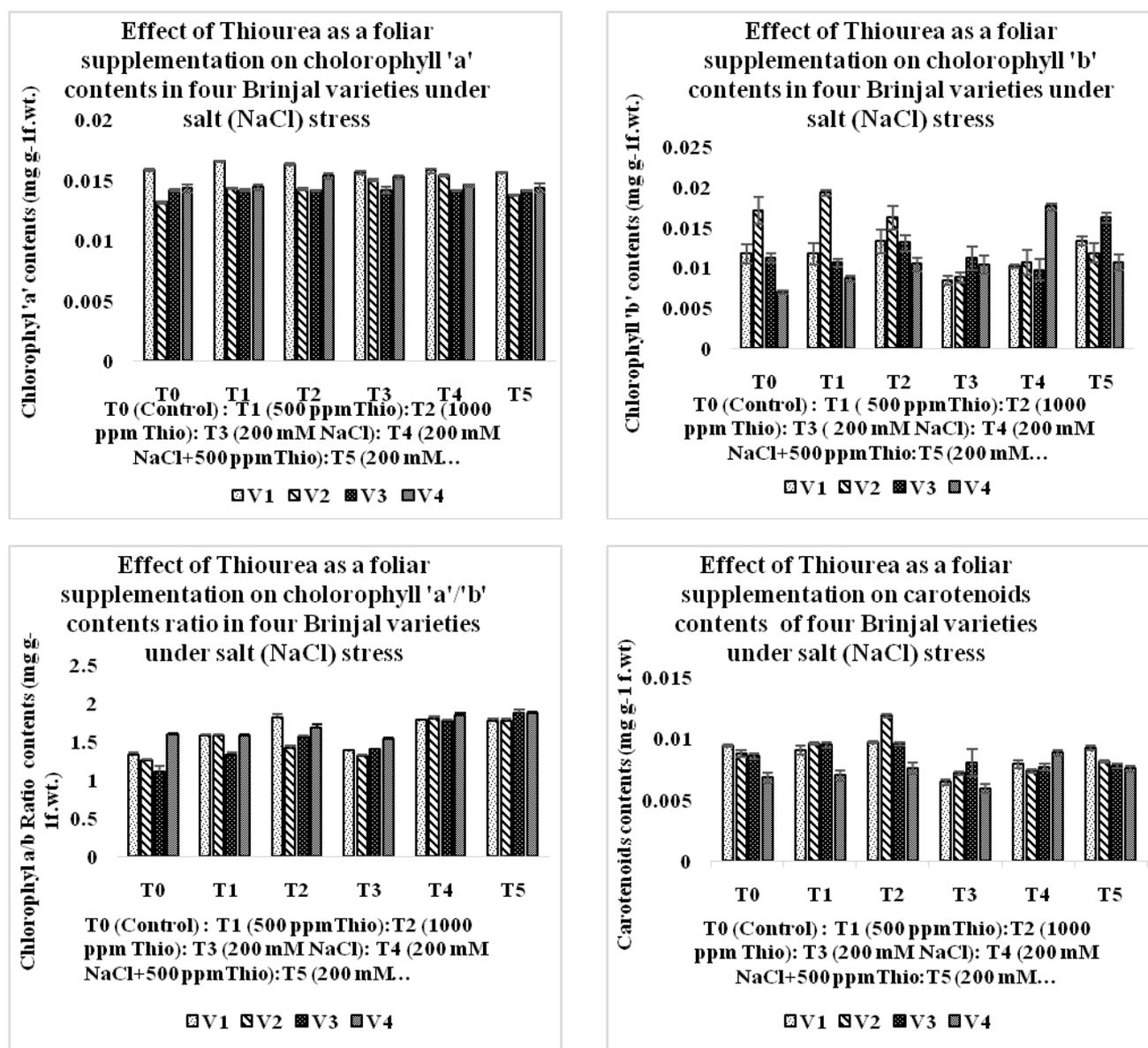


Fig. 2. Chlorophyll 'a', 'b' contents, 'a'/'b' ratio of chlorophyll contents and carotenoids of four varieties of brinjal when thiourea was used as foliar spray under salinity stress.

Table 2. Analysis of variance (ANOVA) data for chlorophyll 'a', 'b' contents, 'a'/'b' ratio of chlorophyll overall contents and pigments of carotenoids of four varieties of brinjal when thiourea was supplemented as foliar spray under salt stress.

Source	df	Mean Squares Values when Thiourea treated foliar parts under salt stress			
		Chlorophyll a contents (mg g ⁻¹ f.wt.)	Chlorophyll b contents (mg g ⁻¹ f.wt.)	Chlorophyll 'a'/'b' ratio contents (mg g ⁻¹ f.wt.)	Carotenoids pigment contents (mg g ⁻¹ f.wt)
Thio	2	3.261*	3.551**	0.949***	1.097 ns
Salt	1	7.320**	1.555 ns	0.712***	1.722 ns
Var	3	7.019 ***	3.383 **	0.100***	1.408 ns
Thio x Salt	2	3.681 **	5.819 ns	0.0468 ***	6.761 ns
Thio x Var	6	2.024*	1.661 *	0.0297 ***	1.114 ns
Salt x Var	3	3.101ns	1.008 ***	0.0581 ***	1.269 ns
Thio x Salt x Var	6	3.054**	1.424 *	0.0137 *	1.290 ns
Error	48	6.805	6.028	0.005	1.060
Total	71				

ns = Non-significant; *, **, ***, Significant at 0.05, 0.01, 0.001 levels, Thio = Thiourea and Var = Varieties respectively

Table 3. analysis of variance (ANOVA) data for total free amino acids, proline contents and glycine betaine contents of four varieties of brinjal when thiourea was supplemented as foliar spray under salt stress.

Source	df	Mean squares values when Thiourea treated foliar part under salt stress		
		Total free amino acids (mg/100g)	Proline contents ($\mu\text{mol/g f.w}$)	Glycine betaine ($\mu\text{g g}^{-1} \text{f.w}$)
Thio	2	0.389 ***	5.111 ns	0.001 **
Salt	1	0.098 ***	1.388 ns	0.003 **
Var	3	0.518 ***	2.099 ns	0.036 ***
Thio x Salt	2	0.345 ***	2.51 ns	0.068 ***
Thio x Var	6	0.426 ***	1.27 ns	0.0149***
Salt Var	3	0.249 ***	2.546 ns	0.022 ***
Thio x Salt x Var	6	0.104***	4.804 ns	0.0171 ***
Error	48	.007	2.129	3.485
Total	71			

ns = Non-significant; *, **, ***, Significant at 0.05, 0.01, .001 levels, Thio = Thiourea and Var = Varieties respectively

Table 4. Statistical analysis data (ANOVA) for SOD, POD and CAT activity of four varieties of brinjal when thiourea was supplemented as foliar spray under salt stress.

Source	df	Mean squares values when thiourea treated foliar part under salt stress		
		SOD activity (units/mg protein)	POD activity (units/mg protein)	CAT activity (units/mg protein)
Thio	2	0.001**	0.002 **	0.003 ***
Salt	1	0.002**	0.030***	0.023 ***
Var	3	0.034 ***	0.002 **	0.0016 **
Thio x Salt	2	0.002 ***	0.006 ***	0.008 ***
Thio x Var	6	0.002 ***	0.005 ***	0.002 ***
Salt x Var	3	0.003 ***	7.673 ns	0.006 ***
Thio x Salt x Var	6	0.001**	0.005 ***	7.965 ns
Error	48	2.824	3.996	3.538
Total	71			

ns = Non-significant; *, **, ***, Significant at 0.05, 0.01, .001 levels, Thio = Thiourea and Var = Varieties respectively

The statistical Analysis of data showed in table 3 regarding Amino acid contents that there was highly significant difference for all treatments when Thiourea was applied to plants under saline conditions. The data showed that all interaction of treatments for free proline contents were not significant. However, for GB contents all treatments were highly significant.

Amino acids are required for normal plants growth under abiotic stress. Decline in normal plant growth and decrease in amino acids concentrations was noticed in wheat (Lesko *et al.*, 2002; Leasko & Simno-Sarkadi, 2003). The vital role of amino acids, especially of proline and GB is important to release the plant cells component from the antagonistic salinity (Hu *et al.*, 2012; Liang *et al.*, 2013).

Recent research revealed that salinity causes a remarkable increase in free proline contents in Pistachio plants (Zahra *et al.*, 2018). Proline is considered as biochemical compatible osmolyte that safe plants under abiotic stress by protecting enzyme, scavenge free radicals' ions, maintain cellular optimum pH and keeps cellular redox balance (Verbruggen & Hermans, 2008; Shamshiri & Fattahi, 2014).

Under salt stress osmolytes especially GB and proline accumulated to overcome stress by maintain osmotic balance condition (Ashraf & Foolad, 2007; Taiz *et al.*, 2015; Rasheed *et al.*, 2016). External supplemented organic compounds and fertilizers applied to handle deteriorate effect of salinity by balancing water relation inside cell and ions transport channel flow entering nutrients and release harmful ions outside plants (Zhu, 2002; Larher, 2003; Kaymakanova & Stoeva, 2008).

In tobacco plants application of bio-regulator Thiourea reduced salt stress in cells by increasing the production of osmolyte proline and glycine betaine (Banu *et al.*, 2010). Mahatma *et al.*, (2009) noted that foliar spray of Thiourea result in enhancement of amino acid concentration that was helpful to fight saline conditions. In the same way Thiourea supplemented to soil seed and foliar spray to external leaf part of plant or through seed treatment of fertilizer results in increase Amino acid of plants studied by Garg *et al.*, (2006). In recent present research Thiourea enhanced organic component of Brinjal plants sown in saline conditions.

Effect of Thiourea Treatments on SOD, POD and CAT enzymes activity When thiourea was applied to Brinjal plants through Foliar Spray under Salt stress.

It was observed that there was higher SOD activity noticed at T₃ (200 mMNaCl), POD showed maximum activity at T₃ (200 mMNaCl) and CAT values at T₄ (200mM NaCl +500 ppm Thiourea) when Thiourea was applied as foliar spray under salt stress (Fig. 4).

Among all four varieties the highest values for SOD activity was noted in V₁ (Bemissal) as shown in Fig. 4 when Thiourea was applied as foliar spray to mitigate the adverse effect of salt. The highest values for POD activity were observed in V₁ (Bemissal). The maximum CAT activity was recorded in V₄ (Purple Pearl Long) leaves of of Brinjal variety when Thiourea was applied as foliar spray under saline conditions.

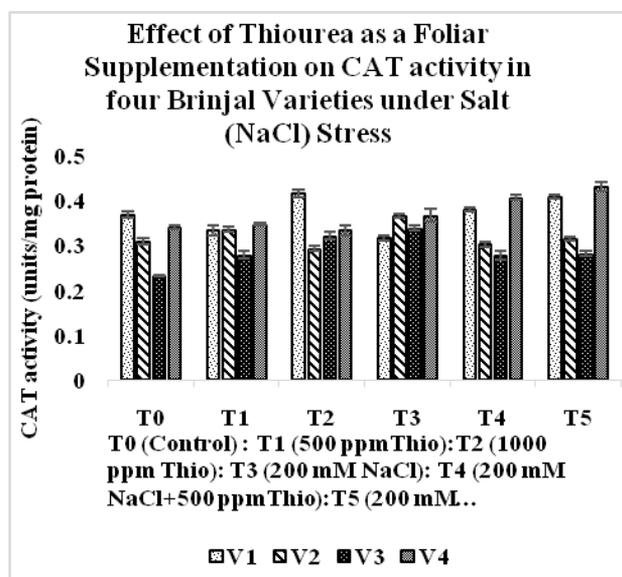
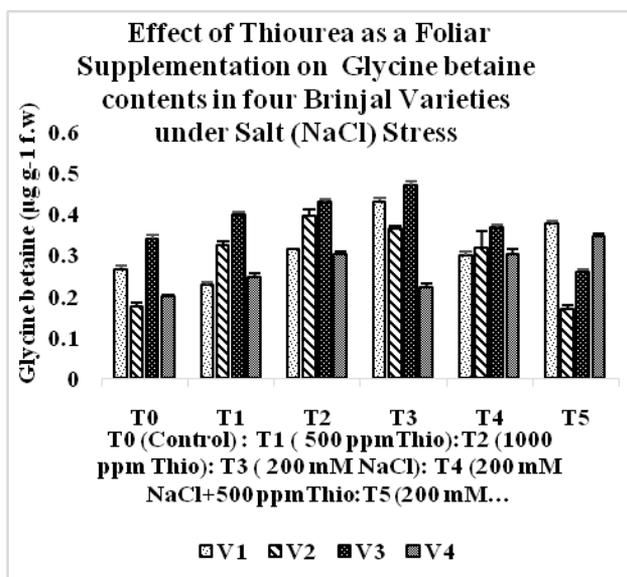
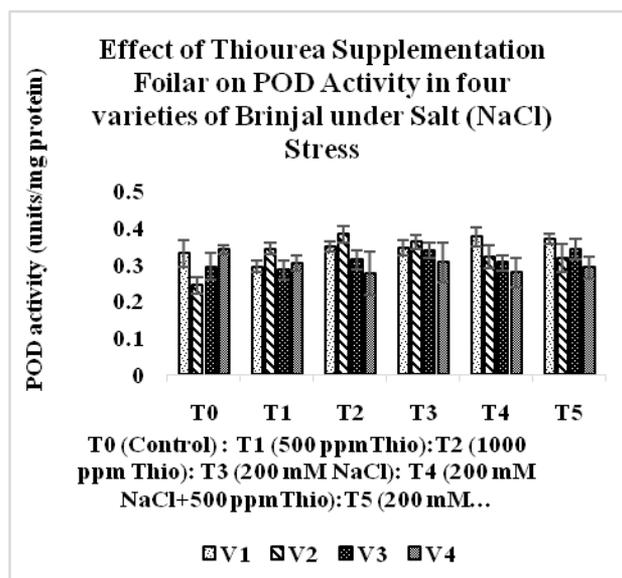
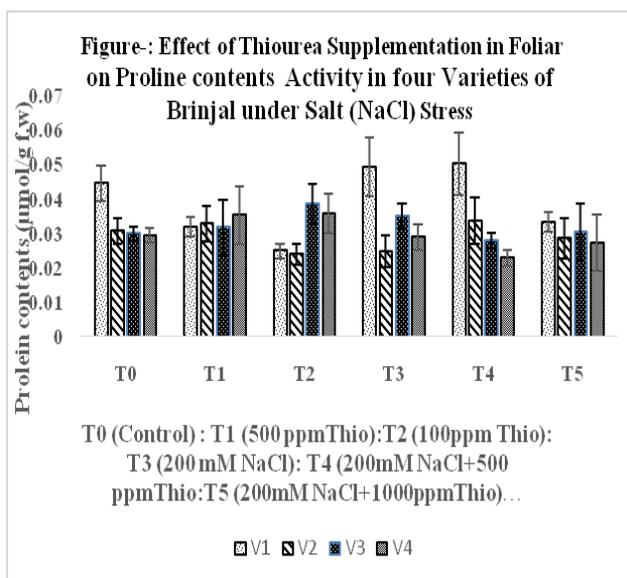
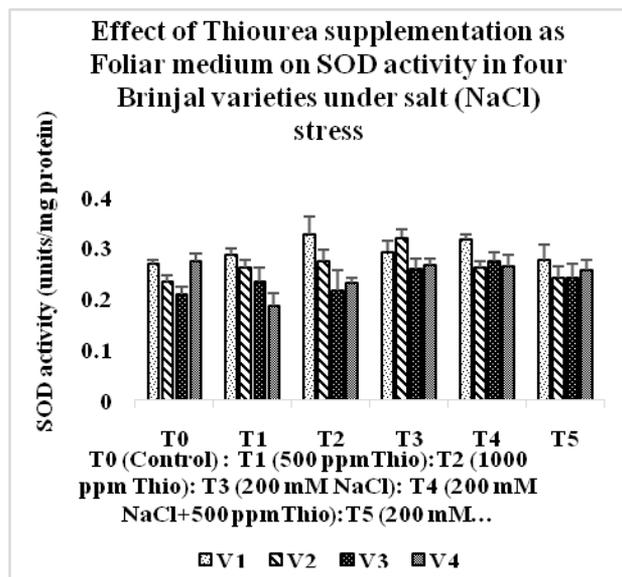
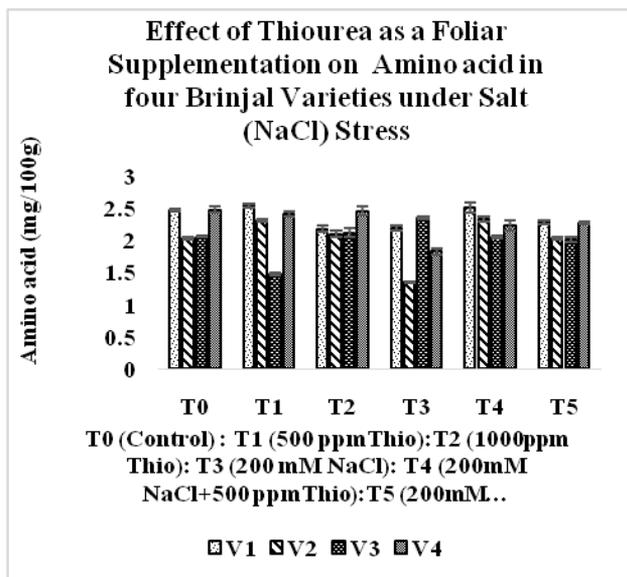


Fig. 3. Total free amino acids, proline contents and glycine betaine contents of four varieties of brinjal when thiourea was used as foliar spray under salinity stress.

Fig. 4. SOD, POD and CAT activities of four varieties of Brinjal When Thiourea was used as Foliar Spray under Salinity Stress.

Analysis of Variance (ANOVA) Table 4 showed that all levels of treatments were significant when Thiourea was applied in foliar form for SOD to alleviate the adverse effects of salt stress. The data in table 4 also revealed that treatments levels were significantly different except for Salt and Variety interactions when observed for POD activity. Analysis of data for CAT cleared that most of treatments were highly significant except for Thiourea x Salt x Variety interactions.

The studies report regarding physiological adjustment of crops to cope with abiotic stress depends on production and enzymatic actions of SOD, POD and CAT (Ramachandra *et al.*, 2004; Chutipajit *et al.*, 2009). The well-known antioxidants POD, CAT and SOD act as scavenge for reactive oxygen species that are helpful to survive under salt stress and their plant production increased under stress conditions (Li *et al.*, 2010; Wahid *et al.*, 2014).

It was noticed that salt stress in maize crop causes elevated antioxidants activities (Liang, 2010). Hydrogenperoxide (H₂O₂) is broken down into simple water and oxygen molecule by action of CAT in wheat salt tolerant varieties (Zheng *et al.*, 2009). In *Medicago sativa* POD is an active antioxidant against salt stress especially, by scavenges H₂O₂ by process of oxidation (Li *et al.*, 2010).

The fertilizer Thiourea serve as an active growth regulator as it alleviates the adverse effects of abiotic stress in various plants by increasing the production of antioxidant actions in crops (D'Souza *et al.*, 2004; Garg *et al.*, 2006; Sahu *et al.*, 2006; Nathawat *et al.*, 2007). The salt stress creates oxidative devastation in maize as stated by Sanaullah *et al.*, (2016), but foliage spray of thiourea ensure the availability of nitrogen element and the thiol derivatives group, that helps plants to tolerate oxidative stress and improves its physiological growth. Our present research work was in according the previous study work that Thiourea reduced the the impacts of oxidative stress.

Conclusion

It is concluded that foliar application of Thiourea alleviate the inhibitory effects of salt stress in four varieties of Brinjal by improving morphological, biochemical and antioxidant activities. It was observed that V₃ (Black Round) Variety possessed highest values for most of growth biomass morphological attributes at 1000 ppm of Thiourea level under salt stress. For Chlorophyll 'a' contents were noted in V₁(Bemisal), Chlorophyll 'b' contents were observed in V₂(Verab) and Chlorophyll contents ratio detected in leaves of V₄ (Purple Pearl Long) variety when 1000 ppm Thiourea was applied as foliar spray under saline conditions.. Finally, it was observed that morphological and biochemical data depict that Foliar supplementation of Thiourea was fruit full to eliminate adverse effects of salt stress in Brinjal plant.

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