

Potential Use of Recycled Water in Crop Production along the Kuiseb

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Abstract

Exploratory research was conducted at Gobabeb Training and Research Centre, with the aim of obtaining data that could be used as a baseline study for future student research in desert agriculture and to help Topnaar communal farmers along the Kuiseb make use of available resources. The general objective of this research was to investigate the potential benefits of water recycling in crop production.

Selection of three crops to be used in the experiment was based on salt tolerance levels of each crop; the three selected were peppers, tomatoes and beetroots. Each crop was divided into two groups and received two irrigation treatments, normal Gobabeb tap water from the borehole and recycled water. Height was recorded throughout the duration of the experiment to compare the growth of each crop, and water analysis was also done regularly to determine the amount of total dissolved solid (TDS) in the water.

The result of the experiment shows significant differences between the two treatments of each crop. Crops irrigated with recycled water did better than the ones irrigated with tap water. The results were presented to Gobabeb Centre and the local Topnaar communities with the emphasis that, in future this system could be used as a water conservation process.

1. INTRODUCTION

Namibia is a dry country with about half of the land classified as semi-arid to arid. In the Namib water region, crop production is limited by the shortage of water resources due to shortage of rainfall and high evaporation rate. Sixty percent of Namibia's bulk water comes from underground water sources, while forty percent is supplied from surface water sources, mainly dams and ephemeral rivers (Ward, 1994).

The central Namib has ephemeral rivers that flow only in the summer rainy season. Such floods are the main contributor to recharging alluvial aquifers. One of the three ephemeral rivers in the central Namib that supports the Namib Desert with its underground water is the Kuiseb River. This river supports communities along the river with the water from boreholes drilled along the river. The Topnaar people in the Kuiseb depend on this water for all their domestic uses and for their livestock consumption. This increases water demand and it becomes more scarce and inadequate for other agricultural activities such as crop production.

The success of any crop production activity is therefore dependent on water management and conservation. The use of recycled water has the potential to benefit crop producers in semi-arid and arid environments. Recycled water is water that has been used, recaptured and used again. In many cases there are considerable treatments before it is used again. The treatment requirements and quality of the recycled water are set by its intended use e.g. if it fits for irrigation purpose (Richard, 1954).

The source of this water may be sewage, storm or industrial water. Water quality testing determines the suitability of water for its intended purpose such as for irrigation. Recycled water improves reliability of the Namibian national water supply, frees up the underground water availability and makes more potable water available. This water is however beneficial in irrigation because it contains higher levels of nutrients, such as nitrogen and phosphorus, than potable water (Bennett, 1993). Application of recycled water for agricultural and landscape irrigation can provide an additional source of nutrients and lessen the need to apply synthetic fertilizers.

Research on potential use of recycled water was carried out at the Gobabeb Research and Training Centre as part of the GIST programme. The main aim of the study was to look at crop reaction to recycled water compared to normal tap water that is from a borehole at Gobabeb. The primary objective of the study was to gather

information that can be fed to crop producers about water conservation and ongoing benefits to agricultural enterprises through great certain of water supply and an assured water quality as well as to increase productivity of crops in a desert environment and the use of improved water quality.

This was achieved by comparing the height of 3 different types of vegetables to different water treatments. Peppers (*Capsicum annum*), tomatoes (*Lycopersicon esculentum*) and beetroots (*Beta vulgaris*) are some of the crops that have a moderate degree of salt tolerance, hence they were selected for the experiment. This is because the soil and water salt levels of arid environments are high. Recycled water also water has high salt levels. This impedes plant growth contributing significantly to the low plant productivity.

The results of this research will therefore be used to raise awareness to people living at Gobabeb and to other people intending to become crop producers in arid environments, about the most efficient use of water. It will also make them aware of the benefits of water recycling, such as cost reduction and protection of crops from drought as this water is enriched and it will add nutrients to the soil reducing fertilizer input cost.

Recycled water is may not be a viable option for some of the Topnaar communities, as most of them could never afford the equipment and do not in any case have centralized plumbing systems. For others in the area it may be an option, however. This recycling system can be used at places where there is a lot water used: for example at schools or clinics.

2. BACKGROUND

Crop production has been unsuccessful in the desert environments due to lack of water. Rainfall is very variable and it can not sustain desert plants. As a result, different options of getting water for crops have to be identified.

Recycled water provides an additional source of water for certain purposes especially in area with scarce water resources. As the world population increases the need of more water is also increasing. Different countries uses recycled water for different purposes such as irrigating parks and school grounds, grow crops and cool power stations. (“Why Recycled Water?”, undated)

Gobabeb, a centre which is located in the Namib Desert, has its own water recycling system. Water that is recycled at Gobabeb is first used for all the Centre's different activities. This water is collected by a trickle filter, which removes insoluble solids. It gets transported to the second stage, which is a sand filter, then down to the garden ready for irrigation. Before the 2006 GIST 2 agricultural trials, this water from the trickle filter was not used for any purpose: after filtration it was released into the Kuiseb River for water table recharge.

Lack of rainfall in desert environments leads to increased salt content in the soil. Salt becomes even more concentrated in the ground water and makes it difficult for each plant to adapt to the desert environment. This therefore leads to the need of identifying crops with special adaptation to high salt in the soil and water (Asghar, 1962). There are therefore some of the crops which have a certain level of tolerating salts in certain environments. These salt tolerant crops therefore have to be identified so that they can be used in trial using recycled water in arid environments because the recycled water is even saltier compared to potable water.

3. PROJECT OBJECTIVES

The following are the major objectives of the project:

1. To compare the effect of recycled water on growth of green pepper, tomato and beetroot compared to normal tap water.
2. To identify a crop that can perform under saline water and soil conditions
3. To identify the vegetable preferences of the people living at Gobabeb and other potential buyers
4. To record vegetable production at Gobabeb to act as a baseline for future agriculturalists

Hypotheses

Null hypothesis (H_0): There is no difference in growth of crops irrigated with the two water sources.

Alternative hypothesis (H_1): There is a difference in growth of two treatments.

[this null hypothesis only applies to objective 1...you may want to make some adjustments]

4. MATERIALS AND METHODS

The following is a list of materials used for the study and description of how they were used:

- One pack of seeds each crop (tomatoes, beetroots, peppers)
- Wheel barrow, pick, spade for digging plots
- 24 black polythene pots for planting seeds
- Ruler and measuring tape for measuring height and measuring of the garden
- Goat manure for fertilization
- River sand for replacing the original soil of the plot
- Electric conductivity meter for analyzing water quality
- Nutrients, Chloride and pH stripes for testing water quality
- Hand trowel for transplanting
- Weight balance for weighing manure
- Water (recycled and normal tap water)
- Watering cans
- Clip board for data collection
- Vehicle for collecting sand, marketing study, and community visit
- Telephone for making appointments
- Effective microorganisms (EM) for pest control

4.1 Description of each crop cultivar

Among crops that can tolerate salt, three crops were selected. These are tomatoes, peppers and beetroots. Below are short descriptions of each crop cultivar and the figure on salt range where each crop can tolerate salt.

4.1.1. Pepper

Pepper originates from Central and South America (Kamukuenjandje, 2005). There are several pepper cultivars but the selected one is California wonder, a most popular cultivar. The fruits have very smooth skin, attractive appearance and dark green colour with the size range from medium to large. It also requires full sunlight with a temperature range of 20°C – 30°C .

Peppers can grow successfully in a wide range of soils but most preferably, sand loam soil. The plants can grow better in soils with a pH between 4.5 and 6.0 (potassium chloride (KCL)). The soil should contain organic matter and be deeper than 40cm. The seeds should be grown 2cm deep with the spacing of 70cm between rows and 40cm in-rows. It takes 125 days to harvest (Kamukuenjandje, 2005)

4.1.2. Tomatoes

Tomatoes place of origin is currently not known but they became popular in the United States only in the 19th century (Kamukuenjandje, 2005). The selected cultivar is Flora Dade can be grown almost through out the year apart from Autumn. Tomatoes can grow well in a wide variety of soils but best results are obtained in sandy loam soil with a pH range of 4.5 to 6.0 (KCL). Its fruit range from medium to large fruits.

Flora Dade should be grown at a place where they receive plenty sunlight. Its growth temperature ranges between 10° C and 30°C. This cultivar can germinate well when grown at the depth of 2cm, spacing of 120cm between rows and 45cm in-rows. Flora Dade is a semi determinate variety with excellent disease resistant that also takes 125 days to harvest (Kamukuenjandje, 2005).

4.1.3. Beetroots

Beetroots are indigenous to Asia Minor and Europe. The Detroit Dark Red cultivar can grow best in fertile sandy loam soil with the pH value of 4.8 to 7.0 (KCL).

Where it is grown in a warm weather it can only take 95 to 120 days to harvest. Beetroots grows well in spring and Autumn when sown at a depth of 1 – 1.5 cm and planting spacing of 25cm between rows and 7cm in-row, particularly for Detroit Dark Red (Kamukuenjandje, 2005).

Table 1: Range of maximum salt concentration at which the chosen crop is likely to produce the acceptable growth or yield level.

Crop	Threshold value	25% growth or yield loss	50% growth or yield loss	100% growth or yield loss
	ECe (ds/m)	ECe (ds/m)	ECe (ds/m)	ECe (ds/m)
Beetroots	<6.0	6.3 – 10.5	9.5 – 15.0	>24.0
Tomatoes	<3.0	2.7- 6.3	4.2 – 9.5	>16
Peppers	<3.0	2.7- 6.3	4.2 – 9.5	>16

Adapted from: Intercropping soil tests (Brown & Smith 1998)

4.2. Plot preparation and layout

24 plots of 1m² each were measured. However the original soil of the garden was not suitable for plants since it is a mixture of gravel and sand soil that is high in salt content.

The original soil of plots was removed and replaced to make the soil suitable for selected crops. This was done by digging out the soil at a depth of 30cm and this soil was replaced with sandy soil from the river bed (see figure below).



Figure 1: Plot preparation

A randomized way of arranging plot was used. This is a way of ensuring that each measurement in the population has the same chance of being included in a sample as every other measurement (Zar, 1999). Randomizing was done by drawing crop names and treatments at random out of a hat. (See Figure 2 below for layout).

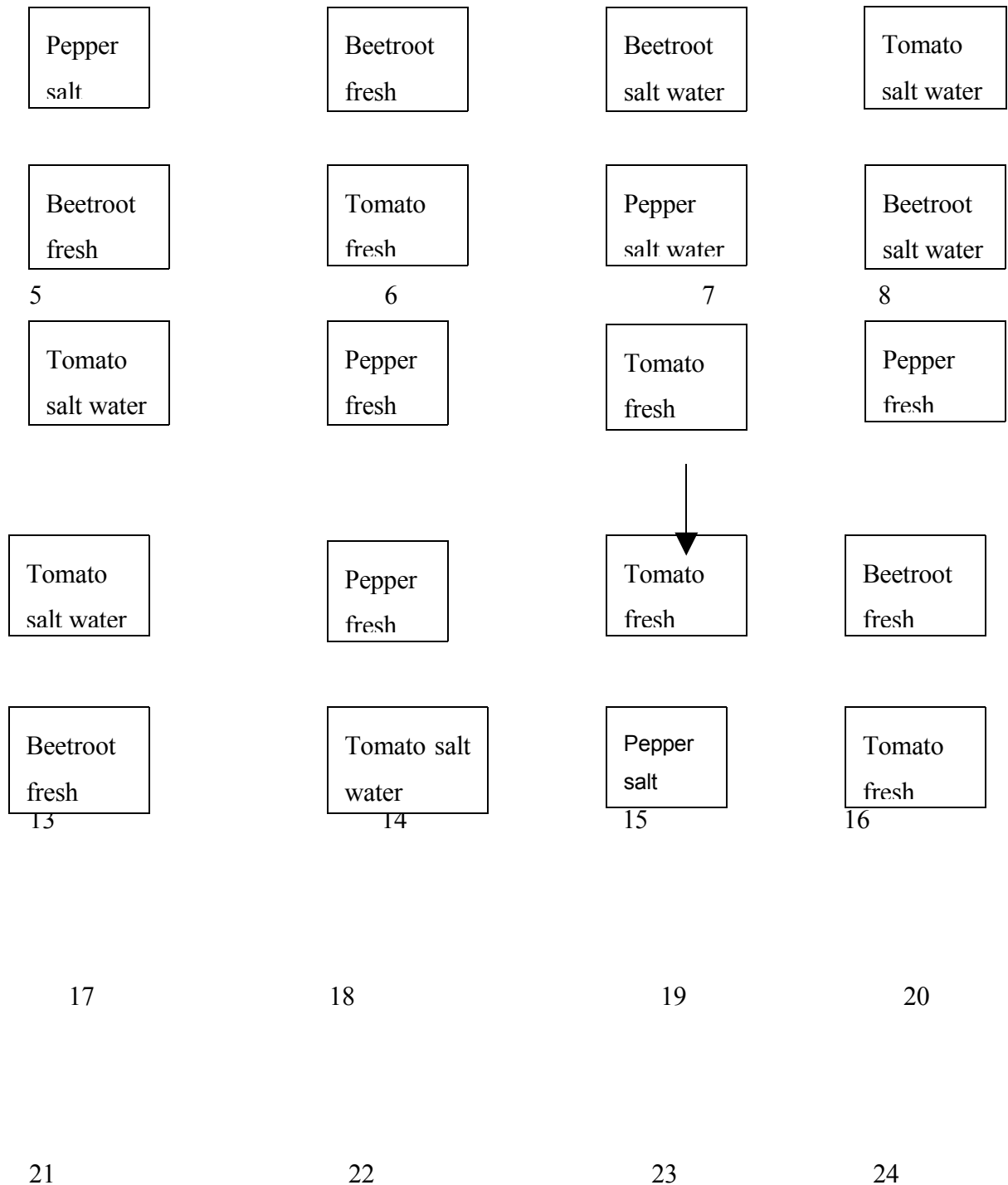


Figure 2: Randomized block design for plot layout

4.4. Soil preparation and fertilization

Each 1m² plot was filled with a sand layer of 30cm. This was done by filling each plot with 2 wheelbarrow to ensure that the amount of sand was more or less equal in each plot.

2kg of goat manure, obtained from the Natab community, was added to each plot and mixed thoroughly with the soil. This was done to help increase crop growth since the riverbed soil is infertile.

4.5. Sowing time and sowing method

Sowing of seeds was done early on the 5th of March 2006. This was done in plastic polythene pots during garden construction to save time since the research was to be conducted within the given time of 6 months.

In each pot about 20 seeds were sown. Since each crop under each treatment was replicated four times, 24 pots in total were prepared. A hand method of sowing was used as plastic pots are small and they are not so many for a planter. Plastic pots were left in the open area behind the wall, which allowed seedlings to get high light intensity during the day.

4.6. Transplanting

Transplanting took place on the 6th of April, All the pots with seedlings were moved inside the garden and a hand trowel was used to dig out the seedling as this helped with prevention of root damage.

Based on the minimum number of samples per plot, each plot was loaded with a population of 16 seedlings with a spacing of 20cm between and in rows. Each plot was watered after transplanting.

4.7. Irrigation

Each 1m² plot was watered twice every week. 4.8 litres were given to each plot per watering, allowing each plant of 16 to get +_ 20mm of water.

During the commencement of the experiment (March 5th) the trickle filter where the recycled water comes from was not working, so there was no recycled water during that time. Rain water was harvested and was therefore used for this purpose to irrigate crops that were to be irrigated with tap water from the borehole. Tap water was used to irrigate crops that were to be irrigated with recycled water. This was done because there

was still a difference in salt content of borehole water compared to rain-harvested water.

In mid-July, some parts of the trickle filter were renovated. This time all crops were irrigated with tap water because there was no rain-harvested water or any other water to irrigate with.

[give us dates of when recycled water was and wasn't available]

4.8. Water analysis

A convenient method of estimating the amount of salt concentration in two water samples was used by measure the electrical conductivity (EC) of each sample. This is because dissolved salts conduct an electrical current that is proportionate to the amount of salt in the water. A conductivity meter was used to measure EC in micro-Siemens per centimetre ($\mu\text{S}/\text{cm}$) [make sure you were using micro and not milliS—mS, as you said before I edited this, actually stands for milliSiemens. You could be ought by a factor of 100



Figure 6: Water analysis in the laboratory

Another analysis was carried out to determine water quality. Two different titrators were used to determine the high and low range of chloride in the water two water samples. A 5 in 1 test strip was used to test: total Chlorine, free Chlorine, total hardness, total alkaline and pH. A 6-8-hydriion paper was used to measure pH, and one strip was also used to measure nitrate and nitrite in the water.

4.9. Data collection

Height of each plant per plot was recorded every 7th day of a week. A data sheet was designed and used during data collection (see appendix 1). At an early growth stage, a 30cm ruler was used and after some plants exceed 30cm, a 50cm measuring tape was used in measuring height.

4.10. Pest control

Effective microorganism (EM) was used to control pests observed in May. These were black diamond moth and white flies. The microorganisms in the substance can change and improve the environment in which it is applied. EM is well known to be eco-friendly (Zimmermann, I. 2005 and Lindros. 2004) therefore many derivatives were made out of it, especially EM-5. It is known for a wide range uses including insect and pest repellents in both livestock and crop farming (Lindros, 2004 & 2005 and Higa, 1982)

4.11. Marketing study

A marketing study was conducted on the 17th of May 2006 at different lodges and a supermarket in Walvis Bay as well as through discussions with Gobabeb residents. The aim of this study was to help identifying potential market for Topnaar communities as well as to find the dollar value for each vegetable crop (see appendix 2 for marketing study questionnaire).

5. RESULTS

5.1. Growth comparison

The height of each individual plant per plot that was collected from April to July and analyzed was added together and divided by the number of plants to get the mean of one plot per week. The weekly data was added together to get the monthly growth height. The monthly data was then added together and divided by the number of months to get the average growth as from April to July (see table 2 below).

Table 2: Total monthly average height per replication.

Monthly mean height / treatment (cm)

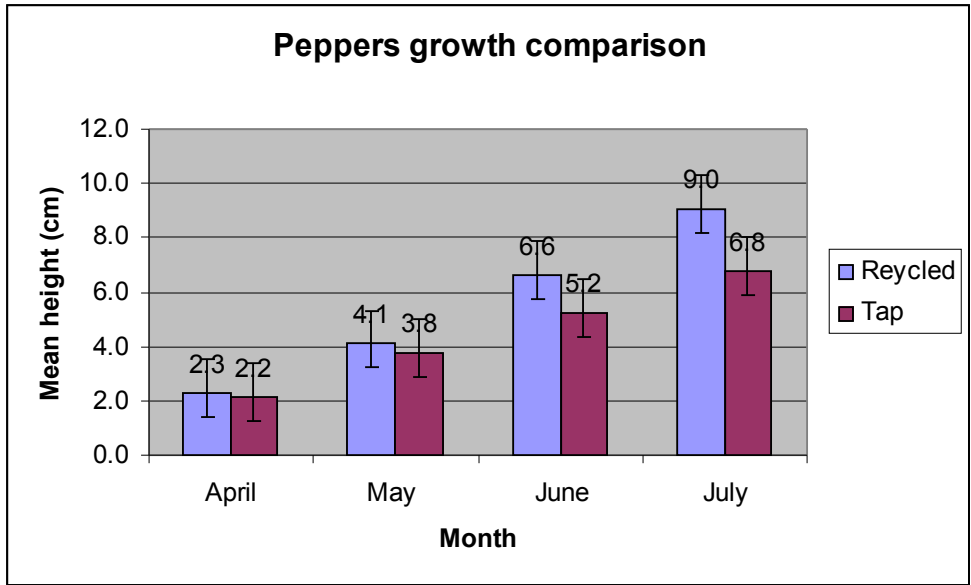
Water type	Crop	Mean	April	May	June	July
Recycled	Pepper		2.3	4.1	6.6	9.0
Tap	Pepper	2.2	3.8	5.2	6.8	
Recycled	Tomato	3.2	9.0	18.6	30.0	
Tap	Tomato	3.9	6.9	12.3	19.9	
Recycled	Beetroot	6.0	15.9	19.3	22.6	
Tap	Beetroot	5.2	10.3	13.4	18	

The table above gives a summary of mean growth of each treatment per month. In April there was no significant difference between the mean heights of peppers under two treatments. The significant difference was observed from May to July. However an opposite occurred with tomatoes. High mean height was observed in crops irrigated with tap water in April but a difference was present as from May onwards. Beetroots show a difference as from April to July.

Independent sample t-tests were carried out to compare growth of crops grown in recycled and tap water, using the final results collected on 25 July. The results of these t-tests are found in Appendix 4. [present results in a table showing degrees of freedom or at the very least the p value]. There is high evidence that growth of tomatoes and beetroots irrigated with recycled water is higher than the ones irrigated with tap water.

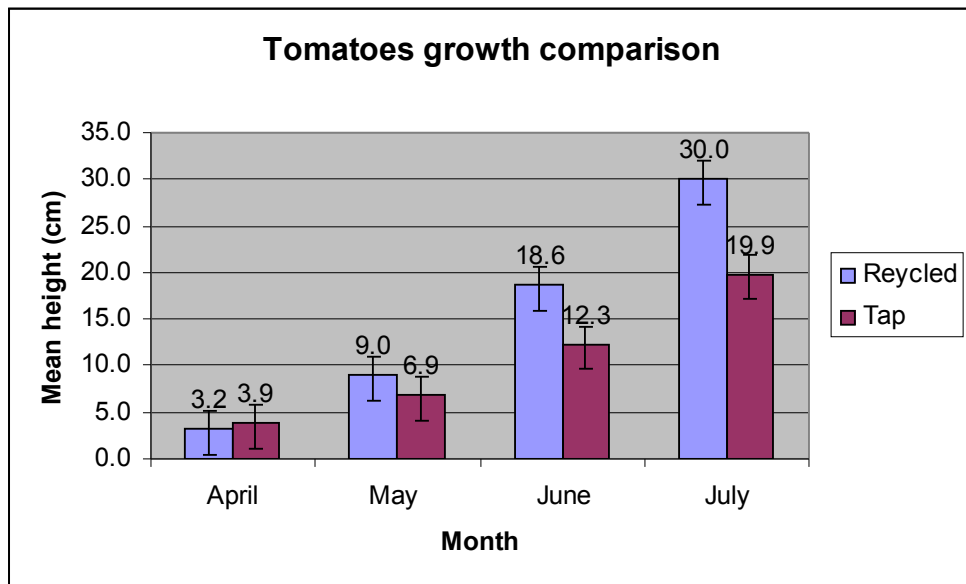
This means the probability of the null hypothesis being true is 0.05 (5%). As the sig. value of each crop is lower than the given p-value of 0.05, then there is a high confidence that the null hypothesis is rejected and the alternative hypothesis is accepted. This however only applies to tomatoes and beetroots as there was no clearer difference in peppers treatments.

The graphs below show the difference in height of each crop under two treatments as from April to July.



Graph 1: Peppers monthly mean height

Graph 1 above shows growth of peppers as from April to July. The figures on top of each bar shows the mean of each treatment on that specific month. The error bars shows the 95% confidence interval of each treatment. There was no significant difference between means of peppers under two treatments. The result of the independent sample t-test gives a p value of 0.120881 that shows that there is no significant difference in the growth of peppers.



Graph 2: Tomatoes monthly mean height

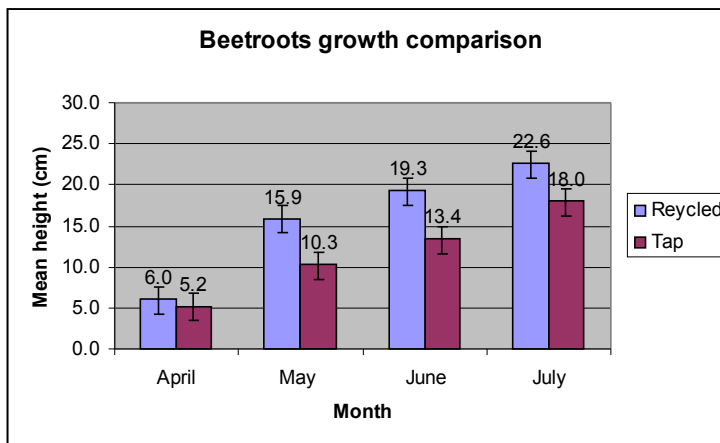


Tap water



Recycled water

Graph 1 and figure... above shows growth of peppers as from April to July. The figures on top of each bar shows the mean of each treatment on that specific month. The error bars shows the 95% confidence interval of each treatment. A high significant difference was then observed as the graph and figure shows. The result of the independent sample t-test gives a p value of 0.004845 that shows that there is a significant difference in the growth of tomatoes.



Graph 3: Beetroots monthly mean height

Graph 3 and figure..... above shows results of beetroots comparison. There is also a high difference is growth as from April to July. The results of the independent sample t-tests show a significant value of 0.01669.



5.2. Water analysis

The result of the water analysis recorded as electric conductivity (dS/m) and total dissolved solid (TDS) in (g/l) was converted to one unit, which is milligram per liter (mg/l) and micro-siemens per cm (mS/cm) and presented in a table form below.

Table 4: Result of the water analysis using electric conductivity meter

Month	Recycled		Tap	
	mS/cm	mg/l	mS/cm	mg/l
April	896	190	432	97.4
May	2070	329	105	67
June	999	551	453	45.3
July	2600	108	652	32

The table above shows results of water analysis, carried out to determine the difference in electric conductivity and total dissolved salt (TDS) of recycled and tap water.

Table 5: Result of water analysis using different measuring strips

Tap water		Recycled water	
Nitrite (ppm)	1.5	Nitrite (ppm)	>3
Nitrate (ppm)	0.3	Nitrate (ppm)	>50
pH	6.8	pH	6.0
Low range Chloride (ppm)	86	Low range Chloride (ppm)	324
High range Chloride (ppm)	<1	High range Chloride (ppm)	304
% High range NaCl (ppm)	0.014	% High range NaCl (ppm)	0.050
% Low range NaCl (ppm)	<0	% Low range NaCl (ppm)	0.053
5 in 1		5 in 1	
pH	8.4	pH	6.2
Alkalinity (CaCO ₂) (ppm)	240	Alkalinity (CaCO ₂) (ppm)	40
Hardness (CaCO ₃) (gram/gallon)	120	Hardness (CaCO ₃) (gram/gallon)	250
Free Chlorine (ppm)	1	Free Chlorine (ppm)	0
Total Chlorine (ppm)	2	Total Chlorine (ppm)	0

5.3. Marketing study findings

The interviewers on the marketing study conducted on 17 May 2006 had positive feeling towards buying and selling local products. The main worry they have towards relying on the local suppliers is on time delivery. If vegetable products are delivered on time and in the right quality and quantity, then there is no point of importing a lot of product.

According to them all, tomatoes play a big role when it comes to their consumers' preference. However, they said there are not enough local suppliers to provide them direct with enough products that is why most of them mainly buy their vegetables in the local vegetable shops such as Pick 'n' Pay, Spar and Shoprite while some of them import from South Africa. Mr. Adams of H&H catering company has a small garden at home but it does not supply him with enough vegetables, so he usually supplement it with vegetables from local shops.

According to Mr. Jossy of Bay Fruits, there is a law that says each businessperson has to buy 10% at least of the local products for reselling or for whatever the purpose of the business is. This helped in identifying the market for local products.

5.4. Pest control

The use of EM was effective on pest control. The observed white flies and black diamond moths disappeared within the first week when EM was applied.

6. DISCUSSION OF RESULTS

6.1. Growth comparison

Results of growth comparison of each crop are discussed below based on the result of the independent t-test.

6.1.1. Peppers

It was observed that peppers did not respond very well to recycled water, when it was compared within its group comparing to tomatoes and beetroots. As given in the description of crops, peppers require full sunlight with a temperature range of 20°C – 30°C. The stunted growth observed could have occurred as a result in sudden change in conditions during transplanting. There was also reduction in light intensity, as with a shade net of 80% shade there was reduced evaporation and increased humidity and it was not hot enough. This can be regarded as a reason why peppers took time to adapt to inside conditions, since there was a significant difference observed in July (see graph 1).

This can therefore be concluded that, peppers do not respond at all to recycled water or the environment (Desert environment) was not favorable for them.

6.1.2. Tomatoes

Among the three selected crops for a trial, tomatoes were the best in growth as it was compared within group (graph 2). They responded very well to recycled water. This difference in growth could be as a result of water, since all other treatments are the same with all crops. It can also be that most nitrite and nitrates or TDS in recycled water were sufficient with requirements of tomatoes growth.

6.1.3. Beetroots

Both visual observation and independent sample t-tests showed a significant difference in growth of beetroots. Recycled irrigated beetroots grew big, green leaves. Beetroot is a root crop and what is needed from it in most cases is underground parts

but not leaves. When beetroots grow big surface parts, this process is referred to as vegetative growth.

High nutrients soil or water can cause vegetative growth. recycled water has high nitrate and nitrite content. High nitrogen content in goat manure used as a fertilizer could be also be a cause of this vegetative growth

6.2. Water quality

Table 4 shows that there is high conductivity in recycled water than in the normal tap water, indicating a larger presence of dissolved salts in the recycled water. This is because the majority of solids, which remains in water after filtration, are dissolved ions. [you CAN say that you found sodium chloride with your measuring strips and that you would EXPECT to find magnesium etc as well based on Davis] Generally, the most common salt in the recycled water is sodium chloride or table salt. Magnesium, calcium and potassium salts are also present in significant quantities and there may be small amounts of other salts (Davis, 1997).

Table 5 shows that recycled water is nutrient-enriched. Recycled water has nitrite values >3 compared to 1.5 of the normal tap water and the nitrate value of >50 compared to 0.3 of tap water. The proportion of various nutrients will largely depend on the source of recycled water and natural treatment. In addition, nitrogen and phosphorus are also present in significant quantities. Recycled water also has most of the micro-nutrients required by crops e.g. boron, chlorine, nickel and cobalt in varying quantities (Richard, 1954). There are therefore elements that are needed as macro elements and without them, a plant can not grow or produce. [a lot of this is background material on recycled water *in general*, not based on your actual findings—understandable, since we don't have a proper water analysis lab at Gobabeb. If they aren't your results, you shouldn't treat them as your results. You *can*, however, use them to explain why recycled water plants did so much better despite higher levels of salt.]

7. RECOMMENDATIONS

7.1. Benefits of Recycled water

As it has been discussed in the result section, recycled water can play a big role in the conservation process. Since Gobabeb is busy with the tourism concession planning to build a lodge, a lot can then be done with the recycled water. A garden can

be established to provide vegetable to tourists visiting the lodge. This water can therefore be used to irrigate crops in that garden as it will reduce water cost.

6.2. Future agriculture

Future agriculture students should try to look at how crop production can be improved along the Kuiseb. Trials should be extended to different communities so that Topnaar community members get involved full time. They should be the ones doing the trials with the help of the students, so that they will have a good understanding an crop farming and new farming technologies such as the use of effective micro-organisms in farming practices.

[relevance of recycled water to community? Some more background material on water recycling mechanisms? Costs? Relevance of Gobabeb garden to community?...could be some interesting possibilities here]

6.3. Crops selection

As given in the result discussion, beetroot grew vegetative because of high nutrients level in the goat manure used for fertilization and in the recycled water used for irrigation. Future trials therefore should look at growing vegetable crops that bear their fruit, rather than crops because the more recycled water used, the higher vegetative growth and the lower the yield. Tomatoes did well and this can be one of the crops to be put into consideration for future production.

6.4. Shade cloth

A shade cloth used for the experiment is an 80% shade cloth. Most of the crops require full sunlight as give in peppers description. The shade cloth to be used, should therefore meet the requirements of crops to be grown. Some trials should therefore be done without a shade cloth to see the survival of crops in the real desert environment as some of the Topnaar community members are currently doing. [or with varied degrees of shade]

6.5. Community feedback

The community feedback had poor attendance. This might be because of poor planning. I therefore recommend future community feedback to be planed before hand so that community members can prepare themselves for the meeting.

8. CONCLUSION

Recycled water is an abundant and reliable local supply that is especially important to arid regions that have to import water at a high cost. Recycled water can be used for a wide variety of purposes, and it not only benefit Gobabeb Centre or the Topnaar community as a conservation measure, but also tends to be cheaper to use than potable water and this can benefit a lot of farmers who are willing to expand their gardens or those who are planning to start grow crops in the dry and harsh environment of the Namib desert.

The experiment conducted, was a success in improving the knowledge on research methodology and experimental design as discussed in different parts of this documents. It also helped improving interaction with community members, more especially with the Topnaar communities. Other general activities carried out at Gobabeb Training and Research Centre also contributed to my knowledge on ecology, climate, hydrology, appropriate technology as well as natural resources management.

9. REFERENCES

- ASGHAR, A.G., et al. 1962. *Salt tolerance of crops. Pak. J. Sci. Res.*, 14: 162-169.
- BENNETT W.F. (editor), 1993. *Nutrient Deficiencies & Toxicities in Crop Plants*, APS Press, St. Paul, Minnesota.
- BROWN, N. & SMITH, K. 1998. *Interpreting soil tests: Rules of thumb (Ag Fact)*, NSW Agriculture.
- DAVIS, J. 1997. *'Hold the salt! Does manure make your ground salty?'* in: *Agronomy News, Vol. 17, No. 4*, Colorado State University Cooperative Extension.
- DRFN, 2003. *Napcod*. Windhoek. Namibia
- DYTHAM, C. 2003. *Choosing and Using Statistics*. Department of Biology, University of New York.
- KAMUKUENJANDJE, R. 2005. *Horticulture part one study guide*. Polytechnic of Namibia. Windhoek.
- LINDROS, et al 2004 & 2005. *EMROSA user manual*. The Advisor in Organic Agriculture. South Africa.
- MATHENY, N. & J.R. CLARK. 1998. "Managing Landscapes Using Recycled Water." *The Landscape Below Ground II*. D. Neely & G. Watson, Eds. International Society of Arboriculture, Champaign, Ill.

More Water for Arid Lands. 1974. Washington DC.

PLATT, E. et al. 2006. *Effects of recycled water on soil salinity levels for cool season vegetables*. http://www.actahort.org/books/664/664_70.htm 12/07/2006

RICHARDS, L.A. , ED. 1954. *Diagnosis and improvement of line and alkali soils*. United States Department of Agriculture.

SALINE AGRICULTURE. 1990. *Salt Tolerant plants for Developing Countries*. Washington DC.

SEAGUL, B. 2006. *Personal communication*. Seagul Bed and Breakfast. Walvisbay. Namibia.

TANJI, K. 2006. *Spotlight on Kenneth K. Tanji D. Scince Principal investigator*, University of California. USA.

TAYLOR , S. 1991. *Dryland salinity introductory extension notes*. Department of Conservation and Land Management, NSW.

WERNER, W. 2003. *Livelihoods among the Topnaar of the Kuiseb*. Namibia.

Why recycled water? Accessed July 2006. <<http://www.redwoodcity.org/publicworks/water/recycling/background.htm>>

ZIMMERMANN, I. 2005. *personal communication*. Polytechnic of Namibia. Winddhoek. Namibia

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Appendices

Appendix 1

Weekly growth data sheet

Date.....25/07/06... Water type...*Salt*... Crop type...*Pepper*.....Plot number...1...

Plant no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Height																

Date...17/07/06... Water type...*Fresh*... Crop type...*Beetroot*....Plot number...2.....

Plant no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Height																

Date.....25/07/06..... Water type...*Salt*... Crop type...*Beetroot*...Plot number...3.....

Plant no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Height																

Date...25/07/06... Water type...*Salt*... Crop type...*Tomato*...Plot number...4.....

Plant no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Height																

Date...25/07/06... Water type... *Fresh* ... Crop type...*Beetroot*...Plot number...5...

Plant no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Height																

Date...25/07/06... Water type... *fresh* ... Crop type...*Tomato*...Plot number...6...

Plant no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Height																

NB. Record and dead plant at the back of the sheet by writing the pot number, number of seedlings died and the date of observation

Appendix 2

VEGETABLES MARKETING SURVEY IN SWAKOPMUND AND WALVISBAY

Market Name: _____

Conducted by: _____ Ref: _____

Interview questions

1. Is there a vegetable garden in the area?

.....
....

2. Where do you get your vegetables?

.....
.....
....

3. Will you consider buying local products?

.....
.....
.....

4. How do you rate the quality of the vegetable to determine the price?

.....
.....
.....

6. What is the price per kilogram for:

Tomatoes

Beetroots

Green peppers

7. Among the above-mentioned vegetables, which one would you say is mostly preferable by most customers?

.....

8. In case of tomatoes, which picking stage do you prefer most?

Light green



Pink



Red



9. What can be the reasons for not buying local vegetables?

Appendix 3: Results of Independent sample T-Test

			Levene's Test for Equality of Variances		t-test for Equality of Means	
			F	Sig.	t	df
CROP						
Pepper	Height 25/7/06	Equal variances assumed	5.884695	0.120881	2.939909799	126
		Equal variances not assumed			2.939909799	112.9534
Tomato	Height 25/7/06	Equal variances assumed	8.225041	0.004845	5.998603003	126
		Equal variances not assumed			5.998603003	113.6925
Beetroot	Height 25/7/06	Equal variances assumed	2.438719	0.016690	3.913405642	126

			Equal variances not assumed			3.913405642	123.6889

			Sig.(2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
CROP					Lower	Upper
Pepper	Height 25/7/06		0.003907	0.767987	0.737989	3.777636191
			0.003982	0.767987	0.736285	3.779340046
Tomato	Height 25/7/06		1.96E-08	1.685288	6.774239	13.44451085
			2.42E-08	1.685288	6.770735	13.44801484
Beetroot	Height 25/7/06		0.000148.	1.175846	2.274598	6.928527232
			0.000149	1.175846	2.274176	6.928948854