Fall 2012

The effect of dirt on inhibition of light absorption in Musa leaves

Lorelle Knight
Pepperdine University

Alexis Carrington
Pepperdine University

Angela French
Pepperdine University

Roxanne Barker
Pepperdine University

The effect of dirt on inhibition of light absorption in *Musa* leaves

Lorelle Knight, Alexis Carrington, Angela French, Roxanne Barker
Pepperdine University Malibu, CA 90263

Abstract

Dirt can be transported by wind, human activity and many other factors. It was hypothesized that dirt particles collected on leaves will decrease leaf reflectance and thus make the leaf less healthy. The rationale for this is that the more dirt present on the leaf, the more inhibited photons will be in reaching leaf pigments. The leaf will therefore be less healthy as it will be less able to perform photosynthesis. To test this hypothesis, eight leaf samples with varying amounts of dirt present, were collected from the plant, *Musa*. A Unispec spectrophotometer was used to test the reflectance of the leaves and from the collected data the NDVI was found. A Dirt Index was created as a second form of measuring the reflectance by a leaf. A Leaf Area Meter was used to measure the area of each of the eight samples. The data was then normalized taking into the account the amount of dirt on each sample and the area of each sample. The data coincided with the hypothesis. The dirt index and NDVI were both correlated with the amount of dirt on the leaf yet the NDVI had better accounted variance. The T-tests of both the DI and NDVI verified the hypothesis that leaves with greater amounts of dirt had lower reflectance.

Introduction

Regardless of a leaf's location on dry land, it is destined to acquire dirt. Dirt buildup on a leaf will impact its capability to thrive in multiple manners, but perhaps the most significant is the inhibition of light absorbance that the built-up dirt causes. As more and more dirt accumulates on a leaf, more light cannot reach the leaf's photoreceptors, i.e. the light needed for the leaf to do photosynthesis is blocked. Therefore, we have hypothesized the following:
The more dirt accumulated on a leaf, the less light the leaf will absorb. Leaves in areas prone to high levels of dirt in the air will appear less healthy than those that live where the air is cleaner. This is in part because the dirt accumulates on the leaf and decreases light absorption, decreasing photosynthetic efficiency.
To test this, we used the NDVI, the Normalized Difference Vegetation Index, to measure and show the leaf's reflectance of light and how this is impacted by dirt. According to Stylinski et. al, "NDVI are often offered as a rapid non-destructive and cost effective means of estimating plant carbon gain over varied special and temporal scales. These indices have been correlated with net primary production and in some instances with photosynthetic rates." Therefore, we would expect a greener, less dirty plant to have a higher NDVI level. Additionally, we selected a range of light wavelength in which the most light was reflected and used this to create what we coined the "Dirt Index," an index that illustrates how dirt levels are directly correlated to light reflectance levels.

Conclusion

The light reflectance was affected as the amount of dirt on the leaf increased.

- The Dirt Index and the NDVI positively correlated with the amount of dirt calculated on the dirty leaves.
- When compared, the NDVI and the Dirt Index displayed the same correlations. Yet, then NDVI had a better result.

Image 5 (from left to right): Alexis Carrington, Angela French, Lorelle Knight, Roxanne Barker

Methods

Image 1: Musa, the species used.

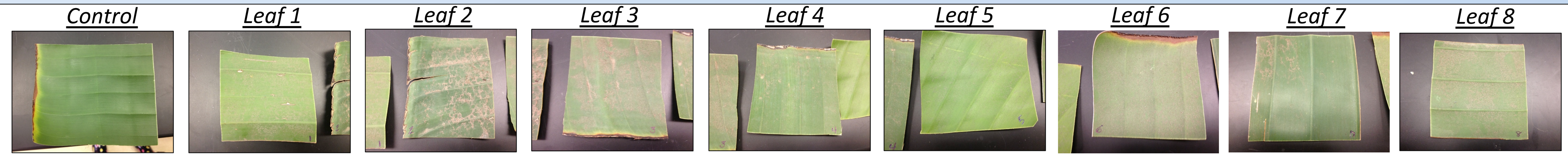


Image 2 (left): Leaves control, 1-8. 4x4 inch squares used

The Unispec Spectral Analysis System was used to determine the NDVI and DI of each individual 4x4 inch square of *Musa* leaf. The leaves were then rinsed and the runoff was collected and dried, and the amount of dirt left after the water had been evaporated was weighed. This number was divided by the area of the leaf (found by the Leaf Area Meter) and the new NDVI and DIs were calculated on the clean leaf for comparison. The "dirty" and "clean" NDVIs and DIs were then compared.

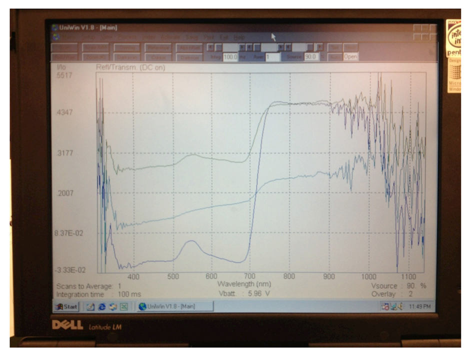
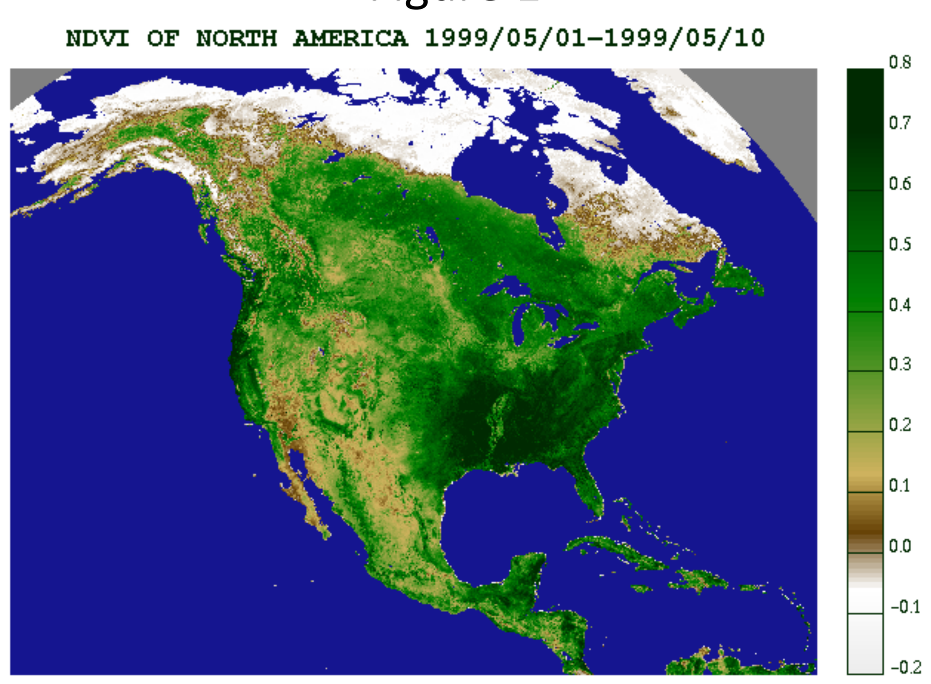


Image 3 (left): Comparison of a clean leaf NDVI spectrum (top line) to a dirty leaf NDVI spectrum (bottom line).

Image 4 (right): Measuring the leaf area without having found the room's light switch…

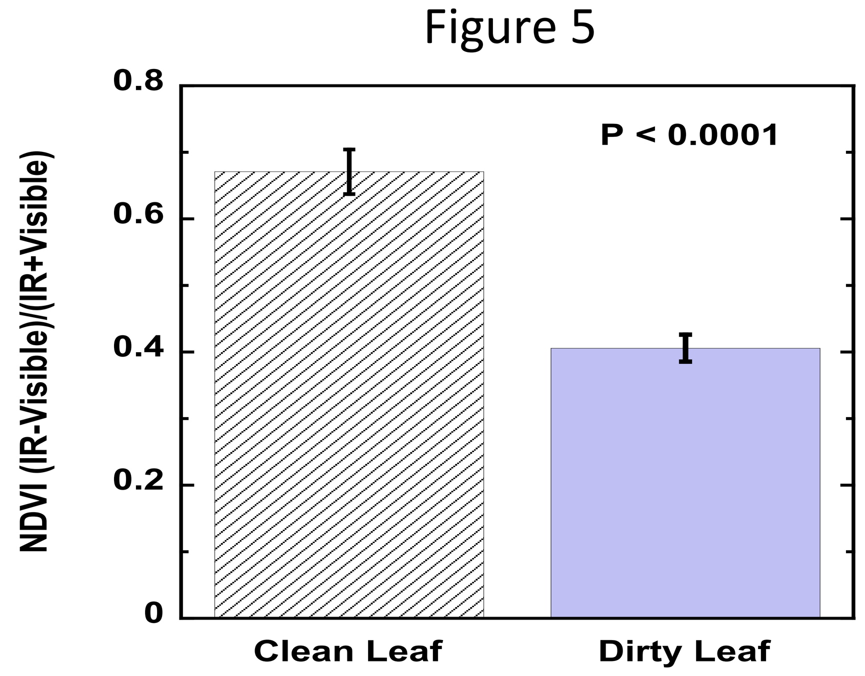
Results

Figure 1



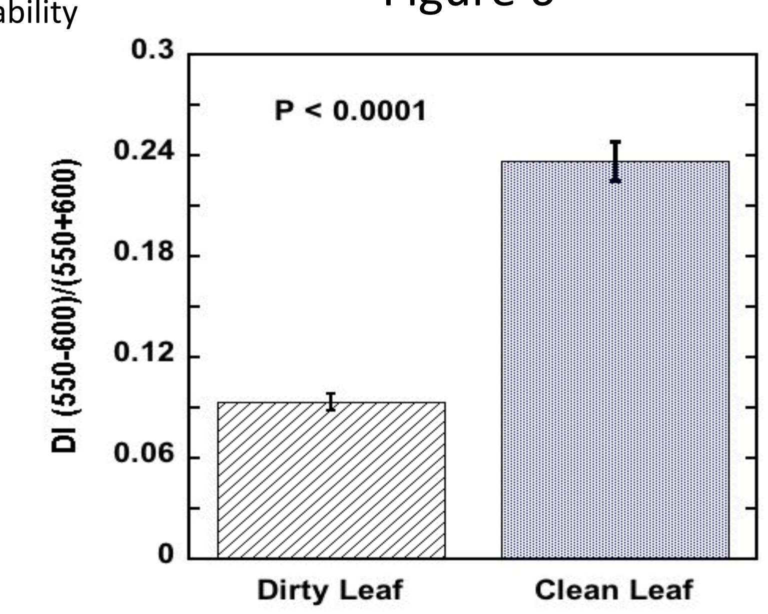
The North American Vegetation Index measures the vegetation present, therefore the amount of light it reflects.

Figure 5



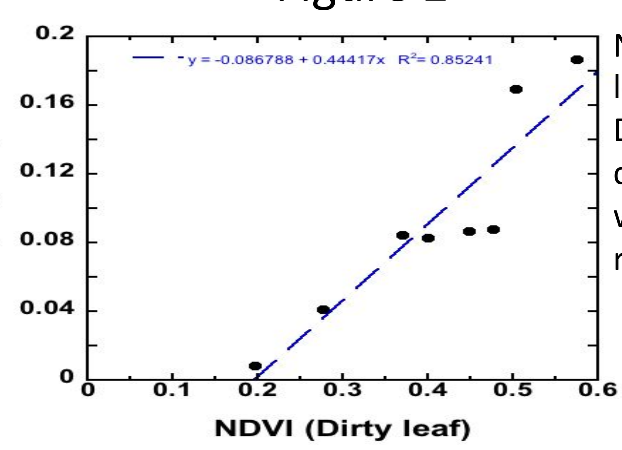
T-test of NDVI of clean and dirty with a probability <0.0001

Figure 6



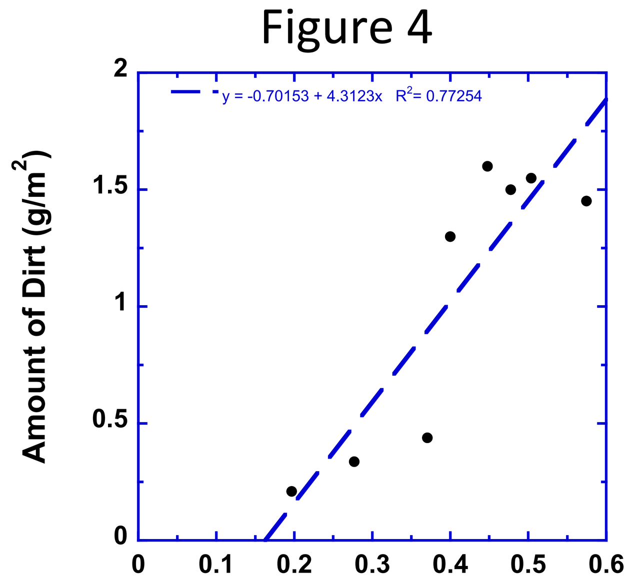
T-test of DI of dirty and clean leaf with a probability <0.0001

Figure 2



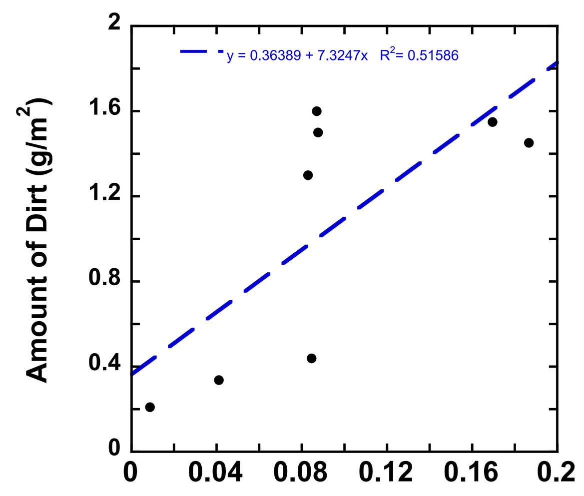
NDVI of a dirty leaf versus the Dirt Index of a dirty leaf along with the linear regression.

Figure 4



The NDVI of a dirty leaf with the linear regression. The linear regression shows 76% of the variance accounted.

Figure 3



The Dirt Index of a dirty leaf with the linear regression shows 50% of the variance accounted.

Discussion

Our findings correlated with our hypothesis. Specifically, our "Dirt Index" (DI) positively correlated with the amount of dirt calculated on the dirty leaves used, shown through the 50% accounted variance through the linear regression. The NDVI had a positive correlation with the amount of dirt on the leaf as well, yet there was a better-accounted variance (76.1%). Our DI correlated with the standard NDVI that is commonly used in this field. This was a positive outcome for our experiment and also illustrates the consistency of the light absorbance varying in the dirty and clean leaves. The NDVI had a higher accounted variance than our "Direct Index" (by about 35%); this additionally illustrates that the NDVI is more accurate at detecting the amount of light that leaves reflect. This accounted variance obtained shows how the NDVI can be obtained (as shown in Fig. 1) from a vast mass of plants to a very small plant and still obtain accurate results. The T-tests of the DI and NDVI confirmed our hypothesis as well; the leaf reflectance was greater in clean leaves than in the dirty leaves and both the indices obtained this. This also agreed with our second hypothesis (how a leaf will appear less healthy if it accumulates more dirt). This second hypothesis was additionally supported by the fact that, upon inspection, dirtier *Musa* leaves were observed to appear more curled and less rigid (more unhealthy) than cleaner *Musa* leaves. Previous experiments performed, such as Rasoul Sharifi's, acquired the same results. Sharifi determined that one of the physiological effects that dust accumulation has is on photosynthesis, especially under summer conditions of high ambient air temperatures. This arid environmental factor correlates to the environment conditions our plant grew in, since there was no rain for months before we performed our experiment. The lack of rain and human activity near the plants caused the accumulation of dirt on the plants. This serves to support our prediction that leaves exposed to much dirt due to human activity, such as construction or landscaping, will show impairment (from what would be ideal) with regards to light absorption. Methods of decreasing this affect must be further explored.

Acknowledgements

This research was funded by Natural Science Division of Pepperdine University.

Work Cited

Sharifi, R. M., Gibson, A. C., Rundel, P. W. 1997. Surface dust impacts on gas exchange in Mojave Desert shrubs. Journal of Applied Ecology, 34:837-846.
Image provided by: www.ccpo.odu.edu