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Effect of Kaolin Application on Growth, Water Use Efficiency, and Leaf Epidermis Characteristics of *Physalis peruviana* L. Seedlings under Two Irrigation Regimes

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ABSTRACT

The anatomical and epidermal characteristics, as well as the physiological response, of 'Colombia' ecotype cape gooseberry plants treated or untreated with foliar applications of kaolin at 2 irrigation levels (well-irrigated plants vs. water-stressed plants) were evaluated. Relative Water Content (RWC), stomatal density, and chlorophyll index were reduced under water stress. Water stress increased leaf temperature and trichome density. In water-stressed plants, the foliar application of kaolin decreased transpiration rates, leaf temperature, trichome density, and leaf thickness. Kaolin also improved the plant height, total plant dry mass, water-use efficiency, and increased stomatal density in water-stressed plants. The results suggest that kaolin may be a useful tool to mitigate the negative effects of water stress and may improve the efficient use of water in cape gooseberry plants with especial water conditions.

Keyword: Leaf characteristics, Leaf transpiration, Water stress.

INTRODUCTION

Cape gooseberry (*Physalis peruviana* L.) is a native plant of the tropical Americas that is found mainly in Colombia, Ecuador, and Peru (Floréz and Fischer, 2000). Colombia produced 12,000 tons of this fruit in 2011, of which 7,000 tons were exported (Agronet, 2011). Cape gooseberry is cultivated in the interior regions of Colombia, where precipitation presents a bimodal behavior pattern, which results in the need for irrigation during certain months to correct seasonal water deficits (Torres *et al*., 2004). Precipitation also drastically decreases during the presence of El Niño Southern Oscillation in Colombia, which affects crop production (Holmgren *et al*., 2001). *Physalis peruviana* production may be affected by water deficits, since most of this plant is cultivated under rainy conditions (Fischer *et al*., 2005). This plant also has an indeterminate growth rate and, therefore, it requires a constant supply of water for its vegetative and reproductive growth, especially when the fruit is ripening (Fischer and Miranda, 2012).

The plants have anatomical, morphological, and physiological adaptations to become acclimatized to conditions of low water availability (Kozlowski and Pallardy, 2002). One of the first responses to drought conditions is stomatal closure, which reduces water loss through transpiration. This behavior is followed by changes in cell division and expansion, causing a reduction of the accumulation of dry mass, which reduces crop yield (Restrepo-Diaz *et al*., 2010). Plants also undergo morphological and anatomical changes under water-deficit conditions (Chartzoulakis *et al*., 1999). It

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has been found that plant leaves under water-deficit conditions may present a thicker cuticular lamina (Kosma *et al*., 2009), lower stomatal density (Xu and Zhou, 2008) and an increase of trichome density (Guerfel *et al*., 2009).

Foliar application of kaolin has been evaluated for its ability to reduce the negative effects of water stress and to improve the physiology and productivity of plants (Rosati *et al.*, 2006). The use of kaolin has been found to improve the photosynthetic rate under water-deficit conditions by increasing photosynthesis levels in olive plants (*Olea europaea* L.) (Denaxa *et al*., 2012), enhancing the leaf water potential of tuberose plants (*Polianthes tuberosa* L.) (Moftah and Al-Humaid; 2005) and grape plants (*Vitis vinifera* L.) (Glenn *et al*., 2010), and increasing the water-use efficiency in grapefruit leaves by 25% (Jifon and Syvertsen, 2003). However, the use of this particle film has also demonstrated irregular responses. Studies by Rosati *et al*. (2006) concluded that applications of kaolin were not enough to mitigate the adverse effects of water stress on photosynthesis in almond trees (*Prunus dulcis* (Mill) D.A. Webb) or walnut trees (*Juglans regia* L.). Moreover, Lombardini *et al*. (2005) found that the use of kaolin did not affect the leaf water content, stomatal conductance, or photosynthesis in pecan trees [Carya illinoiensis (Wangenh.) K. Koch].

Studies on water stress in cape gooseberry plants have mainly focused on determining the effects of drought conditions on fruit quality (Gordillo *et al*., 2004; Torres *et al*., 2004) and little is known regarding the relationship between water deficit and the anatomical, morphological, and physiological responses of this species. In addition, studies on the use of agrochemicals that may reduce the negative effects of water stress are rare in Colombian horticulture. Therefore, the objective of the present study was to evaluate the influence of foliar applications of kaolin on the anatomical and physiological responses of cape gooseberry plants under two water conditions: well-irrigated and water-stressed plants.

MATERIALS AND METHODS

Growth Conditions

The experiment was performed from January to April, 2011, in laboratories and greenhouses at the Agronomy Department of the Universidad Nacional de Colombia, Bogota campus. The greenhouse conditions during the experiment were as follows: an average temperature of 22°C±5, a relative humidity of between 40 and 90%, and a natural photoperiod of approximately 12 hours**.** Two-month-old cape gooseberry seedlings of the 'Colombia' ecotype were transplanted into 2 L pots containing a 2:1 mix of sand and peat as the substrate. Seedlings underwent a 3-week acclimation period and were fertigated with a nutrient solution containing a complete fertilizer (Wuxal®, Bayer, Barranquilla, Colombia), at a dose of 4 mL per L of water, throughout the experiment. The composition of the fertilizer used was the following: total nitrogen 160 g L^{-1} (ammoniacal N 38 g L^{-1}, Nitric N 12 g L^{-1}, Ureic N 110 g L^{-1}), assimilable phosphorus (P_2O_5) 160 g L^{-1}, soluble potassium (K_2O) 120 g L^{-1}, Boron (B) 10.00 g L^{-1}, Copper (Cu) 0.21 g L^{-1}, Iron (Fe) 0.43 g L^{-1}, Manganese (Mn) 0.36 g L^{-1}, Molybdenum (Mo) 0.07 g L^{-1}, Zinc (Zn) 10.00 g L^{-1}.

Water Stress and Foliar Kaolin Sprays

After a 3-week acclimation period, the plants were split into well-irrigated and water-stressed. The well-irrigated plants were watered up to 100% of their daily requirements for total EvapoTranspiration (ET) over the length of the study. Water-stress treatment consisted of reducing irrigation by 25% of *ET* every 15 days. Water-stressed plants received 4 different water levels over the course of the experiment: 100% of *ET* (during the acclimatization period), 75% of *ET* [between 0 and 15 Days After Treatment (DAT)], 50% of *ET* (between 15 and 30 DAT), and 25% of *ET* (between 30 and 45 DAT). The ET was determined gravimetrically (weight of pots with plants) following the techniques described by Moftah and Al-Humaid (2005). The water content of the substrate was monitored using a humidity probe (Kelwa and Soiltester, Kelinstruments Co., Inc., Wyckoff, NJ) at 0, 15, 30, and 45 DAT. Three foliar applications of kaolin were performed in both irrigation regimes (well-irrigated and water-stressed) at 0, 15, and 30 DAT. There were four treatment groups at the end of the experiment: (i) Well-irrigated plants with kaolin application; (ii) Well-irrigated plants without kaolin; (iii) Water-stressed plants with kaolin, and (iv) Water-stressed plants without kaolin. Finally, kaolin applications were performed early in the morning, at a dose of 5% (w/v) (Surround WP, Tessenderlo Kerley, US). Kaolin concentration was selected on the basis of studies carried out by Wünsche *et al*. (2004) and Lombardini *et al*. (2005). The Foliar kaolin applications were carried out with a compression sprayer Style 1.5 (Matabi, Spain), wetting leaf surfaces at the sunset.

Physiological and Morphological Measurements

Mature, fully expanded leaves from the middle of the canopy were collected to determine the Fresh Weight (FW), Turgid Weight (TW), and Dry Weight (DW) at 15, 30, and 45 DAT, with the objective of calculating the Relative Water Content (RWC) and Water-Deficit Saturation (WDS). These indices were determined based on the following equations:

RWC (%)= 100× (FW –DW)/(TW – DW) , and WDS(%)= 100×(TW-FW)/ (TW-DW).

Three completely developed leaves from the upper-middle portion of the canopy were taken to measure the leaf transpiration rate (E), maximum efficiency of PSII (Fv/Fm), leaf temperature, and chlorophyll index (SPAD readings) between 09:00 hours and 14:00 hours on days with full sun. *E* was estimated using a steady-state porometer (Li-Cor 1600, Lincoln, Nebraska, USA) on the same dates when the substrate water content and the *RWC* were measured. Leaf chlorophyll index was measured using SPAD readings as a non-destructive tool (Markwell *et al*., 1995) at 45 DAT; leaf temperature and maximum PSII efficiency (Fv/Fm) were also measured at 45 DAT. SPAD readings, leaf temperature, and *Fv/Fm* were taken using a chlorophyll meter (SPAD-502; Minolta, Ramsey, NJ), an infrared thermometer (MX2SL3U, Cole-Parmer Instrument Company, Vernon Hills, IL), and a continuous-excitation fluorescence chlorophyll meter (Handy PEA; Hansatech Instruments, Kings Lynn, UK), respectively. Then, the same three leaves per plant used to estimate E, leaf temperature, *Fv/Fm* ratio and SPAD were taken in order to obtain *RWC*. Before measuring SPAD readings and *Fv/Fm* ratio, the kaolin particles were removed from leaves. Leaf thickness and stoma, and trichome densities were determined using the techniques described by Sagaram *et al*. 2007, at 45 DAT. Then, plants were collected with the purpose of measuring leaves, stems, and roots dry weight. Plant height was measured weekly during the experiment. Water Use Efficiency (WUE) was calculated using the total DW of the plant over the total quantity of water received by each plant (Raviv and Blom, 2001).

Statistical Aanalyses

To carry out the statistical analyses, the data were analyzed using a factorial design: the foliar applications of kaolin (with kaolin and without kaolin) and the water status of the plant (well-irrigated plants vs. water-stressed plants), with 5 repetitions per treatment. All percentage values were transformed using an arcsine transformation prior to analysis. When significant differences were observed, a separation of means between treatments was performed using Tukey's multiple-range test (P≤ 0.05, 0.01, and 0.001, respectively). Data were analyzed using Statistix software version 8.0 (analytic software, Tallahassee, FL, US).

RESULTS

Significant differences in substrate water content between treatments developed by 15 DAT (Figure 1). The differences between treatments were more noticeable at 30 DAT, including the fact that the substrates of well-irrigated plants (with and without kaolin) had approximately 75% water in comparison to the substrates of water-stressed plants, which contained approximately 35% water; this trend was observed until 45 DAT. At 0 DAT, no differences were observed in the *RWC* and *WDS* due to irrigation or kaolin applications, demonstrating that all the plants started at a homogeneous water status during the experiment (Table 1). There was a progressive reduction in the *RWC* in plants under reduced irrigation, starting at 15 DAT. At 45 DAT, a difference of 12% in the *RWC* between irrigated and water-stressed plants was found. Similar tendencies were found for the *WSD* due to irrigation treatments. These results indicated the existence of a group of plants under conditions of adequate water and another group under conditions of water deficit during the experiment. Applications of kaolin particles reduced the *RWC* and increased the *WSD*, starting at 15 DAT.

Well-irrigated plants without foliar applications of kaolin had the highest transpiration rate throughout the experiment (Figure 2-A). When well-irrigated plants received foliar applications of kaolin, the loss of water through transpiration decreased approximately 65, 30, and 40% at 15, 30, and 45 DAT respectively, in comparison with untreated well-irrigated plants. Transpiration rates also decreased in water-stressed plants due to foliar applications of kaolin, with the group of plants that received reduced irrigation and kaolin treatments having the lowest levels of transpiration at the end of the experiment. The cumulative transpiration was reduced by approximately 47 and 38% in well- and poorly irrigated plants, respectively, due to foliar treatments with kaolin (Surround® WP) (Figure 2-B).

Foliar sprays with kaolin had a positive effect on plant height, total dry weight, and *WUE* (Table 2). Water stress negatively affected the chlorophyll index of the leaf, as measured by SPAD readings. However, SPAD readings were higher in plants that received foliar treatments with kaolin.

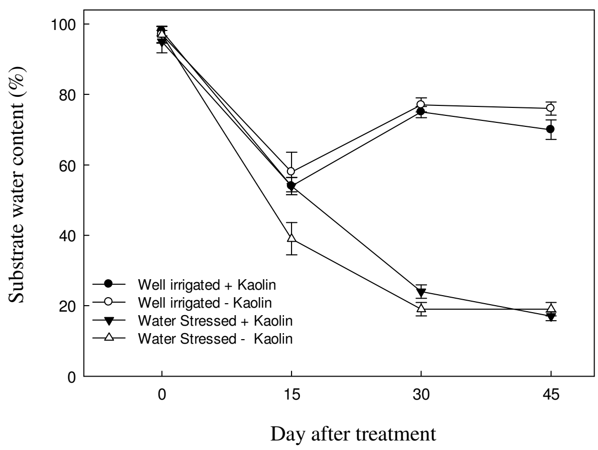

Figure 1. Variations in substrate water content throughout the experiment. Each data point represents the mean of 5 values. Vertical bars represent ±Standard Error.

Table 1. Effect of kaolin particle film applications on the Relative Water Content (RWC) and Water-Saturation Deficit (WSD) in well-irrigated and water-stressed cape gooseberry plants.

Treatments	RWC (%)				WSD (%)			
	0 DAT [a]	15 DAT	30 DAT	45 DAT	0 DAT	15 DAT	30 DAT	45 DAT
Water treatments (WT)								
Well-irrigated	88.95	85.35a [b]	84.08 a	71.47 a	11.04	14.64 a	15.91 a	28.52 a
Water-stressed	87.81	83.05 b	71.57 b	63.94 b	12.18	16.94 b	28.42 b	36.05 b
Significance	NS	*	***	***	NS	*	***	***
Kaolin applications (KA)								
With kaolin	86.68	81.77 a	75.13 a	64.86 a	13.32	18.22 a	24.86 a	35.13 a
Without kaolin	90.08	86.63 b	80.52 b	70.55 b	9.91	13.36 b	19.47 b	29.45 b
Significance	NS	***	***	***	NS	***	***	***
Interaction WT×KA	NS	NS	NS	NS	NS	NS	NS	NS
CV (%) [c]	6.12	2.40	2.01	2.34	22.18	6.89	4.49	3.75

[a] Day after treatment, [b] Values within a column and factor followed by different letters are significantly different at $P \leq 0.05$ by Tukey's test. [c] Coefficient of Variation, NS= Non-Significant (P= 0.05); * and *** Significant at $P \leq 0.05$ or $P \leq 0.001$,

Table 2. Impact of kaolin particle film application on plant height, total plant Dry Weight (DW), Water-Use Efficiency (WUE), SPAD readings, maximal efficiency of PSII (Fv/Fm), and leaf temperature in well-irrigated and water-stressed cape gooseberry plants.

Treatments	Plant height (cm)	Plant DW (g)	*WUE* (g DW L^{-1} H_2O)	SPAD Readings	*Fv/Fm*	Leaf temperature (°C)
Water treatments (WT)						
Well-irrigated	43.87	22.15	12.68	54.40 a [b]	0.82	29.24 a
Water-stressed	45.02	22.56	12.92	46.59 b	0.80	33.75 b
Significance	NS	NS	NS	***	N.S.	***
Kaolin applications (KA)						
With kaolin	46.00 a	25.63 a	14.68 a	52.16 a	0.83 a	30.82 a
Without kaolin	43.90 b	19.07 b	10.92 b	48.84 b	0.79 b	32.17 b
Significance	*	*	*	*	***	*
Interaction WT×KA	NS	NS	NS	NS	NS	NS
CV (%) [a]	5.80	29.30	29.30	5.50	3.06	5.15

[a] Coefficient of variation, [b] Values within a column and factor followed by different letters are significantly different at $P \leq 0.05$ by Tukey's test, NS= Non-Significant (P= 0.05); * and *** Significant at $P \leq 0.05$ or $P \leq 0.001$,

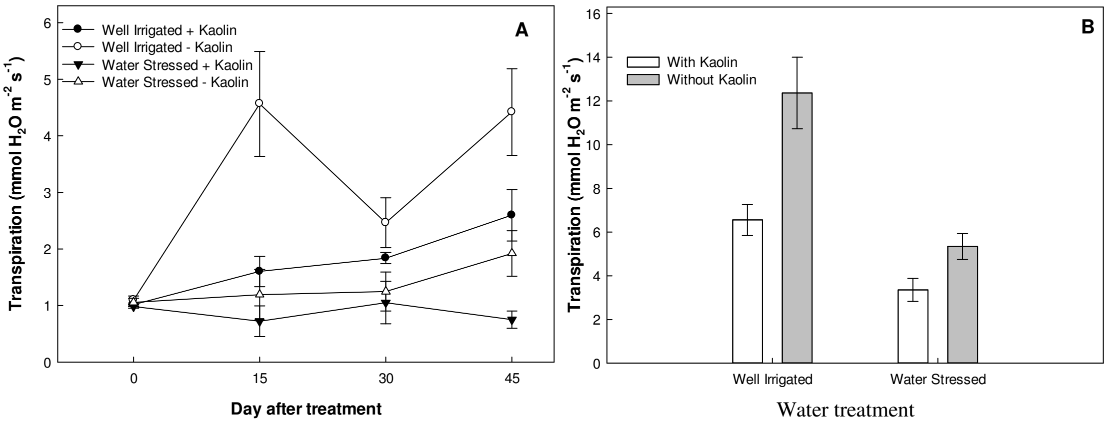

Figure 2 Effect of particle film treatment on leaf transpiration rate (A) and cumulative transpiration (B) in well-irrigated and water-stressed cape gooseberry plants. Each data point represents the mean of 5 values. Vertical bars represent ±Standard Error.

Significant differences were only observed in the *Fv/Fm* ratio due to kaolin treatments. Untreated plants had reduced quantum efficiency [with kaolin (0.83) vs. without kaolin (0.79)]. The leaf temperature of cape gooseberry plants was differently affected by irrigation levels and kaolin use. The cape gooseberry leaf temperature increased by approximately ~4.5°C due to water stress, while treatments with kaolin caused a decrease of approximately ~1.4°C.

Stomatal densities of cape gooseberry leaves were significantly affected by foliar applications of kaolin and the water status (Table 3). Water stress caused a decrease of stomatal density. The cape gooseberry plants that were subjected to reduced irrigation had a lower stomatal density on both leaf surfaces (abaxial and adaxial surfaces). However, foliar applications of kaolin particles increased stomatal density. Plants that were treated with this particle film had a greater stomatal density on the top and the bottom of the leaf. Water stress increased the number of concave peltate trichomes only on the abaxial side of cape gooseberry leaves. Treatment with kaolin caused a decrease in concave peltate trichomes on both the top and the bottom of the leaves. However, differences in the interaction between foliar applications and irrigation treatments on the number of bladder trichomes in cape gooseberry leaves were found. Stressed plants without kaolin applications had a higher density of bladder trichomes on the adaxial side. Plants untreated with kaolin under both irrigation conditions had a greater bladder trichome density on the abaxial leaf side. There was an interaction between kaolin treatments and the levels of irrigation on the thickness of cape gooseberry leaves (Figure 3). Stressed plants without kaolin applications showed the greatest thickness. However, foliar applications of kaolin reduced leaf thickness at both levels of irrigation.

DISCUSSION

Plants subjected to adequate irrigation had higher *RWCs* than water-stressed plants, mainly due to the fact that the amount of water supplied was enough to maintain the turgidity of the leaf tissue. Likewise, *WSD* values were greater in water-stressed cape gooseberry leaves, which indicated a significant loss of water. According to Roussos *et al*. (2010), a high *WSD* value (≥ 35% in our experiment under reduced-irrigation conditions at 45 DAT) can influence negatively the photosynthesis rate and reduce transpiration. The foliar applications of kaolin reduced the *RWC* and

Table 3. Impact of kaolin particle film applications on epidermal characteristics in well-irrigated and water-stressed cape gooseberry plants.

Treatments	Stomatal density (Stoma mm^{-2})		Trichome density (Trichomes mm^{-2}) Concave peltate		Trichome density (Trichomes mm^{-2}) Bladder	
	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial
Water treatments						
Well-irrigated	25.37 a[c]	280.63 a	36.62 a	---	---	---
Water-stressed	17.25 b	179.25 b	39.87 b	---	---	---
Significance	**	***	**	NS	NS	NS
Kaolin applications						
With kaolin	24.12 a	250.50 a	36.00 a	11.62 a	10.87 a	6.12 a
Without kaolin	18.50 b	209.37 b	40.50 b	13.75 b	15.50 b	11.62 b
Significance	*	**	***	*	***	***
Water treatments×Kaolin applications						
Well-irrigated with kaolin	---	---	---	---	12.00 b	6.50 b
Well-irrigated without kaolin	---	---	---	---	13.25 b	10.00 a
Water-stressed with kaolin	---	---	---	---	9.75 b	5.75 b
Water-stressed without kaolin	---	---	---	---	17.75 a	13.25 a
Significance	NS	NS	NS	NS	**	*
CV (%)[b]	23.08	9.16	4.74	15.05	15.21	17.96

[b] Coefficient of variation, [c] Values within a column and factor followed by different letters are significantly different at $P \leq 0.05$ by Tukey's test, NS= Non-Significant (P= 0.05); * and *** Significant at $P \leq 0.05$ or $P \leq 0.001$, [b] Coefficient of variation.

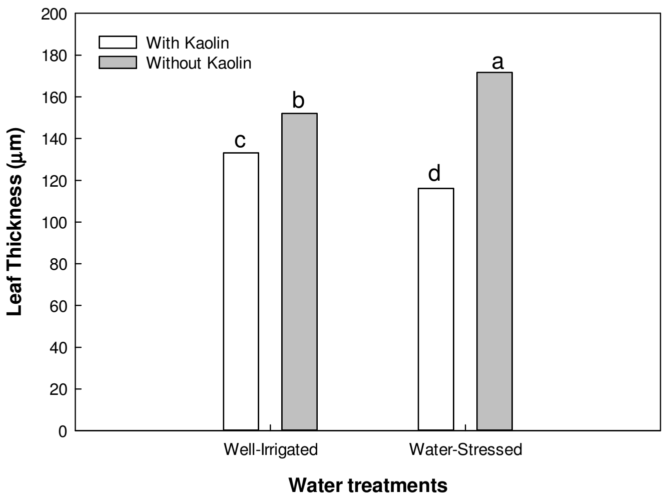

Figure 3. Effect of particle film treatment on leaf thickness in well-irrigated and water-stressed cape gooseberry plants. Each data point represents the mean of 5 values. Different letters are significantly different at $P\leq 0.05$ by Tukey's test

raised the *WSD*, throughout the experiment. Nakano and Uehara (1996) found similar observations on the Relative Water Content (RWC) of tomato leaves treated with kaolin and suggested that an insoluble solid fraction of kaolin can be the cause of this effect, since a fine powder particle must absorb a slight amount of water from the leaf surface. On the other hand, particle film application enhanced Water Use Efficiency (WUE) in cape gooseberry plants. Studies performed by Glenn *et al*. (2010) on grape plants also reported that foliar applications of kaolin increased *WUE*.

Kaolin applications reduced leaf temperature. Similar effects have been cited in other horticultural crops, such as grape, olive, and pecan (Lombardini *et al*., 2005; Glenn *et al*., 2010; Denaxa *et al*., 2012). While it was not evaluated in this study, the mechanism for reducing leaf temperature usually involves an increase in the light reflectance of treated leaves, which causes a reduction of the amount of light they absorb. This mechanism has been corroborated by Wünsche *et al*. (2004), who showed that apple leaves treated with kaolin absorbed 20% less light due to increased reflectance in comparison with control leaves. However, the chlorophyll index, expressed through SPAD readings, was greater in leaves treated with kaolin. Lombardini *et al*. (2005) also observed a positive effect on the chlorophyll index after the kaolin treatment. A possible explanation for this increase in chlorophyll content may be due to the fact that leaves not treated with kaolin could show a lower light reflectance, suggesting an increased degradation of the photosynthetic pigments because a protection mechanism for high luminosity consists of regulating the loss of chlorophyll by chloroplasts (Anderson, 1986). Water stress also diminished SPAD readings, for instance, Guerfel *et al*. (2009) reported that a reduction in the chlorophyll index when the leaf shows a low water potential could be attributed to the sensitivity of this pigment to an increase of stressful conditions, especially to conditions of a water deficit. The present study suggests that treatment with kaolin may reduce the leaf transpiration rate. Similar observations regarding the effect of kaolin on reducing transpiration rates have been reported by various authors (Moftah and Al-Humaid, 2005; Glenn *et al*., 2010). Kaolin particles, as mentioned above, reduce the leaf temperature, which reduces the Vapor Pressure Deficit (VPD) between surrounding tissues and the atmosphere (Glenn and

Puterka, 2005); the reduced *VPD* results in a lower transpiration rate and a loss of water compared with the control. As mentioned earlier, the use of kaolin may promote *WUE* in cape gooseberry plants, as demonstrated in other fruit species (Glenn *et al*. 2010; Jifon and Syversen, 2003).

The cape gooseberry leaf epidermal characteristics were influenced by both water stress and foliar applications of kaolin. The water deficit reduced stomatal density on the top and the bottom of cape gooseberry leaves. Similar observations were made in tomato plants (another species in the Solanaceae family) under water-stress conditions (Sam *et al*., 2000). The negative effect of water stress on stomatal density may be the result of a reduction in the leaf cellular division and lengthening (Taiz and Zeiger, 2006). Leaf temperature may also affect stomatal density. At the end of our experiment, the leaf temperature of plants under water stress was approximately 4.5°C higher than that of the leaves of well-irrigated plants. Studies conducted by Beerling and Chaloner (1993) found that increasing the leaf temperature reduced the stomatal density in *Quercus robur* leaves. Trichome density also increased in cape gooseberry leaves due to water stress. Similar results were reported in jatropha plant leaves under water stress (Abdulrahaman and Oladele, 2011). Trichomes have the potential to alter plant physiology, as they help reflect light and can reduce the quantity of light absorbed, temperature, or leaf transpiration rate (Abdulrahaman and Oladele, 2011). This suggests that, under drought conditions, cape gooseberry leaves have the ability to increase the density of trichomes to regulate their temperature and to avoid the loss of water through transpiration. Leaf temperature was approximately 1.5°C lower in plants treated with kaolin compared to untreated plants. The influence of temperature on stomatal density and trichomes, and the effect of kaolin on the reduction in temperature in cape gooseberry leaves, may help explain why leaves treated with kaolin had a greater number of stomata per square mm and a reduced number of trichomes per unit of area.

It has been reported that an increase in leaf thickness may be the plant's response to conditions of water stress (Nobel, 1980). Our data show that leaf thickness increased in stressed plants. However, leaf thickness was considerably reduced when stressed plants received foliar application sprays with kaolin. Studies conducted by Cameron *et al*. (2006) on tobacco plants (another species of the Solanaceae family, as is the cape gooseberry) under conditions of water stress showed an increase in leaf thickness caused by an increase in cuticular waxes aimed at limiting transpiration to avoid the dehydration of leaf cells. In addition, the literature shows that leaf thickness may increase under high levels of irradiation (Evans and Poorter, 2001). The roles of kaolin in altering the optical properties of the leaf and in reducing the transpiration rate may help to explain the decrease in leaf thickness caused by kaolin treatments in well- and poorly-irrigated plants. Particle film applications had a significant positive effect on almost all of the growth parameters evaluated in this experiment (Table 2). Kaolin clay treatments resulted in higher plant height and plant dry weight, which could be attributed to the reduced water loss due to the reduction of leaf temperature and *VPD* (Jifon and Syvertsen, 2003; Roussos *et al*., 2010), resulting in lower transpiration and higher WUE.

CONCLUSIONS

The water-stress treatment resulted in reductions in the leaf chlorophyll index and stomatal density and in increases in the density of trichomes and leaf thickness in cape gooseberry leaves. Foliar application sprays with kaolin improved the water use efficiency by reducing the leaf transpiration rate and the leaf temperature. Kaolin applications also reduced the leaf thickness, especially in plants under reduced-irrigation conditions. These results suggest that the use of kaolin may be a helpful tool to mitigate the negative effects of water stress and to improve the water use efficiency in cape gooseberry plants, especially under water-deficit conditions.

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اثر کار برد کائولین روی رشد ، کارآیی مصرف آب و ویژگی های اپیدرم برگ گیاهچه *Physallis peruviana* در دو رژیم آبیاری

س. سگورا- مونروی، ا. اریب-والجو، ا. رامیرز-گودوی، و ه. رستریپو-دیاز

چکیده

در این پژوهش، ویژگی های آناتومی و اپیدرم و نیز واکنش های فیزیولوژیکی گیاهچه 'Colombia' ecotype cape gooseberry تیمار شده یا نشده با پاشش کائولین روی برگ ها و

تحت دو تیمار آبیاری(آبیاری کامل در مقایسه با تنش آبی) بررسی شد. در شرایط تنش آبی، محتوای نسبی آب (RWC)، تراکم تعداد روزنه ها و نمایه کلروفیل کاهش نشان داد ولی در جه حرارت برگ و تراکم کُرک ها افزایش داشت. درگیاهان تحت تنش آبی، برگپاشی کائولین نرخ تعرق و حرارت برگ را کم کرد و نیز تراکم کُرک ها و ضخامت برگ را کاهش داد. همچنین، با مصرف کائولین، طول گیاه، جرم خشک کل گیاه، کارآیی مصرف آب و تراکم تعداد روزنه ها در گیاهان تحت تنش افزایش یافت. نتایج حاکی از آن است که مصرف کائولین برای کاهش اثرات تنش آبی روش مناسبی است و کارآیی مصرف آب را در گیاه cape gooseberry که در شرایط (کم) آبی خاصی باشند بهبود می بخشد.