RESEARCH ARTICLE

# Potential Anti-transpirants for Inducing Drought Tolerance in Tea [*Camellia sinensis* (L.) O. Kuntze]

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## Abstract

Climate change is one of the major challenges affecting the tea industry in Malawi that has led to prolonged periods of drought. Tea in Malawi is largely grown under rain-fed conditions hence it is prone to the effects of drought. The use of antitranspirants is one of the ways of increasing the ability of plants to withstand drought. The effects of green miracle (GMI), muriate of potash (MOP), calcium carbonate ($CaCO_3$) and alexin on the response of two cultivars, PC 185 and SFS 204, subjected to three water levels were evaluated in a split-split plot pot experiment. The plants were assessed for days to wilting, degree of wilting and leaf sun-scorch. There were significant differences between the tea cultivars, anti-transpirants and water levels. Plants that were subjected to 50% water level took longer to show signs of wilting when treated with $CaCO_3$, GMI and alexin than those treated with MOP and the control. $CaCO_3$ lessened the degree of sun scorch whereas GMI appeared to be relatively more effective in lessening the degree of wilting. Therefore calcium carbonate, green miracle and alexin can potentially be used to reduce the effects of water stress in tea plants.


**Keywords:** Tea, climate, anti-transpirants, drought, tolerance.

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## INTRODUCTION

The rainfall in Malawi is not evenly distributed across the different months of a year. As such, the tea crop which is perennial undergoes periods of water stress or drought in some months of the year. This is applicable to about 85% of the tea in Malawi that is grown under rain-fed conditions.[1] Drought is defined as a period without rains during which soil water content is reduced and plants suffer from water deficit.[2,3] Drought brings about physiological changes in plants such as reduction in leaf water potential, loss of turgor, closure of stomata, reduction in rates of transpiration, photosynthesis, mineral uptake, cell enlargement and growth.[3,2] Wilting, defoliation and die-back occur on tea bushes that are subjected to drought.[4] Drought also predisposes tea bushes to some fungal infections such as *Phomopsis theae.*[5] All these effects of water stress or drought may lead to the death of tea bushes and significant yield losses.[6,4] Drought can also negatively affect the quality of tea since water-stressed bushes tend to have a low content of total polyphenols in the shoots.[7]

The extent of water stress on tea bushes tends to vary with cultivar or type of tea, age, amount of rainfall received, type of soil and agronomic practices. Drought-tolerant cultivars and composite plants suffer less from drought than susceptible cultivars or un-grafted plants.[8] Effects of drought are more pronounced in tea bushes that are more than two years in the field and in unpruned tea that is in the semi-mature stage.[4,8]

Tea growers can use a number of technologies to reduce the impacts of drought including the use of tolerant cultivars or composite plants, mulching, irrigation, pruning on time and use of shade trees.[4,9] The use of anti-transpirants is another possible technology that has been used to reduce the effects of drought in several crops. Anti-transpirants are chemicals that reduce the transpiration rate when applied to plant foliage.[10] Anti-transpirants are categorized into three based on their mode of action namely: film-forming, reflecting and stomata closing. Film-forming anti-transpirants coat leaf surfaces with films that are impervious to water vapor. The reflecting anti-transpirants reflect back a portion of the incident radiation falling on the upper surface of the leaves. The stomatal closing anti-transpirants affect metabolic processes in leaf tissues, for instance, photosynthesis.[10,11]

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The effect of different types of anti-transpirants has been studied in tea and other crops with varying successes. For example application of 2% green miracle on banana plants improved water use efficiency, photosynthetic rate and root carbohydrate content.[12] Spraying of 2% Calcium carbonate on the banana plants also improved water use efficiency.[12] Foliar application of 2% muriate of potash at an interval of 21 days over four months increased photosynthesis, water use efficiency, root starch accumulation as well as the quantities of cuticular waxes and proline.[13] Green miracle when applied at 1000 ppm concentration significantly increased the rate of photosynthesis and shoot water potential in tea plants.[14]

## METHODOLOGY

An experiment was conducted in a rain shelter at Mimosa Research Station (16° 05.771' S and 035° 37.248' E) in Mulanje, Malawi to evaluate the effects of anti-transpirants on the response of two tea cultivars PC 185 (drought tolerant) and SFS 204 (drought susceptible) to water stress. Fifteen-months-old nursery plants of the two cultivars were transplanted into plastic pots (one plant per pot), filled with 21.7 kg of sandy clay top soil (50% sand, 39% clay and 11% silt) with bulk density of 1.36 $g/m^3$. The soil for each pot was mixed with 60 g of single super-phosphate fertilizer during transplanting. Based on the bulk density, the soil moisture content when the soil is at field capacity (FC) was determined using a Delta HH2 moisture meter, following the procedure described by Zekri and Parsons.[15] The volume of water required to bring the soil in each pot to field capacity was thus calculated.

Three weeks after transplanting, 30g of ammonium sulfate was applied to each plant. The plants were thereafter acclimatized by maintaining the water level in the pot soil at 100% FC for a period of 129 days. Acclimatization was done to allow them to recover from the transplanting shock and get established in the bigger pots before imposing the experimental treatments. After acclimatization, the plants were subjected to three water levels (W1 = 25% FC, W2 = 50% FC and W3 = 100% FC) and different anti-transpirants (AT): AT 1 = control (no anti-transpirant), AT 2 = 0.5% Green miracle (GMI), AT 3 = 2% Muriate of potash (MOP) at 2% concentration, AT 4 = 2% Calcium carbonate ($CaCO_3$) and AT 5 = Alexin at 1.5L $ha^{-1}$. The anti-transpirants were applied to the plant foliage using a knapsack sprayer at the start of the treatments and repeated twice on a 21 days interval. The experiment was laid out in a split-split-plot design with tea cultivars, water levels and anti-transpirants as the main-, sub- and sub-sub-plot factors, respectively. Each treatment combination had three replicates. Observations were made for 72 days on: days to start of wilting. The degree of wilting was assessed on a score of 1 to 5 where a score of 1 represented no wilting and 5 represented severe wilting and, degree of leaf sun scorch was scored on a scale of 1 to 5, whereby a score of 1 represented no leaf scorching and a score of 5 represented severe leaf scorching. The degree of wilting and leaf sun-scorch was assessed at an interval of 10 days. The data was subjected to analysis of variance using GENSTAT 19.1 statistical package.

### Description of the anti-transpirants tested in the experiment

Green miracle is a reflective type of anti-transpirant and surfactant based on long chain fatty alcohols fortified with amino acids and peptides. Muriate of potash (MOP) is a granulated fertilizer containing 60% of potash; Alexin is a liquid organic nutrient complex containing salicylic acid, calcium (33.3 g/ℓ), magnesium (10.6 g/ℓ), potassium (56.7 g/ℓ) and boron (3.0 g/ℓ); Calcium carbonate also known as limestone is a chemical compound containing 40% of calcium.

## RESULTS AND DISCUSSION

Results of various parameters that showed significant differences among different factors or their interactions have been presented and discussed in this article.

### Effect of cultivars, water levels and anti-transpirants on days to wilting

The number of days when wilting was discerned was not affected by the application of anti-transpirants in both PC 185 and SFS 204 plants that were subjected to 25% FC and 100% FC water levels. Days to wilting for these plants ranged from 4 to 9 for both tea cultivars at 25% FC water level. Plants of both SFS 204 and PC 185 that were subjected to 100% FC had not yet wilted by day 72 regardless of the anti-transpirant treatments.

**Table 1:** Wilting scores for PC 185 and SFS 204 subjected to different water levels and anti-transpirants on day 53

| *Cultivar* | *Water level* | *Control* | *GMI* | *MOP* | *$CaCO_3$* | *Alexin* |
|---|---|---|---|---|---|---|
| PC 185 | 25% FC | 1.3 | 1.3 | 1.0 | 1.7 | 1.7 |
| | 50% FC | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 100% FC | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| SFS 204 | 25% FC | 2.0 | 2.3 | 4.3 | 2.7 | 3.3 |
| | 50% FC | 2.3 | 1.7 | 3.3 | 2.0 | 2.0 |
| | 100% FC | 1.0 | 1.0 | 1.0 | 1.3 | 1.0 |
| P value | | 0.03 | | | | |
| LSD $p_{\leq 0.05}$ | | 0.91 | | | | |
| CV (%) | | 29 | | | | |

**Table 2:** Leaf sun-scorch scores for plants under different water levels and anti-transpirants on day 62

| *Water level* | *Control* | *GMI* | *MOP* | *$CaCO_3$* | *Alexin* |
|---|---|---|---|---|---|
| 25% FC | 3.0 | 3.3 | 4.3 | 2.8 | 3.0 |
| 50% FC | 2.8 | 3.2 | 3.8 | 2.2 | 2.5 |
| 100% FC | 2.2 | 2.2 | 2.3 | 2.0 | 2.2 |
| *p-value* | 0.016 | | | | |
| LSD $_{0.05}$ | 0.57 | | | | |
| CV (%) | 16.8 | | | | |

A notable difference in the number of days to wilting was observed between the two cultivars at 50% FC water level. The 50% FC water level was critically low for SFS 204 plants that started to wilt by day number 4 whereas plants of the drought-tolerant cultivar PC 185, took 65 days to start showing wilting signs. In fact, PC 185 plants that were treated with calcium carbonate, alexin and green miracle at 50% FC water level had not yet wilted by day 72, suggesting that these anti-transpirants helped in delaying the wilting.

### Effect of cultivars, water levels and anti-transpirants on degree of wilting

Interaction effects of cultivar x water level x anti-transpirants on degree of wilting were significant on day 53 (Table 1). At 25% FC, SFS 204 low wilting scores were observed on plants treated with GMI (2.3), $CaCO_3$ (2.7) and the control plants (2.0) as opposed to plants treated with MOP (4.3) and Alexin (3.3). At 50% FC, degree of wilting was lowest (1.7) in plants treated with green miracle while those treated with Alexin and $CaCO_3$ had similar wilting scores to the control plants. It was noted that at 25% FC, the wilting scores for PC 185 ranged from 1.0 to 1.7. At 50% FC, all plants recorded a wilting score of 1.

### Effect of cultivars, water levels and anti-transpirants on degree of leaf sun-scorch

The degree of leaf scorching was significantly affected by the interaction of water level x anti-transpirants on day 62 (Table 2). Plants at 25% FC, had relatively high sun-scorch scores than those at 50% FC and 100% FC across all the anti-transpirants treatments. The fact that there was less scorching on the control plants highlights the cooling effect that adequate moisture has on the leaves. Plants treated with $CaCO_3$ showed some level of heat tolerance and had a relatively low sun-scorch score than the control and other anti-transpirants. Similar effects of enhanced heat tolerance due to calcium were reported in tall *Fescue* grass and *Kentucky* bluegrass.[16] Plants treated with green miracle or alexin had similar leaf scorch scores to the control plants unlike plants treated with MOP that generally had higher leaf sun-scorch scores than the control plants at both the 25% FC and 50% FC.

### Summary

The two cultivars responded differently to the anti-transpirants and levels of water stress. PC 185 showed more tolerance to water stress than SFS 204. Calcium carbonate reduced the degree of leaf sun- scorch while green miracle seemed to be relatively more effective in decreasing the degree of wilting than the other anti-transpirants. Calcium carbonate, green miracle and alexin showed potential in delaying the onset of wilting under water stress. These anti-transpirants therefore have the potential to lessen the effects of water stress in tea plants. There is, however, a need to confirm the current observations on the effects of these anti-transpirants and include measurements of objective physiological parameters that are directly associated with drought tolerance in tea.

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