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Determination of rainfall effects on kaolin clay coverage rates used in prevention plant from sunburn

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Abstract

Sunburn, which is an important problem in agricultural products grown in arid and semi-arid regions, causes economic losses of up to 40-60% in some years. Sunburn occurs as a result of overheating of the surfaces of fruits exposed to high air temperature and solar radiation from the sun. Increase in the temperature stress for plants is observed during months of high temperature, this is one of the main reasons for many negative conditions (changes in fruit colour, cell death in plants, etc.) in fruits and leaves. While the shelf life of damaged agricultural products is shortened, deterioration is observed even in the storage stage. Today, different applications are made to reduce the sunburn in many kinds of fruits and sunburn damage can be significantly reduced as a result of these applications. For this purpose, it was aimed to reduce the temperature on the leaf surface by the application of kaolin clay (Trade name; Güneş Stop) applied to the plant surface at the beginning of the season. In the study; eight different concentrations of kaolin clay with tree application volume were applied and after the application, leaf samples of the citrus trees were taken from the predetermined regions, and the coverage rate was measured in an image processing program. From 8 different regions, 15 pieces of leaf were randomly taken from each region. The same process was carried out again by collecting leaf samples from the same regions after the rain; thus, the performance analysis of kaolin clay was determined after the rainfall. As a result of kaolin clay application; according to the results of image analysis of average leaf surface coverage rates obtained by regions and after the rainfall, the results obtained from the same regions showed that kaolin clay was washed at a rate of 39.64% with precipitation.

Keywords: Image processing, Temperature stress, Solar radiation, Plant Protection

Introduction

With global climate change, high temperatures and frosts may happen in parts where no high temperatures and extreme colds were experienced before. Considering the temperature projections of the century we live in, it is believed that extremely high temperatures and colds will be experienced a lot more. Agricultural products are the leading species that will be most affected by this situation and the food chain will be affected. As the regional high temperatures increase, agricultural products' tolerance to the environmental factors will decrease, thus, the yield and product quality of the agricultural products will inevitably decrease.

It is essential to preserve the plant for the sake of achieving a high yield product in agriculture. It is also vital to heal environmental factors and ensure comfort in terms of the product although pest control is thought of in the first place for plant protection. Product surfaces may burn and color changes may be seen in some fruit types such as apples, pears, grapes, pomegranates, olives, walnuts, citrus fruits and vegetables such as peppers, tomatoes, watermelon that are exposed to sunlight and high temperature directly. Consequently, the product is no longer appealing and rapidly deteriorates and its market value

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decreases. This situation, which is called sunburn, is oxidative damage caused by intense light such as high temperature and ultraviolet (UV) (Finkel and Holbrook, 2000). At extreme temperatures, stains happen due to the damage of the fruit cells that are in the open parts of the crown (Yazıcı and Kaynak, 2006). Considering the high temperature and exposure time, most plant species cannot survive at temperatures above 45°C. The ambient temperature of 27-28 °C is suitable for an adequate vegetative development. In their study, Wünsche et al. (2002) revealed that sunburn is a defence mechanism performed by the fruits and leaves of the plant due to their efforts to protect themselves. Two examples can be given for this situation: Sunburn in Fuji apples appear as a color change from yellow to brown, and it appears as surface whitening in Granny Smith apples (Yazıcı and Kaynak, 2006).

Since the consequences of sunburn are acknowledged, for the purpose of eliminating this situation, various covering studies are executed in our country, as well as many sunburn prevention studies. One of these is to use kaolin clay on the leaf and fruit surface, which bears the quality of reflecting the sun's heat and rays back. Often the kaolin clay is mixed with water and applied with the high pressure motorized backpack sprayer, by doing so, the fruit and leaf surfaces are covered with a thin layer of clay. Hence, the relationship of the fruit and leaf surfaces with the environment is diminished and the water content of the related parts is protected. Due to the kaolin clay, the leaf part can provide better photosynthesis and respiration since its heat transfer with the environment decreases. Besides, the leaf part draws less water from the root zone so the water will not be lost due to the evaporation. And there are secondary benefits of kaolin clay. As the fruit and leaf surfaces will be covered, it provides protection against some insect and fungus species. It also provides protection against frost since kaolin clay can be applied in cold weather.

In this study, kaolin clay (trade name: Güneş Stop) was applied to the leaf surface with a motorized backpack sprayer in a garden with okitsu tangerine trees; and particularly after the application, the effects of precipitation on kaolin coverage ratio were determined.

Material and Method

The study was conducted in a garden with 5-year-old okitsu tangerine trees in Adana, Turkey. The row width of fruit trees in the garden was 5 m, the tree crown height was approximately 2 m and the tree crown width was 2 m. The trade name of kaolin clay applied to cover the leaf surface was 'Güneş Stop'. This commercial product applied in the study can be started to be used when the fruit diameter reaches 2.5 cm. In terms of frequency of application of kaolin employed in the research, consecutive applications in dry conditions can be performed 14 and 21 days after the first application and it is suggested that the final application should be made approximately 1 month before the harvest. In the research, kaolin was applied in 8 different concentrations (GS1, GS2, GS3, GS4, GS5, GS6, GS7, GS8) and also the producer of the kaolin clay advices to use the concentration between 1.2% to 2.8%. These concentrations were 1.3%; 1.5%; 1.6%; 1.8%; 2%; 2.2%; 2.4%; 2.7 % in the range of GS1 and GS8, respectively. The concentrations prepared were sprayed at a pressure of 15 bar in 2 L / tree volume.

In the research, pH, leaf contact angle, surface tension values of the solution in the tank were measured to identify the effect of different kaolin concentrations on the physical features of the spray liquid in the tank. The contact angle and surface tensions of the drops on the leaf surface were calculated with the Drope Shape Analysis System DSA 10 Krüss brand device to identify the effect of the performed applications and spray solutions of various concentrations on the coverage rate.

Spraying applications were performed with the Palmera OS-768 High Pressure Motorized Backpack Sprayer.The power of this sprayer was 1.9 HP and its tank storage was 25 L (Figure 1).While applying with motorized backpack sprayer , 15 bar operating pressure was preferred. The bypass line of the sprayer was kept open constantly so the relevant concentrations did not accumulate in the storage tank of the sprayer. After each operation, the tank of the sprayer was cleaned and washed with pressurized water. For preparing the concentrations, tap water was used.

Figure 1. Application of the kaolin clay to the trees with the motorized backpack sprayer

Kaolin solutions prepared in different concentrations were sprayed on random parcels with a motorized backpack sprayer according to the trial pattern as 3 replicates. Then 15 leaf samples were randomly taken from each tree, from the outer, inner and different locations of the tree. The coverage rates on leaf samples taken from different points on the tree were measured one by one and the average coverage rate per tree was calculated.

The leaves collected from 8 different parts where kaolin solution was sprayed were put in paper envelopes and preserved in the refrigerator. After taking these leaves out of their packaging in the laboratory, they were photographed with an Olympus (E620, Japan) camera which was placed on a black exposure box (Figure 2). During the photographing session, the camera was calibrated in the following format: ISO: 800; shutter speed: 1/60; aperture: 5.6; resolution: 4032 x 3024 and JPEG. The distance between the camera lens and leaf samples was 25 cm. 12 VDC, 48 led light sources (Cata, TL-4481) were used in the illumination of the exposure box and they were placed around the camera lens for obtaining a homogeneous illumination. A DC power source (Pacific, 2305D +) was used to supply the in-box lighting system. The coverage ratios of the kaolin clay, which created white spots on the leaves, were measured by the image processing technique.

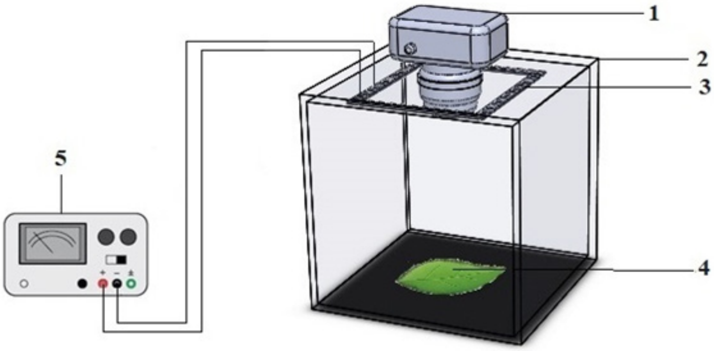

Figure 2. Schematic view of the system (1. Camera, 2. Box of black exposuring, 3. Light Source of LED, 4. Leaf Sample, 5. DC Power Supply)

The image processing technique is frequently used in agriculture today for purposes such as measurement of leaf area, color analysis and classification in fruits; determination of pesticide drop size, drop density and drug coverage rate in spraying applications; determination of leaf area, conducting color analysis in fruits, determination of weeds, determination of grinding degree, monitoring plant growth and root development. In this way, some very difficult measurements are performed easily, faster and precisely (Karabacak, 2007; Mustafa et al., 2008; Zhao et al., 2009; Örge, 2012; Kuncan et al., 2013; Sabancı and Aydın, 2014). The actual shape of the leaf was visually produced by carving the rectangular shaped photographs according to the shape of the leaf by means of the screen snipping tool.

The leaves were photographed in a dark environment and under a constant light source to reveal the coverage area of Güneş Stop containing kaolin clay on the leaves with image processing in the most accurate form. After the threshold values of these pictures displayed with the ImageJ 1.51p program (Özlüoymak and Bolat 2020) were separately identified; RGB was defined as the color space, and particle analysis was conducted to find the coverage rate of the Güneş Stop particles on the leaf (Figure 3).

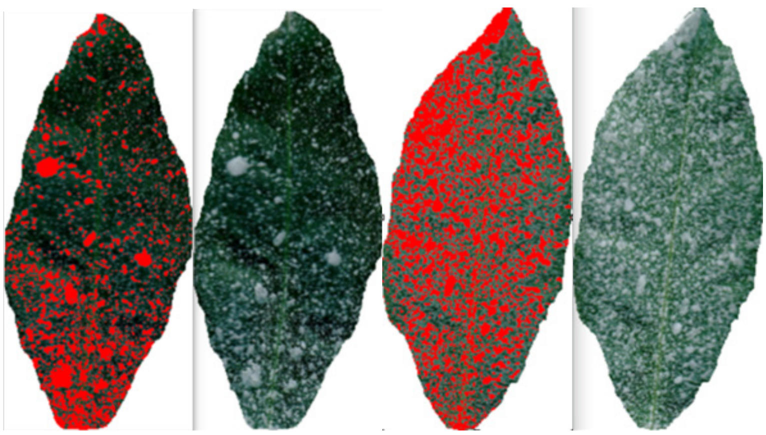

Figure 3. Photographed leaf samples and analysed in ImageJ 1.51

The image processing process was applied to pre-rain leaf samples (15 pieces) and leaf samples which were taken after three days of the rain (15 pieces). These leaf samples were taken from 8 pre-defined locations. Coverage rates of the leaf samples -before and after the rain-taken from each location were compared. Statistical tests were conducted with the SPSS package program.

Results and Discussion

Coverage rates of leaf images were determined by using the image processing program and statistically analysed. Firstly, it was investigated whether 8 different kaolin concentrations applied to the leaf surface demonstrate any differences among themselves; Levene Homogenity Test was carried out before one-way ANOVA test. The Duncan test was conducted to determine the differences (Table 1). According to the Levene test, surface coverage data was distributed homogeneously (P> 0.05). So, there was a difference between the coverage rates achieved in different concentrations. There were also significant differences according to the one-way ANOVA test.

Table 1. One Way Anova results of coverage rates obtained from the image processing program

Levene Statistic	df1	df2	Sig.
2,013	7	112	,060*

One Way Anova Test	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0,331	7	0,047	11,111	0,000*
Within Groups	0,476	112	0,004		
Total	0,807	119			

*P<0,05 significant

In the SPSS program, Duncan test was conducted with the results of the one-way ANOVA test and according to the results, the coverage rate achieved with GS8 (highest kaolin clay concentration) was the best coverage concentration (Table 2). Additionally, the lowest coverage rates were achieved with GS1, GS2, and GS3. Hence, high concentrations produced high coverage rates.

Table 2. Comparisons of the kaolin clay concentrations that cumulated on Leaf Samples

	Concentration	Number of Leaf	GS6	GS7	GS8
Duncan a	GS3	15	0,400		
	GS2	15	0,412		
	GS1	15	0,438		
	GS4	15		0,487	
	GS6	15		0,492	
	GS5	15		0,512	
	GS7	15		0,519	0,519
	GS8	15			0,561
	Sig.		0,140	0,234	0,078

The surface tension and contact angle values of the kaolin clay concentrations with different kaolin clay content employed in the laboratory study are presented in Table 3. In the three-replicate experiments, when the data of the surface tension was examined, it was definitely observed that the concentration did not affect the surface tension however, no significant increase or decrease was observed. When the contact angles of kaolin clay containing droplets on the leaf were assessed, it was noticed that the contact angle did not alter much with higher concentration rates.

In Table 4, the average kaolin coverage rates (%) per leaf noted in the applications before and after the rain are presented. At the GS8 concentration, providing the highest coverage rate before the rain, 39.64% of the kaolin clay washed under rain. Accordingly, it was discovered that more washings occurred at concentrations providing high coverage.

Coverage rates of leaves scanned before and after the rainfall were compared. This comparison aimed to understand washing under the rainfall whether statistically significant or not. In the comparison, pre-rain coverage rate data for each concentration and post-rain coverage rates were compared. Firstly, normality tests were carried out since the binary comparison was applied to the data. Since the number of data was below 50 in the normality test results, the Shapiro-Wilk test result was considered as the basis (Kalaycı, 2016), and it was discovered that the data did not statistically distribute normally according to this result. Therefore, the Mann-Whitney U test, which is a nonparametric binary comparison test, was selected to understand whether the data that did not conform to the normal distribution would reveal a significant difference among themselves. According to the data achieved (Table 5), it was observed that they were seriously washed after the rain and a small amount of kaolin clay coverage remained on the leaf surface. Thus, regardless of the used proportions; kaolin clay, which was sprayed on the leaf surface, flowed statistically with the rainfall.

Table 3. pH, surface tension and contact angle values of each kaolin clay concentrations

	Kaolin Clay Concentration (%)	Surface Tension (N/m)	Contact Angle (°)	pH
GS1	1,3	73,5	72,57	9,55
GS2	1,5	74,53	72,13	9,88
GS3	1,6	74,79	71,13	9,23
GS4	1,8	74,9	70,53	9,7
GS5	2	73,83	71,73	9,73
GS6	2,2	74,16	71,17	9,46
GS7	2,4	74,54	72,6	9,35
GS8	2,7	73,58	72,03	9,87

Table 4. Coverage rates of leaf samples before and after the rainfall (%)

Kaolin Clay Concentration	Coverage rate before rainfall (%)	Coverage rate after rainfall (%)	Coverage Rate Reduction (%)
GS1	35,84	28,24	7,6
GS2	39,27	27,02	12,25
GS3	40,35	25,56	14,79
GS4	44,12	23,88	20,24
GS5	45,7	21,26	23,44
GS6	46,93	18,54	27,39
GS7	48,37	15,09	33,28
GS8	52,11	12,47	39,64

Table 5. Coverage rate comparisons of leaf samples after and before the rainfall

	GS1	GS2	GS3	GS4	GS5	GS6	GS7	GS8
Shapiro Wilk-Asymp Sig.	0,022*	0,013*	0,002*	0,022*	0,00*	0,02*	0,02*	0,013*
Mann Whitney U Asymp Sig.	0,00**	0,00**	0,00**	0,00**	0,00**	0,00**	0,00**	0,00**

* 0,05>P not homogenous

** 0,05>P significant

Conclusion

It is vital that kaolin clay does not harm health in terms of both humans and other living creatures by skin contact or breathing. It was demonstrated that Güneş Stop concentrations prepared in different concentrations did not cause very dissimilar results on pH, surface contact angle, surface tension; and concentrations prepared with high amounts of Güneş Stop, just increased operating cost a little. So, it is proper to employ in high concentration unless it rains and it was observed in applications that a good coverage was achieved on the leaf surface by doing so. When the leaves photographed after the rain, it was seen that there was a certain amount of Güneş Stop remaining on the surface of the leaves despite the heavy rain continuing for three days. Besides, it was found that the stains on these leaves were not statistically significant. With Güneş Stop, the direct contact of the leaves and fruit with the sun was blocked until the first rain subsequent to the application, and moisture content of these sections was preserved. It is believed that Güneş Stop, which ensures improved protection against pests with absorbent mouths, will be beneficial in every rain (until harvest).

Compliance with Ethical Standards

Conflict of interest

The authors declare that for this article they have no actual, potential or perceived the conflict of interests.

Author contribution

The contribution of the authors is equal. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

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