# REPORT

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TITLE: **Plant moisture stress and the water content of tree leaves at different times during the day in the Kuiseb River flood plain.**

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# TITLE

## Plant moisture stress and water content of tree leaves at different times during the day in the Kuiseb River flood plain

**Abstract**
Leaf water content and plant moisture stress, or plant water potential and their relationship with the floods and underground water were determined at different times during the day for tree species such as *Faiherbia albida*, *Acacia erioloba*, *Tamarix usneioudes, euclea pseudebenus and salvadora persica,* which are the most dominant tree species in the Lower Kuiseb River near Gobabeb where the study was done. PMS or plant moisture stress measures the demand for water within a plant and water content tells us how much water a plant hold in its tissue. PMS is measured in Bars and water content in percentage, the average maximum PMS measurements were recorded at mid day with Salvadora percica going up to 37 bar, the lowest PMS was recorded before dawn at 18:00 and in the morning at 06:00. Water content in tree leaves decreased in the late afternoon and highest in the late morning. Environmental conditions such as fog, wind, heat etc affected the results greatly.

### 1. INTRODUCTION

### 1.1 Vegetation and moisture

Knowing that water is very scarce in the desert environment, the relationship between vegetation and water is a very important factor to focus on; trees in particular have a very big influence on the water table. The aim of this study was to find out how water stressed plants are and to compare to the water content in their leaves. This could help in analysing the condition of vegetation and to find out if the results could tell us anything about the water table especially as one moves away form the main river channel. Desert plants, like any other plants, need water to grow and as water is a vital resource for plant growth and survival it is often scarce especially in an arid environment, For this reason, many desert plants have adaptations that conserve water such as thick cuticles, pubescence that creates a thicker boundary layer on the leaf surface, sunken stomata, and succulent (large amounts of water- storage tissue), (Rabas and Martin; 2003). In addition, they develop and grow longer roots to reach the water table. Plants hold water under tension. The pressure required to exude water from a leaf is defined as the water potential of the leaf, (Nott; Savage, 1983) Desert plants retain moisture by limiting water loss through their leaf surface. Many plants accomplish this by adapting the size, sheen, or texture of their leaves. Small leaves or spines limit the amount of surface area exposed to the drying heat, for examples *Acacia erioloba, Faidherbia albida, euclea pseudebenus and tamarix usneoudes*. Plants such as *salvadora persica* have glossy leaves, which reflect the sun's radiant heat reducing leaf temperatures and evaporation rates. Waxy leaves prevent moisture from escaping. Water escapes from leaves through the stomata, or leaf pores. A behavioural adaptation used by some plants is to only open leaf pores during the night when air temperature is cool and evaporation rate is low. Five trees were studied; *Acacia erioloba, faidherbia albida, Euclea pseudebenus, salvadora persica* and *Tamarix usneioudes.*

This study focuses on the relationship between the vegetation and the floods and how the plants affect the water table. The theme of this project was to determine plant moisture stress and water content of tree leaves of different species. This project and three others done by Gobabeb In-Service Training (GIST) students are components of a research theme to find out the relationship between vegetation in the Kuiseb River and the floods. The whole project will contribute to the WADE project (floodwater recharge of alluvial aquifers in dry land environments) which aims to assess long-term water resources in selected semi arid to hyper arid river basins by determining long-term transmission losses from flood and quantifying floodwater recharge into alluvial aquifers, (WADE project file). The Desert Research Foundation of Namibia (DRFN) is one of the twelve participating WADE partners and is facilitating this project, which will contribute to site characterization one of the nine work packages of WADE.

### 1.2. STUDY AREA

This project was done in the lower Kuiseb basin near the Gobabeb Centre**.** Gobabeb lies next to the ephemeral Kuiseb River 120km by road away from Walvis Bay. The Kuiseb River rises in the Khomas Hochland, near Windhoek, and with the relatively high rainfall in its catchment area, it is the largest river in the coastal belt between the Orange and the Kunene (Myburgh, 1978). The mean annual rainfall in the Namib Naukluft Park is 18.7mm (Theron and Van Rooyen, 1979). The most common plants in the lower Kuiseb near the Gobabeb Training and Research Centre includes trees such as *Faidherbia albida, Acacia erioloba, Euclea pseudebenus and Tamarix usneoides,* and *Salvadoa persica,* as well as alien species such as *nicotiana glauca*, which can be found growing in the main river channel.

The Kuiseb River was chosen for the WADE project because it is the best-studied ephemeral river in Namibia; other countries involved in the WADE project are Israel, South Africa, Spain and Namibia.

## 2. PROJECT OBJECTIVES

1. To determine the water stress and water content of tree leaves of *Faidherbia albida*, *Acacia erioloba*, *Salvadora persica* and *Euclea pseudebenus* at different times during the day.
2. To determine the water stress and water content of tree leaves at varying distances from the main river channel.
3. To determine water stress and water content of leaves from trees coppicing and trees not coppicing.
4. To determine whether age of tree affects leaf water content and water stress levels.

## 3. PERSONAL OBJECTIVES

1. To gain more experience in doing research

2. To learn to work in a team
3. To achieve my project objectives
4. To increase my chances of getting a job in a related field
5. To update my c.v.
6. To apply my theoretical knowledge into practice

## 4. MATERIALS AND METHODS

### 4.1. To determine the water stress and water content of tree leaves of *Faidherbia albida, Acacia erioloba, Salvadora persica, Tamarix usneoides* and *Euclea pseudebenus* at different times during the day the day.

A PMS (plant moisture stress) instrument with a pressure chamber was used to measure the water stress of trees. This actually measures the force or pressure required by the tree to "suck" up water from the soil. The complete instrument consists of a pressure chamber, pressure tank filled with nitrogen gas, and a pressure gauge. Plant water stress or plant water potential indicates the demand for water within a plant and its water status.

Samples were taken from each tree species along each transect. Measurements were be done in the field, immediately after taking a sample it was be put in the pressure chamber to measure its moisture stress and recorded on the data sheet. Relative humidity and ambient temperature was taken using the sling Psychrometer.

**Figure 1: Pressure tank, PMS instrument with pressure chamber**

- The last 10 cm of a growing shoot was cut from each tree. The branch was cut off using pruning scissors and then put in a plastic bag to minimize transpiration. The plastic bag was sealed or tied and marked or given a code to identify what species it is, the time of day it was collected and the distance from the main river course. It was then put in a cooler box to keep it fresh and retain its moisture content. This was done along the ten transects done across part of the lower Kuiseb flood plain near the Gobabeb training and research station. Two samples were taken for measurements from each individual tree for water content and three samples for the PMS.

**4.2. To determine the water stress and water content of tree leaves at varying distances from the main river channel.**

- The distance from the main river channel was measured for each tree sampled. The distance measurements were taken with a 60m measuring tape and comparisons were made with the water content of the same species from varying distances, although this was difficult for some species that do not occur at certain distances from the main channel e.g. *Faidherbia albida*, which is mostly found next to the main river channel where there is enough water (personal observation).

**4.3. To determine water stress and water content of leaves from trees coppicing and trees not coppicing.**

- Along each transect fallen trees coppicing were identified and samples were taken from the coppicing (re- growing) shoot, and compared to the tree of the same species not coppicing or not fallen, the water status of these trees was measured.

**4.4. To determine whether the age of a tree affects leaf water content and water stress levels.**

This was not done as aging was difficult in this case and mostly the mature or fully grown tree's leaves were not easily accessible. But according to some literature, young leaves or plants contain more water than old leaves and trees.

## WATER CONTENT DETERMINATION

Each sample was weighed separately on balance mettle 100 back at the station each day of data collection. The sample were then dried in an oven at 70 °C for 24 hours and re-weighed again, fresh weight of the sample –the dry weigh after drying gives the moisture content in grams. To calculate the moisture content of a sample the moisture weight removed in drying was divided by the fresh weight of the sample, and then multiplied by 100.

## WATER STRESS DETERMINATION

A plant sample is sealed in a pressure chamber with the cut end exposed through a hole in the chamber cover. Chamber pressure is slowly increased until water in the plant sample is forced back to the cut surface. The pressure indicated on the pressure gauge is the plant moisture stress. It is equal to the tension on the water column in the xylem at the time the sample was cut from the plant.

## 5. Results and Discussion

### 5.1. **Water** content of tree leaves at different times during the day

At the time of this study, the ambient temperature and relative humidity varied greatly through out the day, temperature was between 24 37de. Cel. This in turn had a great effect on the water content in the tree leaves. Figure 1 shows the percentage moisture content in the leaves of different tree species. Often more than 90% of the plant is made of water, but the highest water content recorded in this study was 64% (in *salvadora persica* leaves at 10:00). Most species show the higher water content at 10:00, this could be because during this study Gobabeb was experiencing foggy and cold mornings almost each morning of sampling and it usually increased after the 06:00 samples have been collected, so the fog collected on the leaves of these plants could have resulted in these high figures during this time, Leaf water content decreased soon after sunrise in the late afternoon and this was expected as this is the time they transpire the most and loose more moisture from their leaves. After 14:00 all the plants gained some moisture at 18:00 this is because as each water molecule evaporates especially in the afternoons when it is very hot, it pulls another water molecule into its place to prevent wilting.

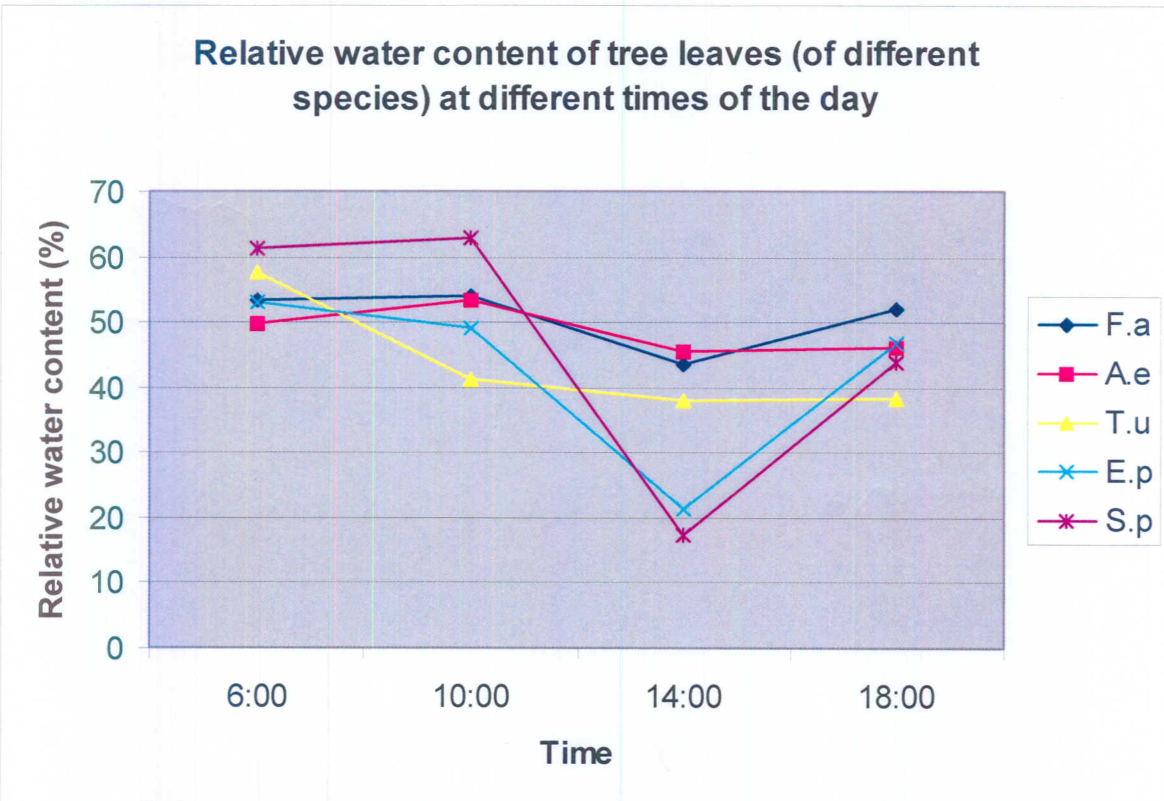



**Figure 1.** F.a=Faidherbia albida; A.e=Acacia erioloba; T.u=Tamarix usneioudes; E.p=Euclea pseudebenus and Sup=Salvadora persica

## 5.2. Water content of tee leaves form trees coppicing and trees not coppicing.

The results show that coppicing trees have the highest moisture contents in the entire coppicing trees that were sampled. This could be because coppicing trees are usually new resprouts and new shoots contain more moisture than bigger trees. Another reason could be that most coppicing trees are not tall trees and so they are mostly under shade from tall non-coppicing trees, meaning that they do not lose much moisture as the air moisture under tees would be higher, and they are not exposed too much to sun shine, the environment under the shed is that of high humidity and cool air and so plants would not release too much moisture, this could also explain why the results are so, There was less literature to find out if maybe the fact hat these coppicing trees grow from stems could have affected the results. It can be observed from the graph though that there's not much difference in the water content of both these pants surprisingly though *Faidherbia albida* non- coppicing showed a high water content at 18:00 and *Acacia erioloba* at 10:00. I will not be able to explain why this was.

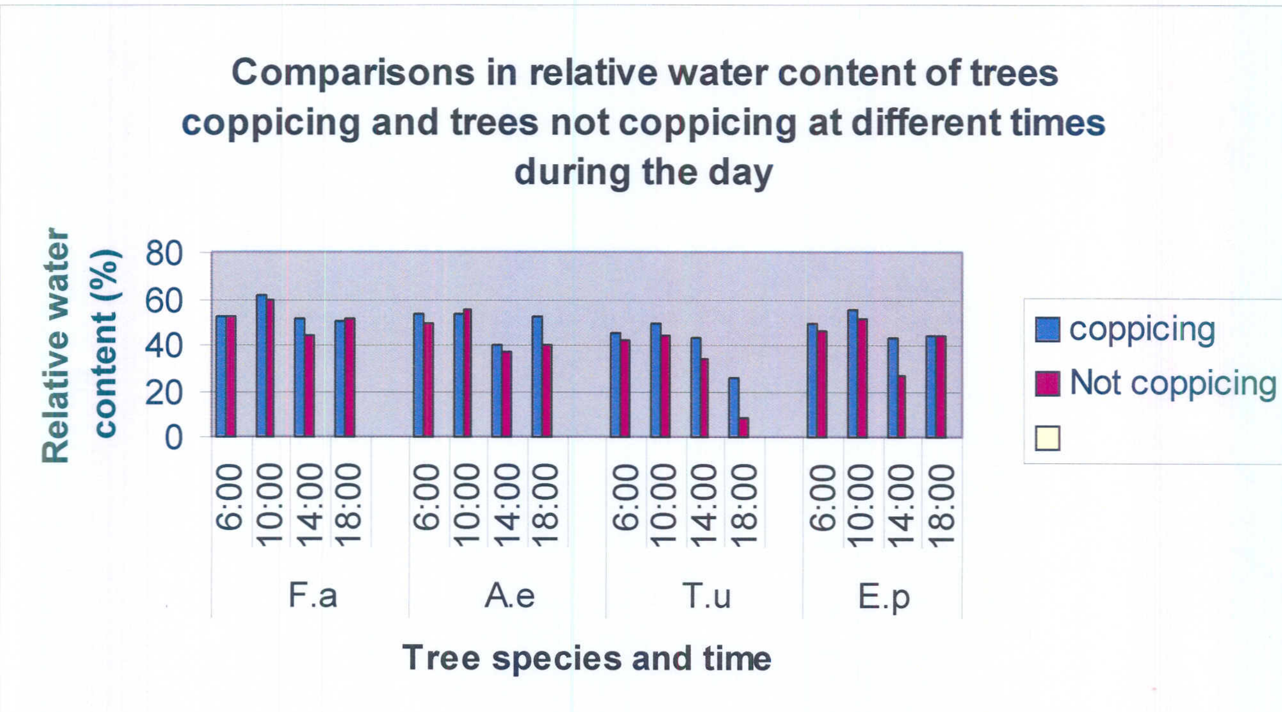



**Figure: 2. F.a- Faidherbia albida, A.e- Acacia erioloba, T.u- Tamarix usneioudes, E.p- Euclea pseudebenus.**

## 5.3. Plant moisture stress of trees at different times of the day

According to the results in fig.3, PMS was highest in the noon, this is the time when plants transpire the most and loose more water through their leaves, the results could be an under estimation or over estimation given the possibility of evaporation of water from the sample during preparation. PMS of the day shows that plants were less stressed in the early mornings and just before dawn, this is thought to be because at night the plant is exposed to cool moist air and in the morning is most likely to experience fog,. The water conservation fact sheet, March, 1997, pg.4, says, readings are lowest just before sunrise and increase rapidly until solar noon.and according to Miller, 1983 Xylem pressure potentials at mid-day can be low because of restricted water supply or because of high transpiration losses. According to the graph Euclea pseudebenus and Salvaodra persica were the most stressed in the late after noon, with S. persica reaching up to 37bars. The plant's morphological structure could have played an important role here as S. persica has simple leaves that are open and fully exposed to the heat causing the plant to loose water at a aster rate, a faster rate of water loss causes a more negative water potential (pressure-chamber.shtml). The most important leaf factor in hits regard is the rate of water loss at the moment of sampling.

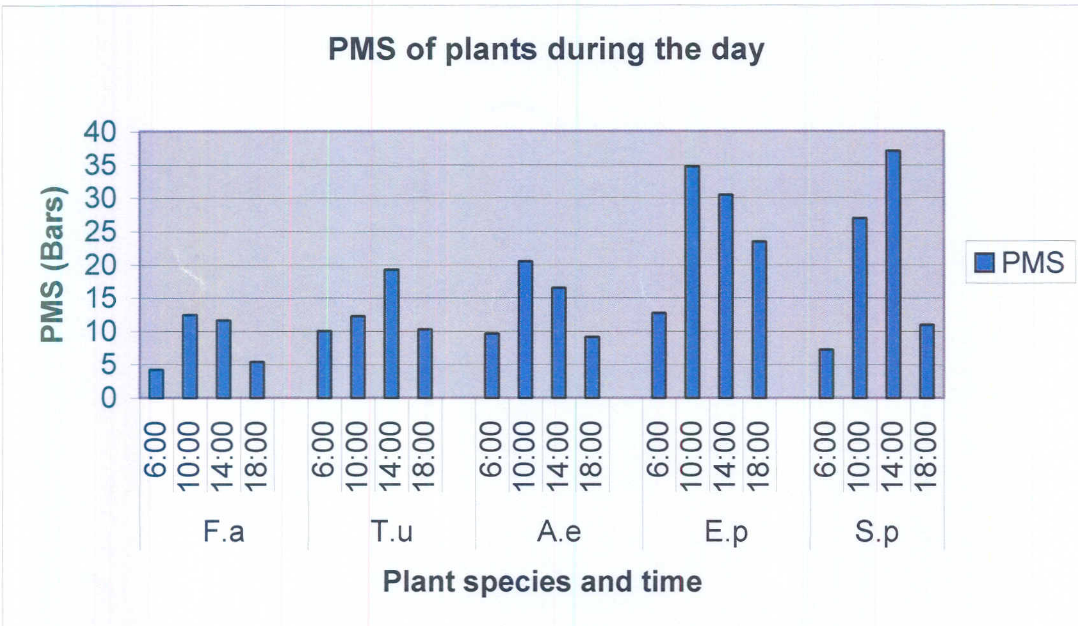
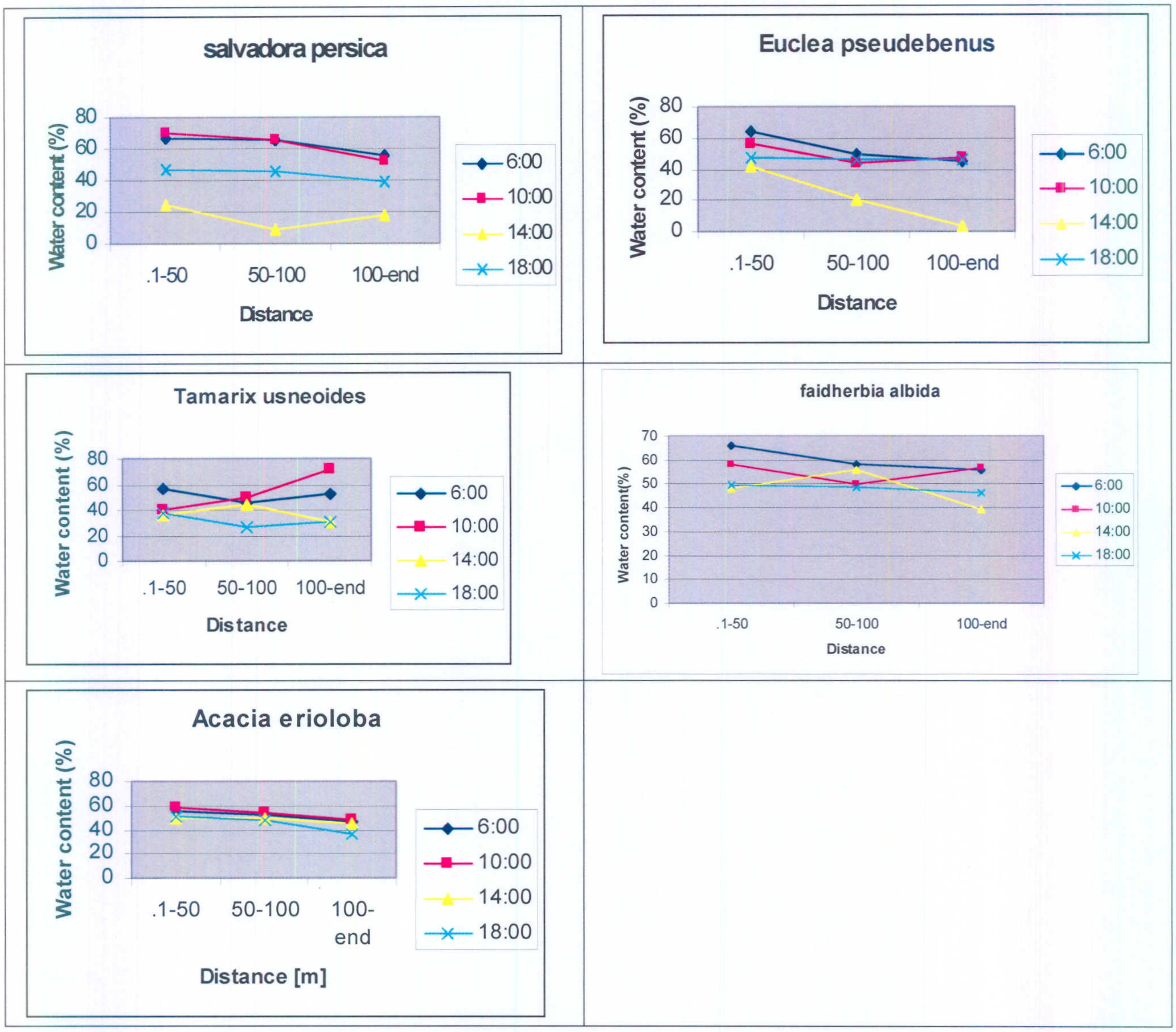



**Figure 3. Plant moisture stress of different tress at different times during the day.**

## 5.4. Relative water content of different tree species at varying distances from the main river channel.

The different graphs show the water content of each tree species at different distances from the main river channel at each time sampled. For most or all of the trees water content tended to be highest next to the main river channel which was expected. This could mean that the water table near the river is very shallow that it is accessible by the roots, especially for Faidherbia albida that grows near the river and since this tree was mostly found growing next to the river channel it could also mean that the water is not very far. Towards the end of the transects the trees were more spaced and more bare ground this also could be an indication of less water or that the water table is deep for plants to reach it and so they die and thus the less water content.




## 5.5. Water content vs. pms

A graph showing the moisture stress and the water content could not be done as PMS is measured in Bars and Water content is in percentages, so the table below is just to show the average PMS and their average water content of different tree species during the different times of the day. The maintenance of a steady osmotic potential and high water content occurs even though the water potential drops too low (Maxwell and Redman, 1978). The use of water content as a more simply-determined indicator of water potential has proven difficult, because water potential-water content relationships are variable, even within the same species (Knipling, 1976). This is because some species E.G. *Fadherbia albida* have a very high water content and so are less stressed at most of the times while trees such as *Eulea pseudebenus* have a fairly high water content but more stressed. In most trees it shows that the higher the water content the lower the PMS, this is to show that the more water it has the less stressed it is. Maxwell still states that water content can vary but water potential can be the same in different plant species, E.G. if we take Tamarix usneoides it has 57% water content at 06:00 and 38% at 18:00 but the PMS is 10bars at both these times. The maintenance of a steady osmotic potential and high water content occurs even though the water potential drops too low (Maxwell and Redman, 1978).

## Table 1.

| | | PMS | Water content |
|---|---|---|---|
| F.a | 06:00 | 4.2 | 53.46092 |
| | 10:00 | 12.43333 | 54.09924 |
| | 14:00 | 11.625 | 43.80904 |
| | 18:00 | 5.375 | 52.10303 |
| T.u | 06:00 | 10.05 | 57.60523 |
| | 10:00 | 12.25 | 41.14141 |
| | 14:00 | 19.25 | 37.80146 |
| | 18:00 | 10.25 | 38.38054 |
| A.e | 06:00 | 9.666667 | 49.81206 |
| | 10:00 | 20.5 | 53.44413 |
| | 14:00 | 16.5 | 45.56944 |
| | 18:00 | 9.125 | 46.26463 |
| E.p | 06:00 | 12.75 | 53.1274 |
| | 10:00 | 34.75 | 49.01775 |
| | 14:00 | 30.5 | 21.39455 |
| | 18:00 | 23.5 | 46.87333 |
| S.p | 06:00 | 7.25 | 61.03493 |
| | 10:00 | 27 | 62.65265 |
| | 14:00 | 37.125 | 17.29417 |
| | 18:00 | 11 | 43.8094 |

## 6. Conclusion

It is thus concluded that water content in tree leaves in the Kuiseb river flood plains near Gobabeb is higher in the morning and decreases in the late afternoon as lots of the leaf water is lost into the atmosphere due to transpiration, and that as one moves away from the main channel in most trees, water content decreases. It is also concluded that during the day when it is hot Plant Moisture Stress is high and the lowest Plant Moisture Stress occur in the morning and late evening, this is because during the day plants lose more moisture than any other time of the day and thus the highest stress. Coppicing trees have higher water content than non- coppicing trees because coppicing trees have mostly younger leaves that contain more water than bigger trees, and thus the conclusion that younger leaves contain more water than bigger trees or leaves.

There are factors though that could have affected the results a great deal: Temperature; transpiration rates go up as the temperature goes up, Relative humidity; as the relative humidity of the air surrounding the plant rises the transpiration rate falls. It is easier for water to evaporate into dryer air than into more saturated air. Wind and air movement; increased movement of the air around a plant will result in a higher transpiration rate. This is somewhat related to the relative humidity of the air, in that as water transpires from a leaf, the water saturates the air surrounding the leaf. If there is no wind, the air around the leaf may not move very much, raising the humidity of the air around the leaf. Wind will move the air around, with the result that the more saturated air close to the leaf is replaced by drier air. Type of plant; Plants transpire water at different rates, as they are made up of different morphological structures, E.G. A. erioloba has compound leaves while S. Persica has simple leaves.

## 7. Recommendations

I would recommend that GIST continues, as it really helps students as a platform to be able to do research projects and to learn more about the natural environments and to be given a chance to apply their theoretical knowledge into practice. I would also recommend that more studies be done on vegetation to really understand the relationship between the kuiseb vegetation and the floods recharging the alluvial acquirers, and that some more accurate methods be discovered or used on how to measure the rate of transpiration or how much of the recharged water is used by the plants, this is very important especially to the water affairs people so that they can monitor the water trends.

## 8. Acknowledgements

I would like to thank the following people for their assistance during my stay at Gobabeb and with my report and my project: My fellow GIST students for their support and assistance in data collection and analysis, Mark Gardiner for his devotion and willingness to assist in everything that we did at Gobabeb concerning our projects and for his advise, Veronica Siteketa for her willingness to help in anything and for being a friend, the rest of Gobabeb staff for being there to assist in in everything, Mrs:Theron for willing to tutor me and Mary Seely and the Desert Research foundation of Namibia for giving me the opportunity to gain the knowledge that I gained at Gobabeb.

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