Tea Research Institute of Sri Lanka

Can Salicylic Acid Application Induce Drought Tolerance in Immature Tea Plants?

Project Team

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Overview

- Drought impact on Tea
- Drought Mitigation Strategies
- Salicylic acid (SA)
- Exogenous SA Application
- Objective
- Experiments
- Materials and Methods
- Results and Discussion
- Benefits of SA Application
- Conclusions
- Future Directions

Drought Impacts on Tea

Rain-fed plantation crop

- Climate change impacts on tea

Frequent and prolonged dry spells,

- 1992, 2016 and 2024

Reduction of crop

- Reduction of crop (i.e. 1983- 4%, 1992- 26%, 2016-11%)
- 15 - 40% in different cultivation areas in different parts of the world

Casualties

- New clearings during 1991 were wiped out entirely due to the drought occurred in 1992

Necessary to take timely provisions to minimize long-term and short-term drought effects to sustain yield

Drought Mitigation Strategies

- Planting of drought tolerant cultivars
- Following proper agronomic practices (mulching etc.)
- Irrigation
- Spraying of 2% K+

Foliar application of SOP or MOP prior to anticipated drought

- Exogenous application of plant hormones

Salicylic acid (SA)

Abscisic acid (ABA)

Gibberelic acid (GA)

Salicylic Acid (SA)

- SA is an endogenous growth regulator
- Produced by the plant naturally
- Phenolic acids

It plays an important role in regulating,

- Plant growth
- Development
- Regulation of physiological processes in plants such as: growth, photosynthesis, and metabolic processes
- Improves plant resistance to biotic and abiotic stresses

Exogenous SA Application

Plant	Parameters considered
Gardenia *(Gardenia jasminoides)*	Gas exchange parameters, chlorophyll, relative water content, proline accumulation and activity of antioxidant enzymes
Rubber *(Hevea brasiliensis)*	Stomatal conductance and biomass accumulation
Red bayberry *(Myric rubra)*	Gas exchange parameters, chlorophyll content and relative water content
Tomato *(Lycopersicon esculentum)*	Gas exchange parameters, membrane stability, water potential and activity of antioxidant enzymes

Objective

To evaluate the potential of exogenous Salicylic acid (SA), application on improving survival and productivity under short-term drought conditions in immature tea

Experiments

Experiment 1

Effect of exogenous application of salicylic acid (SA) on alleviation of drought stress of immature tea plants (Under glasshouse condition)

Experiment 2

Plant hormonal regulation on physiological changes in field grown immature tea plants during drought stress

Materials and Methods

1

Application of SA on alleviation of drought stress of immature tea plants Glasshouse trial (At TRI)

One year potted plants (TRI 2025, TRI 2023)

RCBD

2 blocks and 24 replicate plants per cultivar per treatment

- Exposed to drying cycle No Spray (NS)
- 0 (Water-Spray = WS)
- 50, 100, 150, 200 mg L^{-1}
- Well Watered (WW)

2

Plant hormonal regulation on physiological changes in field grown immature plants (At Field No 8NC, Fairfield Division, Bearwell Estate, Talawakelle)

Three-year-old plants

RCBD - 3 Blocks

- At moderate moisture stress (25% moisture reduction)

Foliar sprayed

- SA in selected concentrations
- Water-spray (WS)
- No-spray (NS) treatments

Data were collected at 7days, 14 days and 21 days after applying the treatments (DAS) from randomly selected plants

Parameter	Effect
Leaf relative water content	Optimum physiological functioning, growth and survival
Gas exchange parameters	Plant growth and production
Osmolytes (Leaf total soluble sugar content and leaf proline content)	Compatible solutes accumulate /plant self-protective mechanisms
Starch content	Contributes to plant growth and survival
Pigments (Chlorophyll a, b and carotenoid)	Can induce the tolerance of plants to drought
Antioxidant activity	Plants can scavenge ROS by producing antioxidants
The dark respiration	Contributes to drought tolerance by reducing the consumption of soluble sugars
Recovery of plants	Glasshouse trial: At 21 DAS, plants were re-watered, visually assessed after another 7 days Field trial: after rain
Soil moisture	

Data Analysis

Drought Tolerance Index for each treatment calculated using the corresponding values of well-watered plants taken as the reference

$$DTI_P = \frac{X_P}{W_P}$$

DTI_P = Drought Tolerance Index for Photosynthetic rate

X_P = Photosynthetic rate of specific treatment at a particular measurement interval

W_P = Corresponding Photosynthetic rate of WW condition at the same measurement interval

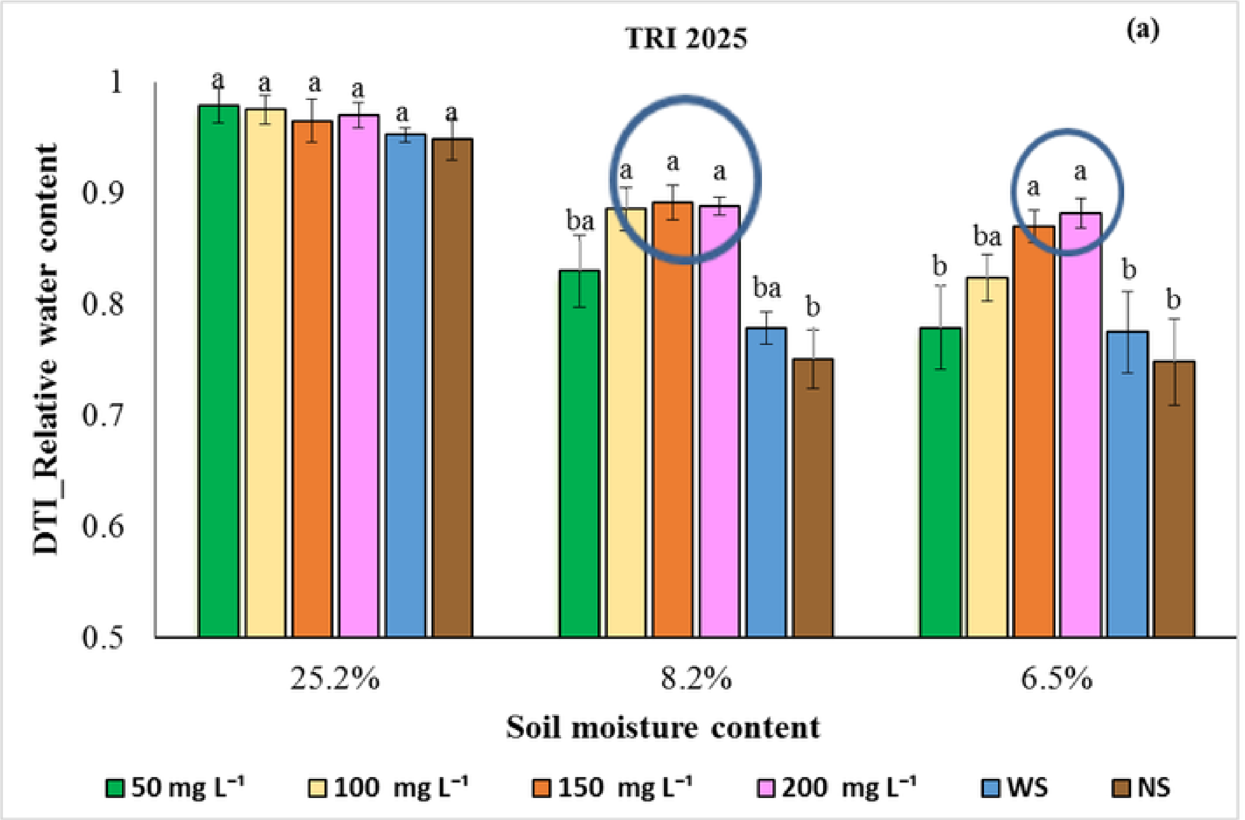
(Cheruiyot et al., 2007; Al-Azab et al., 2022)

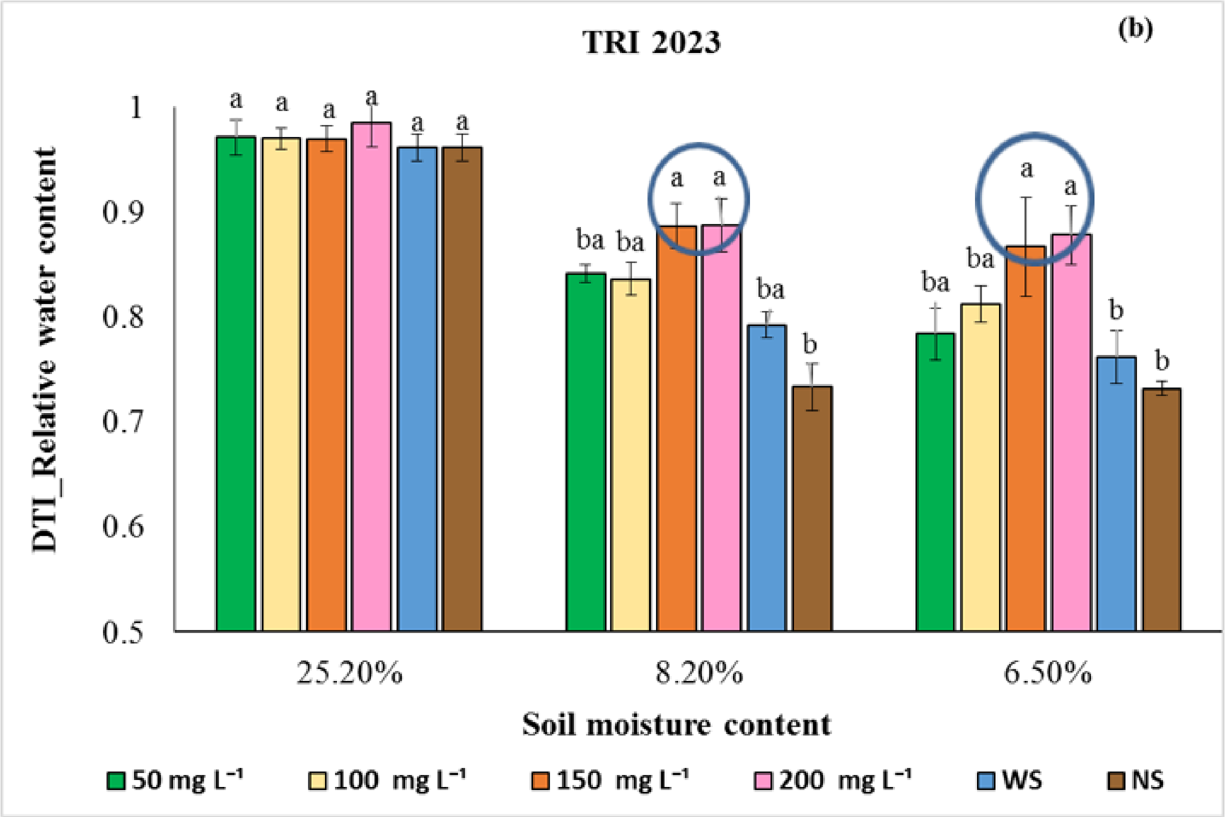
  

Results and Discussions

Glasshouse Experiment - RWC

- Relative water content (RWC) - Amount of water in a leaf at the time of sampling relative to the maximal water a leaf can hold.
- RWC - Measure of internal plant water status and reflects metabolic activity of tissues
- Exogenous SA application helps the plants for better maintenance of DTI for RWC



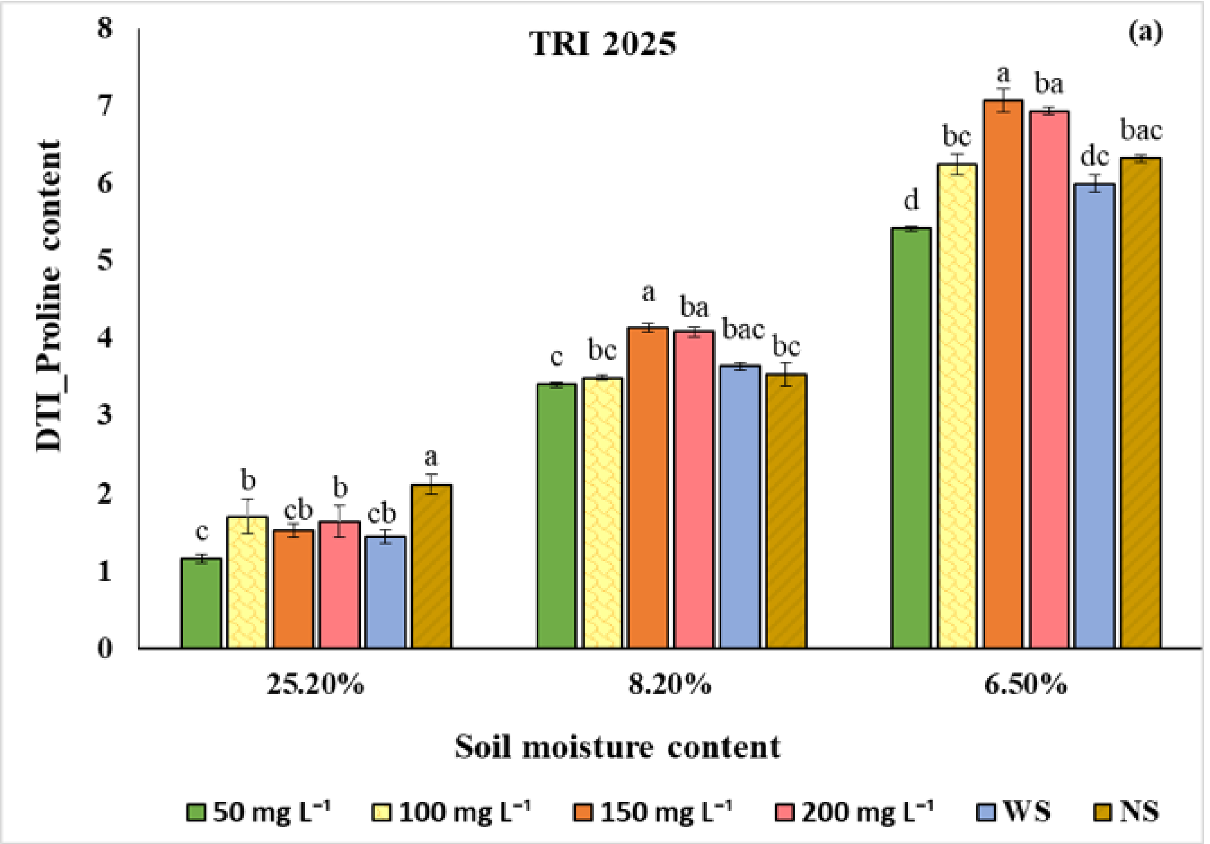


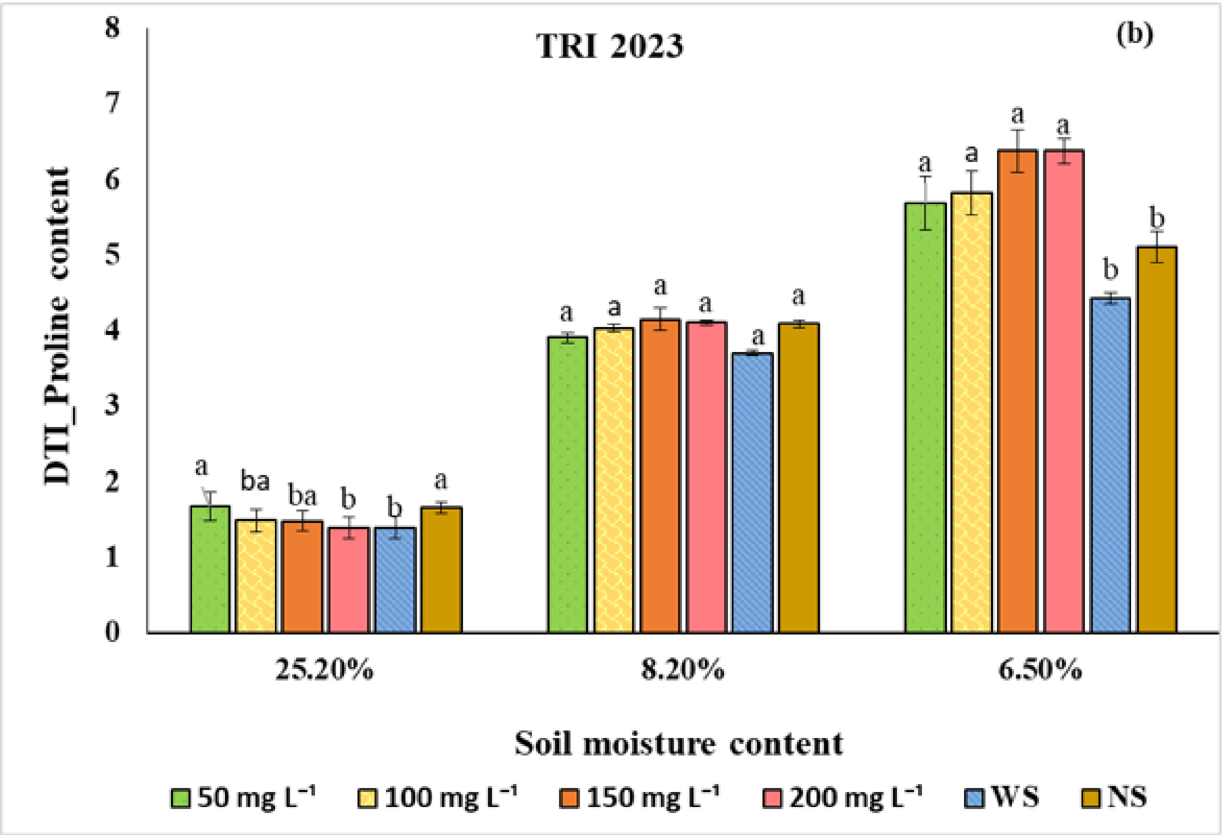
Field Experiment - RWC

Relative water content (%)			
Treatment	Soil moisture content (%)		
	27.6	25.0	16.6
SA	85.33	**83.68**	**83.45**
WS	84.62	81.99	81.55
NS	84.37	81.80	81.43

- RWC declined with the progression of drought
- SA treated plants showed significantly the highest RWC
- Maintenance of higher RWC - indication of more tolerance to drought
- It influences the capability of the plant to recover from stress condition and yield stability

Glasshouse Experiment - Osmolytes Accumulation





- The accumulation of compatible solutes - Play an important role in the plant self-protective mechanisms
- Osmotic adjustment - Important adaptive response to abiotic stress, enhancing plant function and survival during periods of drought

Field Experiment - Osmolytes Accumulation

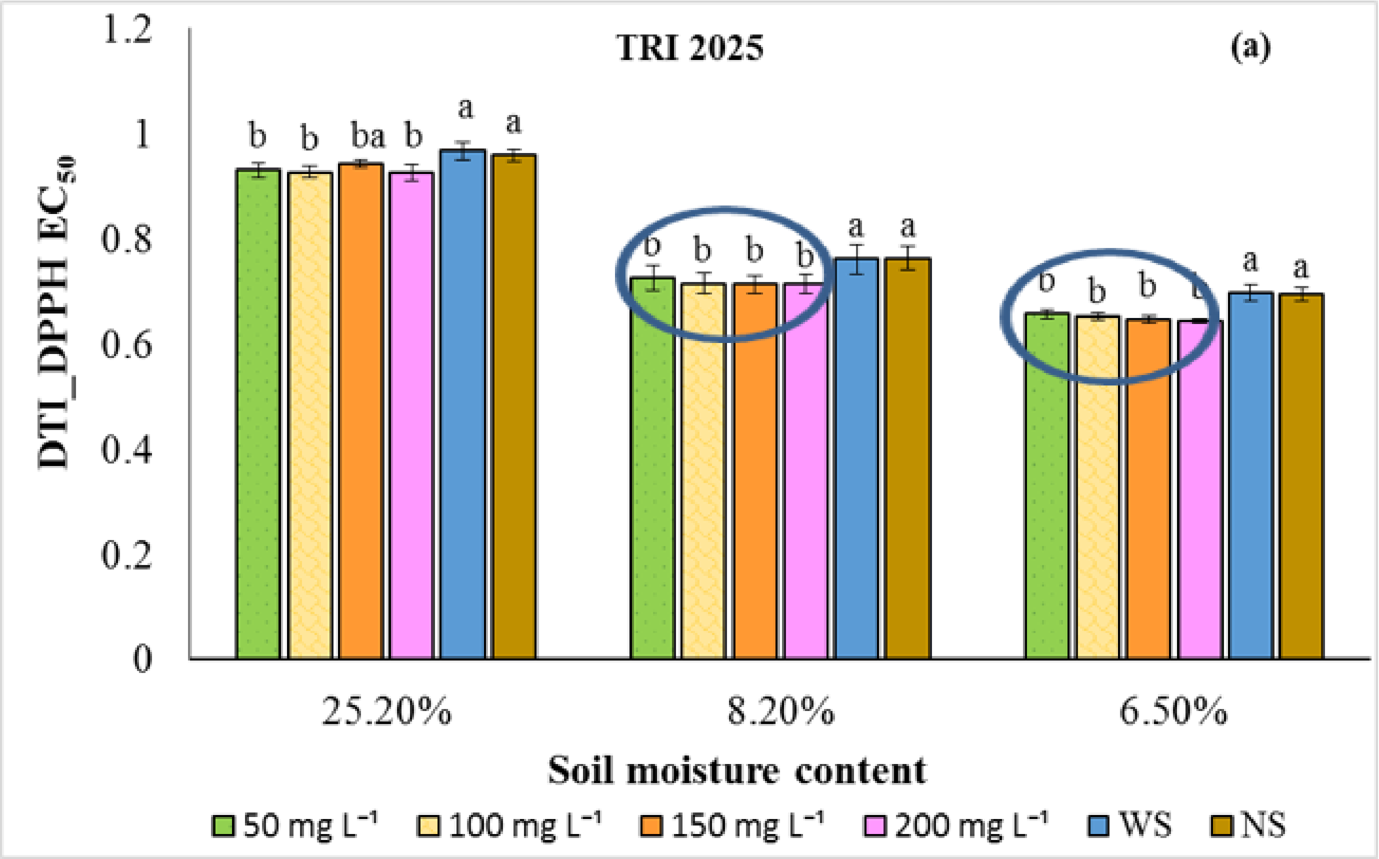
Treatment	Proline content ($\mu g\ g^{-1}$)		
	Soil moisture content		
	27.6%	**25.0%**	**16.6%**
SA	48.01	**91.07**	**123.48**
WS	45.50	81.64	108.44
NS	50.27	90.87	116.37

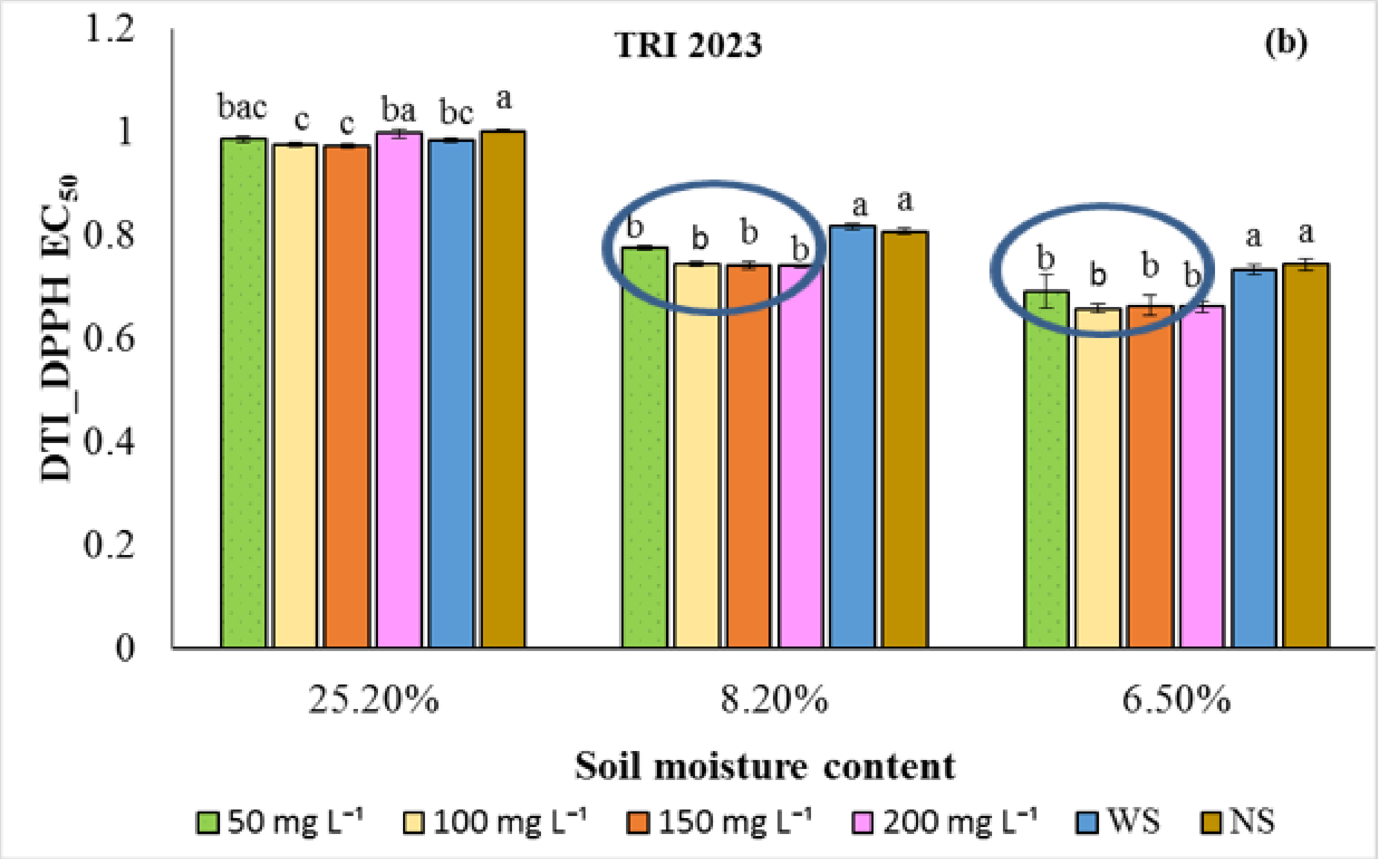
Osmotic adjustment → Cell osmotic potential → Maintain cell turgor and physiological processes under short-term drought stress condition

- SA induced osmolytes accumulation partly increases the osmotic adjustment which helps the plants for better survival under drought condition.

Glasshouse Experiment - Antioxidant Activity

- Plant cells produce oxygen radicals and their derivatives are called reactive oxygen species (ROS)
- Abiotic stresses induce the overproduction of highly reactive and toxic ROS
- ROS can cause serious damage to DNA, RNA, protein, lipids, pigments and eventually cell death
- Plants scavenge ROS by producing antioxidants
- Antioxidants play a critical role in the alleviation of abiotic stresses





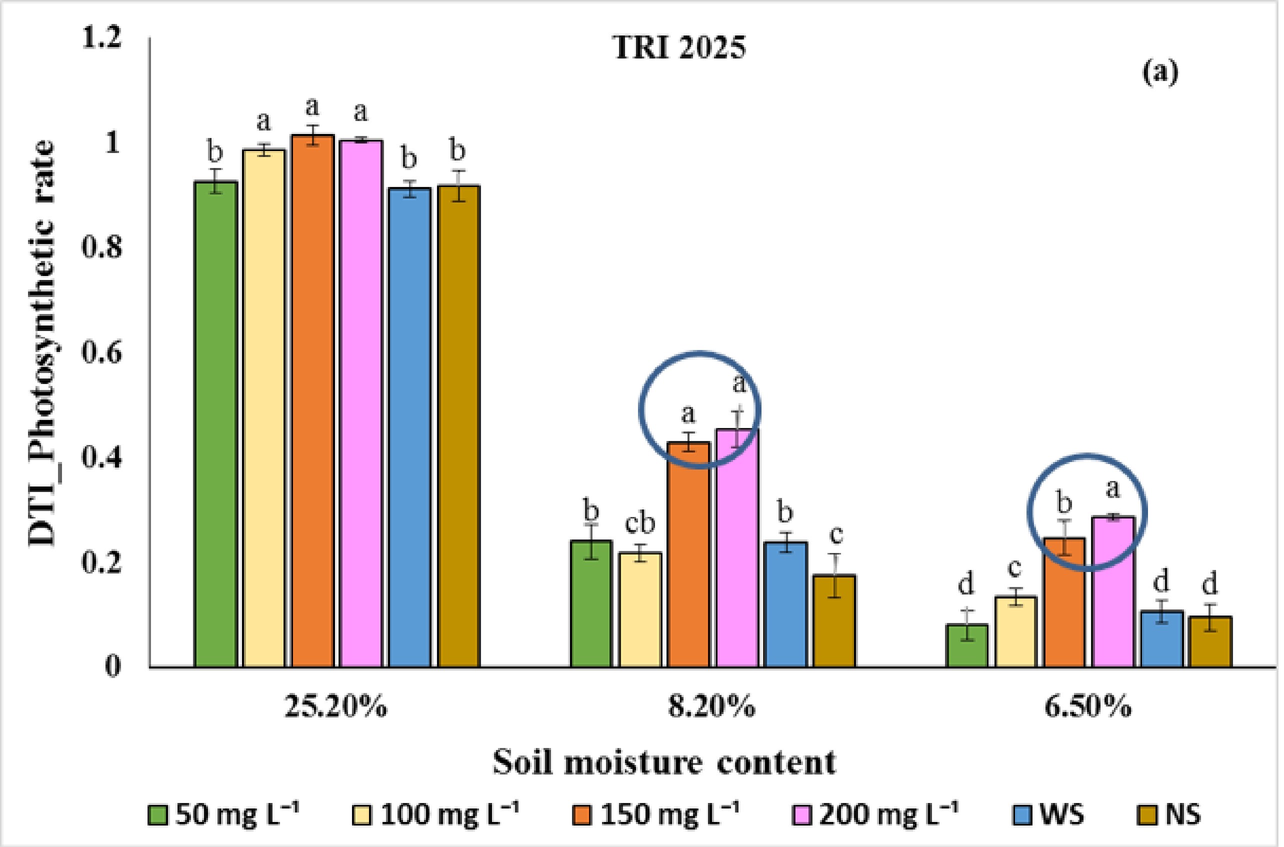
Field Experiment - Antioxidant Activity

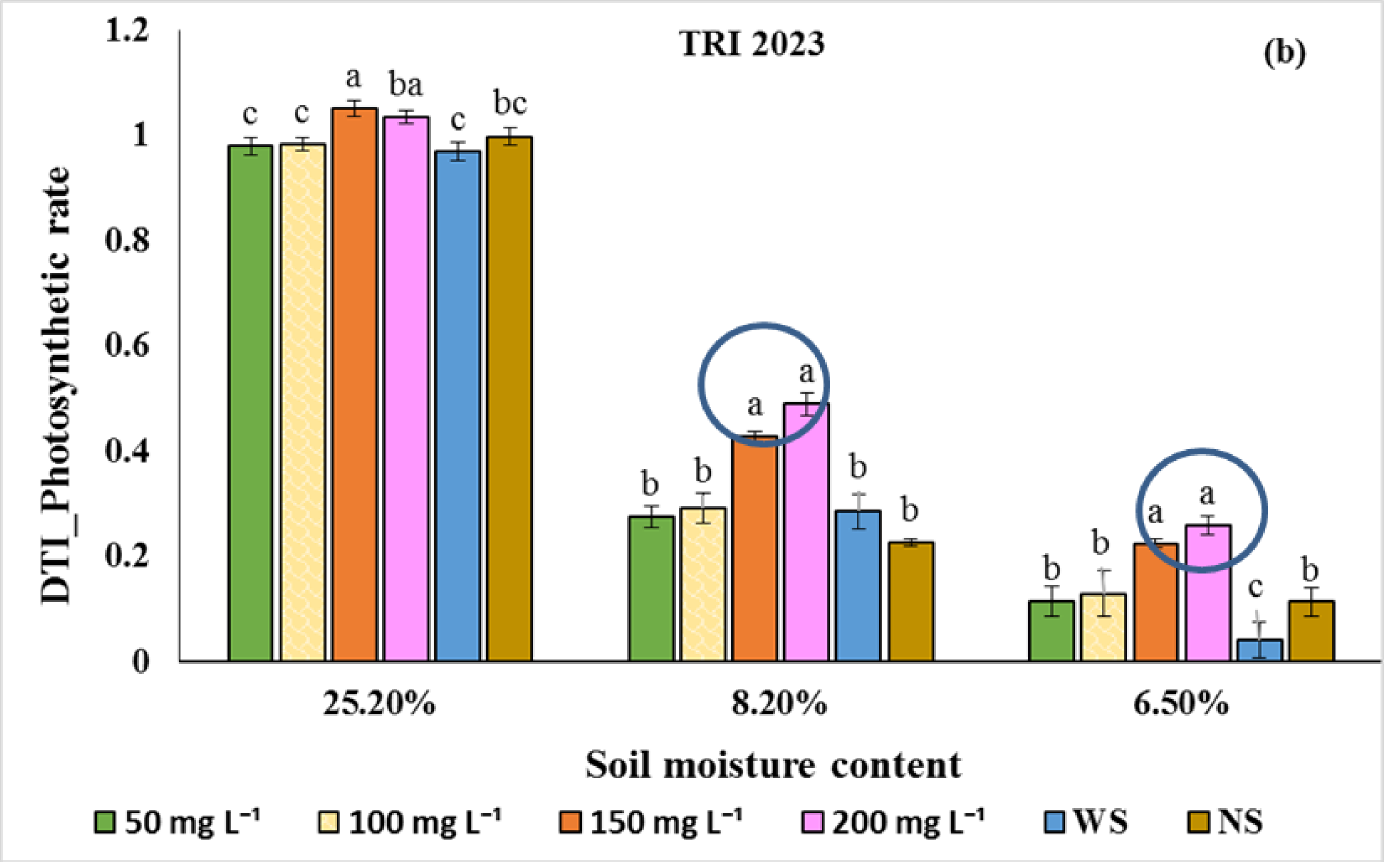
Treatment	DPPH EC50 value			FRAP value		
	Soil moisture content			Soil moisture content		
	27.6%	25.0%	16.6%	27.6%	25.0%	16.6%
SA	203.10	161.81	108.00	141.88	163.48	184.19
WS	220.42	169.08	123.26	137.47	159.96	180.57
NS	221.90	169.67	114.90	137.52	159.80	181.31

- SA treated plants exhibited the highest antioxidant activity (i.e the lowest DPPH EC_{50} value)
- SA treated plants showed significantly the highest FRAP value
- An ability to maintain the antioxidative mechanisms during drought has usually been associated with a rapid recovery of plants

Glasshouse Experiment - Gas Exchange Parameters

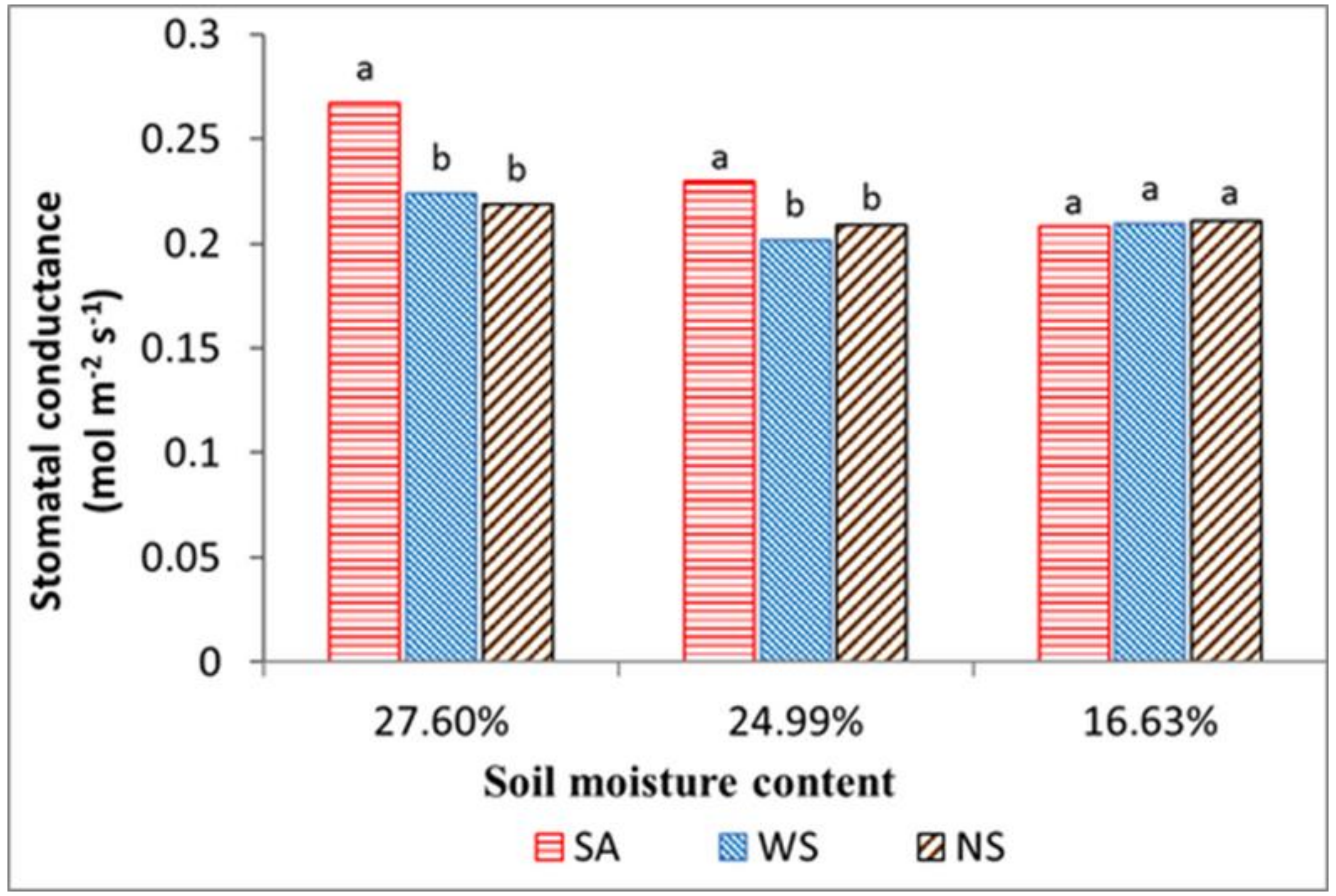
- Photosynthesis is the driving force of plant productivity
- Drought stress inhibited the photosynthesis of plant leaves through stomatal closure, imbalanced water, and decreased enzymatic activity in the Calvin cycle
- The ability to maintain an optimum photosynthetic rate under environmental stresses is fundamental to the maintenance of plant growth and production



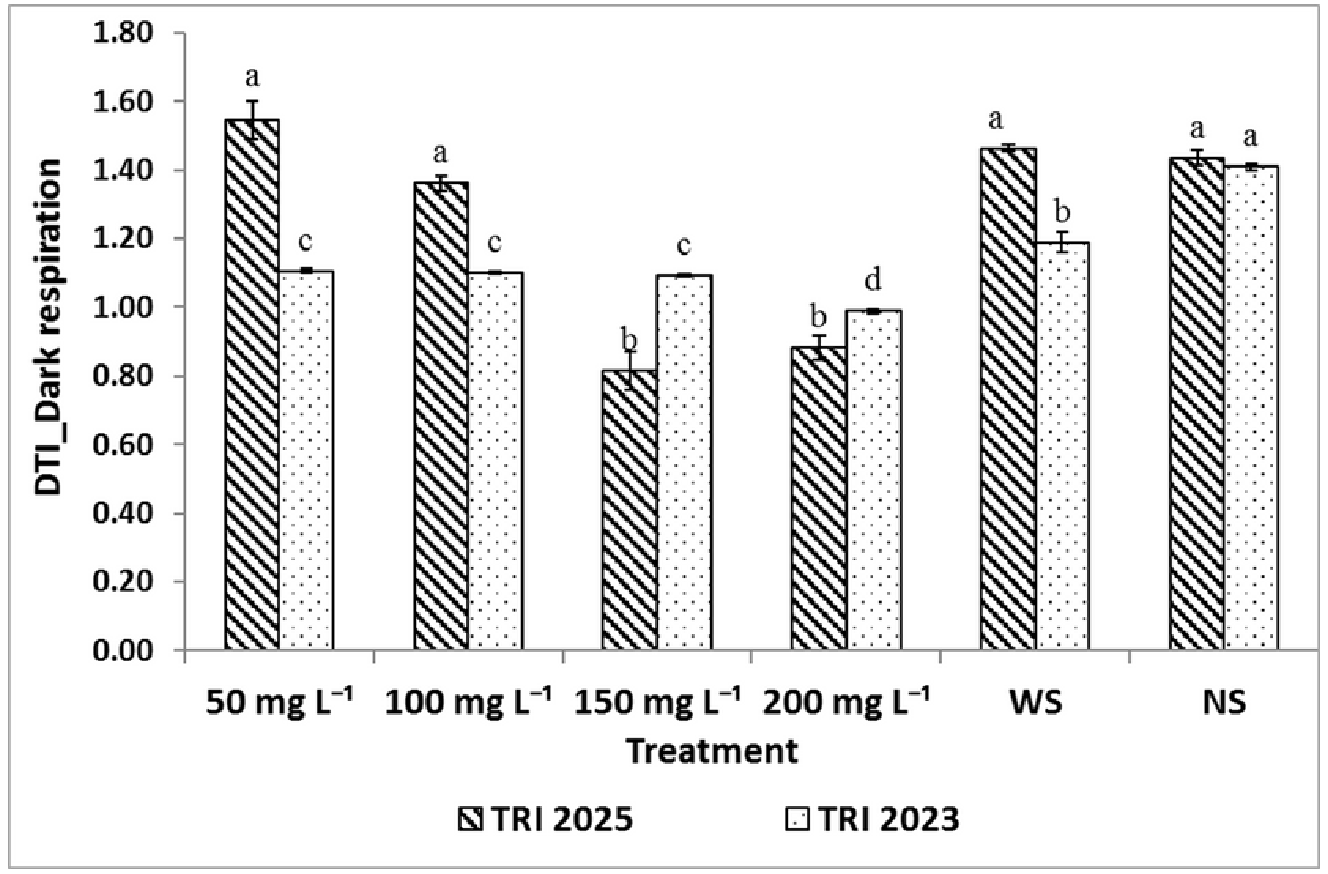


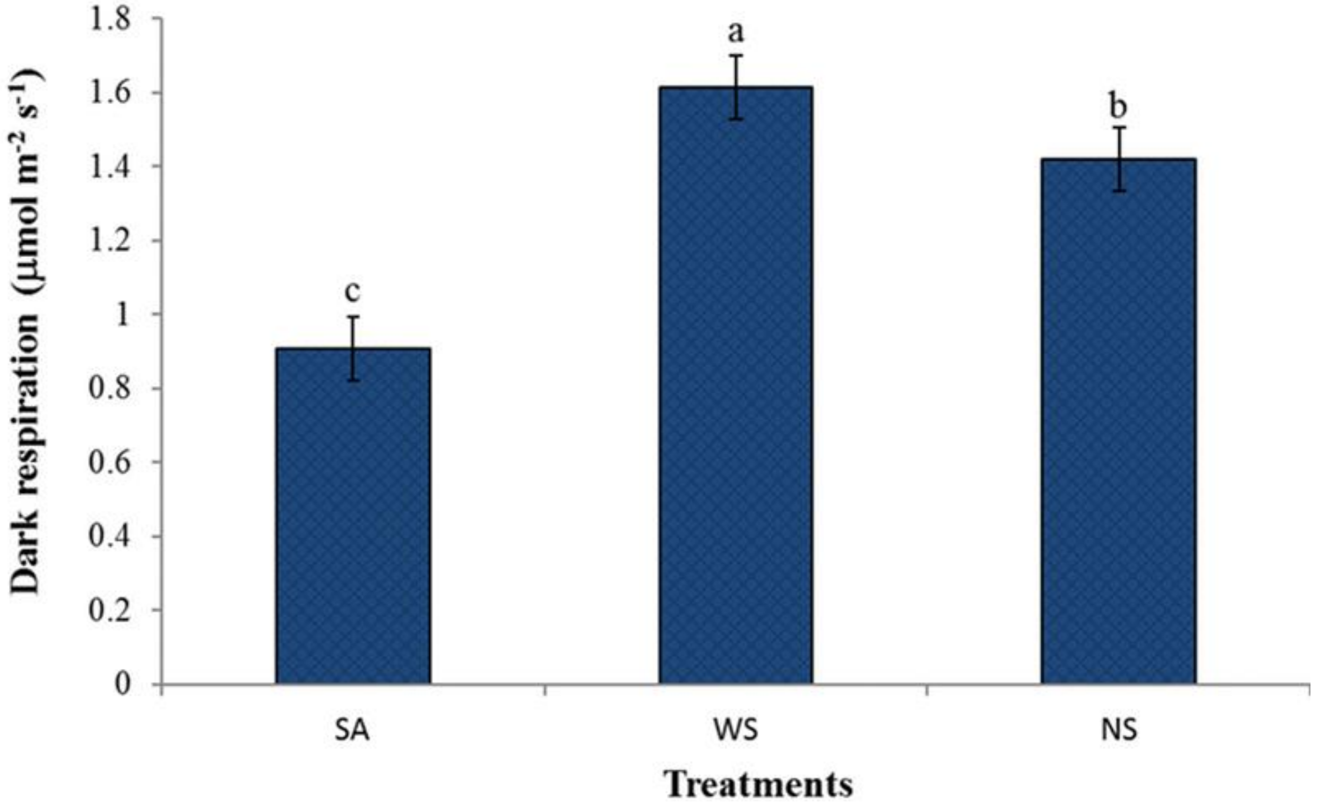
Field Experiment - Gas Exchange Parameters

Treatment	Photosynthetic rate (μmol m^{-2} s^{-1})		
	Soil moisture content (%)		
	27.6	**25**	**16.6**
SA	9.94	8.23	7.53
WS	8.50	7.36	6.87
NS	7.94	7.93	7.27



Dark Respiration





Dark respiration rates generally increase during drought

The maintenance of significantly a lower dark respiration was observed in SA sprayed plants

Dark respiration ↓ ↓ the consumption of soluble sugars- which plays a crucial role in osmotic adjustment and protection against photodamage

Glasshouse Experiment - Recovery Percentage

Treatments	Recovery percentage (%)	
	TRI 2025	TRI 2023
50 mg L^{-1}	34.29	28.57
100 mg L^{-1}	69.05	64.29
150 mg L^{-1}	**80.00**	**79.17**
200 mg L^{-1}	**81.67**	**80.36**
WS	28.57	12.50
NS	14.29	7.14
WW	100.00	100.00

- Well-watered plants in both cultivars remained unaffected throughout the experiment
- SA resulted higher recovery percentages

Recovery

NS

WS

50 mg L^{-1}

100 mg L^{-1}

150 mg L^{-1}

200 mg L^{-1}

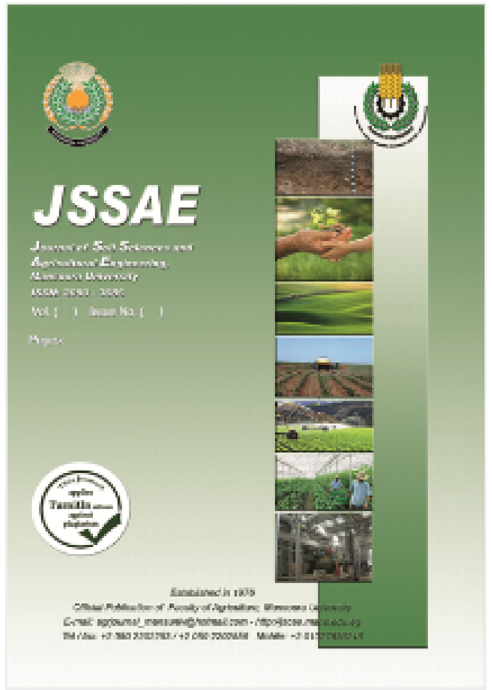
Summary

Exogenous SA application

- Helps the plants for better maintenance of RWC
- Maintenance of comparatively higher gas exchange parameters
- Increased the accumulation of osmolytes
- Improved the Starch content
- Improved the total chlorophyll content
- Improved antioxidant activity
- Decreased dark respiration
- Better recovery after drought upon re-watering

Publications

Journal of Soil Sciences and Agricultural Engineering



Salicylic Acid is an Effective Eco-Friendly Technique

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Abstract

The rate of salicylic acid (SA) degradation in the experimented peat soil was conducted to determine the degradation by five concentrations of ^{14}C radioactive salicylic acid (i.e. 0.001, 0.01, 0.1, 1.0 and 10 µM) at different time periods. Results showed that the rate of salicylic acid degradation increased as the concentration raised from 0.0001 to 10 mM. Thereafter, the rate of SA degradation increased slightly to reach about 28.7% after one week (168 h). In addition, a pot experiment was carried out at Bilqas city, Dakhalia Governorate during summer season of 2017 to study the effect of salicylic acid spraying on its translocation in lettuce (*Lactuca sativa L.*) tissues, as well as its effect on fresh yield and chemical analysis. Salicylic acid was sprayed at concentrations of 0, 0.0001, 0.001, 0.01, 0.1, 1.0 and 10 mM at pH values of 4 and 7 after one week from cultivation once a week, and stopped two weeks before harvesting. Further, spraying with salicylic acid at concentration of 0.01 mM was the best concentration on enhancing chlorophyll content, fresh weight yield, phosphorus and potassium concentrations, in addition, alleviation of free nitrate accumulation in lettuce tissues. Concerning the effect of pH value, it was noticed that pH value 7 was better than pH value 4 on enhancing chlorophyll content, fresh weight yield, phosphorus and potassium concentrations, while pH value 4 was better than pH 7 on alleviation of free nitrate accumulation in plant tissues.

Keywords

Salicylic acid degradation; Chemical composition; Lettuce plants

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Review Open Access

The Plant Pathology Journal

Salicylic Acid as a Safe Plant Protector and Growth Regulator

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Since salicylic acid (SA) was discovered as an elicitor of tobacco plants inducing the resistance against *Tobacco mosaic virus* (TMV) in 1979, increasing reports suggest that SA indeed is a key plant hormone regulating plant immunity. In addition, recent studies indicate that SA can regulate many different responses, such as toler-

and temporally as endogenous signals at a very low dose to regulate various physiological functions. Unlike the animal systems producing hormones in specialized organs and transferring them to another parts via blood stream, each living plant cell can produce hormones on their own (Went and Thimann, 1937). To successfully survive under the

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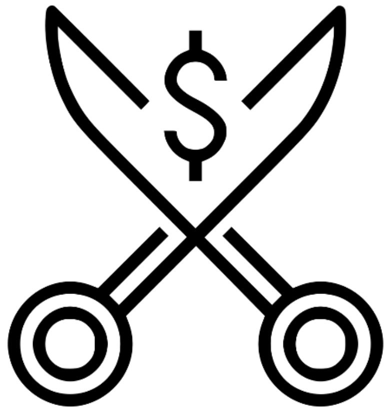

Benefits of SA Applications

- Onset of drought application
- Effective with low concentration
- Low cost
- Green application
- Alternative foliar application for drought mitigation

Conclusions

- Foliar application of 150 and 200 mg L^{-1} SA were the best treatments for reducing the drought impacts on immature tea.
- Considering the environmental impact and cost effectiveness, application of 150 mg L^{-1} SA may be considerably effective in reducing the drought impact on young tea.
- Field study also confirmed that the exogenous application of 150 mg L^{-1} SA under drought was helpful in enhancing drought tolerance in field grown immature tea plants.

Future Directions

- Mature tea
- Commercial product – Availability low SL

Locally available plant-based materials which contain a higher amount of natural SA - White willow, **Eucalyptus**

Development of a product for drought mitigation

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Our Team

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THANK YOU !

For Listening to this presentation

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