ASSESSING THE EFFECT OF IRRIGATION WATER QUALITY ON PHYSIOLOGICAL CHARACTERISTICS OF AFRICAN NIGHTSHADE *(Solanum Scabrum* Mill)

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ABSTRACT

The use of wastewater for irrigation is widespread across the world. In Nairobi County, many farmers are using untreated sewage to irrigate fodder and crops. However, there is scant literature on the agronomic effect of wastewater irrigation on some of the post popular vegetables grown for the local market. This experimental study was carried out to assess the effect of different qualities of irrigation water on the agronomic parameters of *Solanum Scabrum* Mill. Different types of water used included wastewater, tap water, water from shallow wells and from borehole. The experiment was carried out under randomized complete block design (RCBD) with four replications. Results show that at day 30, there was a significant difference between the number of mature leaves ($p \leqq 0.00$) and height ($p \leqq 0.01$) between the plant samples grown using tap water as compared to that of shallow well. The results of the study demonstrate that *S. Scabrum* Mill is affected by the type of quality of the irrigation water used. This is owing to the fact that crops samples grown using shallow wells, recorded the highest mean values of 0.38 (0.02) cm^2, 9.53 (0.37), and 22.81 (0.85) cm as far as the girth area , number of mature leaves, and height are concerned respectively. This is a factor that can be attributed to the high level of nitrogen and phosphates in surficial aquifers due to leaching.

Key terms: *Borehole water, shallow well, Solanum Scabrum, tap water, waste water.*

1.0 INTRODUCTION

Water has been described as the single physiological and ecological factor upon which plant growth and development depends more heavily than other factors. This can be proved by the fact that not only does water comprise 50-90% fresh weight of all plant tissues but also the distribution of plants on earth's surface is controlled by the availability of water where temperature permits growth (Muthomi and Musyimi, 2009). In their experiment to determine the growth responses of *Solanum Scabrum* MILL (African nightshades) seedlings to water deficit, it was clear that there were significant differences ($p \leq 0.05$) among treatments which involved varying of watering regimes in term of shoot dry weights, leaf number, leaf water content, leaf area, shoot height and root. The results indicated that seedlings of *S. Scabrum* MILL were sensitive to drought as the stressed seedlings exhibited about 88% reduction in shoot dry weight, 84% reduction in shoot height, 97% reduction in leaf area, and 63% reduction in chlorophyll.

This is supported by Bouchard *et.al* (2007) who indicates that there are three important things that a plant needs in order to grow; sunlight, nutrients and water. Therefore, if any of these necessities are altered in terms of quantity and quality the agronomic parameters of a plant such as height, weight, length and area of the leaf are affected. The uptake of water from the roots, through the xylem and into the rest of the plant is an essential part of a plants ability to photosynthesize. Also, water is necessary to create cell tension, which gives plants their form.

Further, some mineral such as calcium are stored in water, and the plant can only access these minerals by up taking water. Due to the extreme importance of water in the life of a plant, there is the need to study how quality of irrigation water affects the growth of a plant. Based on their study on the effect of various types of water on the growth of *Raphanus sativus* (radishes) where four different types of water were used, Bouchard *et.al* (2007) concluded that tap water treated with commercial Miracle-Gro™ produced the best plant growth (yield) in both length and weight categories, while fish water resulted to the smallest and lightest plants. Rain water produced taller plants while tap water produced heaver plants. Therefore, these studies affirm that water is critical to the growth of a plant, thus any alteration in term of quality and quantity affect the plants. Therefore, the specific objective for this study was to assess the effect of irrigation water quality on physiological characteristics of African nightshade (*S. Scabrum* Mill)

1.1 Health Benefits of Consuming African nightshades

Along Kiu River, Kiambu County, Kenya, the growth of *S. Scabrum* has gained pace due to the short growth period of 30 days after transplant as well as due to the fact that not many areas in Kiambu County grow this crop for commercial purposes as most farmers still regard it as a bush plant. The various species of the African nightshade grown in the area have become popular as they contain high level of proteins, iron among other nutrients as compared to the traditional vegetables such as kales. As noted by Muthomi & Musyimi (2009), the composition of 100g edible portion of *S. Scabrum* is 87.8 g of water, protein 3.2 g, energy 163 kJ (39 kcal), carbohydrate 6.4 g, fat 1.0 g, β-carotene 3.7 mg, Ca 200 mg, ascorbic acid 24 mg, fibre 2.2 g, Fe 0.3 mg and P 54 mg. The leaves also contain high levels of vitamin A, B, and C, and phenolics and alkaloids. A diet incorporating African nightshade is recommended for pregnant or nursing mothers, as it is good for people with iron deficiencies, and malaria patients. It is based on this that the study will contribute to the literature by providing a perspective on how the agronomic properties of *S. Scabrum* are affected by wastewater irrigation. The results were compared to three other types of water available along Kiu River. They include tap water, water from shallow well and from borehole.

2. 0 MATERIALS AND METHODS

2.1 Study area

The study was located at 1°11'59.43"S and 36°56'00.03"E. This area has around 100 farmers mainly growing *S. Scabrum* among other leafy vegetables. The study area was preferred due to its proximity to the Githurai market, which serves majority of people residing along the river.

2.2 Seedbed and Land preparation

A nursery bed is a specially prepared portion of land used to raise seedlings. For this project, the nursery bed will act as a temporary part where the young seedlings of the *S. Scabrum* will be used. A raised bed, between 10 and 15 cm above the ground was be used, in order to prevent the edges from being eroded by the irrigation water. This was also an important way through which underground water was prevented from seeping into the bed as the plant species cannot tolerate standing water at the time of germination (Infonet Biovision, 2016).

The bed was located 15 meters from the planting site, in order to ensure that the transplants are taken to the study site without any damages that may be involved. The bed was between 1.2 metres wide and 2 meters long. In addition to this, the bed was oriented from east to west to provide better shade against the mid-day sun. After demarcation, the land was dug 0.3-0.45 meters using a hoe, in order to ensure that roots and stones were removed outside the nursery bed. Planting of the seeds was done in rows, where straight lines, 2 cm deep at a spacing of 7 cm apart were used (Forestry Nepal, 2014). The nursery bed was watered twice a day using a rose spray, early in the morning and late in the evening, with approximately 1 can per square metre to avoid overwatering (Ministry of Food & Agriculture, Ghana, 2016). Once planted, the bed was mulched by the use of dry grass, and then watered using a watering can until germination.

For African nightshade, germination takes occurs between the 5 and 7 days. After germination, mulch was removed, and 1 meter high shade erected, while ensuring some sun light go through the bed for effective growth. Transplanting was done after 30 days, and only seedlings with more than four true leaves and a height of at least 10 cm were selected. They were then randomly allocated to various treatments in the experimental area. One day prior to transplanting, the shade was removed in order to harden the crops. Transplanting was done late in the evening at plant spacing of 20 cm by 20 cm for complete harvesting (Infonet Biovision, 2016). Thereafter, the land in the selected experimental area was cultivated in order to mix the soil as well as remove unwanted materials such as root stumps. The experiment was carried out under randomized complete block design (RCBD) with four replications (Bawatharani *et. al*, 2016).

2.3 Growth measurements

Since complete harvesting was to be done, a spacing of 20 x 20 cm was adopted (Parthasarathy, 2008). All the individual plants in the various treatments were watered daily at 6.00 pm for a period of 30 days (Muthomi and Musyimi, 2009). Data on the agronomic properties (girth area, number of mature leaves, leaf area and height) of the four selected crop samples in the four blocks and the replicates were noted and labeled as;

T_0: Agronomic parameters 7 days after transplant

T_1: Agronomic parameters 15 days after transplant

T_2: Agronomic parameters 30 days after transplant (time of complete harvest).

2.3.1 The leaf numbers

The number of fully expanded mature leaves on the main stem and branches were counted and recorded.

2.3.2 Leaf area: Leaf area was calculated using the following formulae:

A_L=0.73 (L_LX W_L), where L_L is the leaf length and W_L is the maximum width measured for each leaf on each plant (Jose *et.al*, 2000).

2.3.3 Plant height

The plant height was measured using a meter rule from the stem base up to the shoot apex.

2.2.4 Girth Area

The diameter of the stem was determined by the use of a vernier caliper. The area of the stem was then calculated using the formulae: A_S= π (D/2), where π=22/7 and D is the diameter measured from each randomly selected plant.

2.4 Data analysis

Wilcoxon signed-rank test was conducted using STATA 14 statistical computer package at a significance level of $P < 0.05$.

3.0 RESULTS AND DISCUSSION

Previous studies describe water as the single ecological and physiological factor upon which the growth and development of plants depends more heavily than other factors (Muthomi & Musyimi, 2009). Therefore, in this study, it had been hypothesized that the physical characteristics of *S. Scabrum* such as such as leaf area, girth area, number of mature leaves and height would be affected by the type of irrigation water used. Results of the four parameters (leaf area, girth area, number of mature leaves and height) were measured after 7 days, 15 days and 30 days after transplant. It is worth noting that 30 days was the day of complete harvest. From the table 1 , it is clear that at day 7 after transplant, the leaf area of *S. Scabrum* treated using wastewater had the highest mean value of 14.53 (0.83), while that grown using water from the shallow well was the lowest with a mean of 10.83 (0.64). The mean value of number of mature leaves from plant samples grown using shallow well was the highest at 3.23 (0.13), where as those grown using tap and borehole recorded the lowest values both at 2.90 (0.12). However, table 4 show that there was a significant difference between the number of mature leaves ($p \leq 0.00$) and height ($p \leq 0.01$) between the plant samples grown using tap water as compared to that of shallow well. This is supported by a study done by Debrewer *et.al* (2007) who indicated that in surficial aquifers, the level of nitrogen is high.

According to Debrewer and Ator (2007), in soils that are poorly drained, excessive nitrogen and phosphorous that is not taken up by plants can be leached from the soil zone into shallow ground water with infiltrating rain. These two elements are critical in determining the health of a plant, especially as far as photosynthesis and development of new tissues is concerned. In this regard, plants samples grown from the shallow well recorded highest means as far as number of mature leaves and height is concerned after 30 days. Further, there was a significant difference ($p \leq 0.05$) between the height of the plant samples grown by the use of water from the borehole with that of the tap water. This is owing to the fact that water from the borehole is rich in sodium and useful minerals such as fluoride that may be useful to plants though in small quantities.

Table 1: Descriptive statistics of mean values (μ (S.E), n=16) of agronomic parameters (leaf area, girth area, number of mature leaves and height) in the four treatments (waste water, tap water, borehole and shallow well) at T_0: 7 days

Treatment	Leaf area (S.E)	Girth area (S.E)	Number of mature leaves (SE)	Height (S.E)
Wastewater	14.53(0.83)	0.09 (0.01)	3.08 (0.13)	7.04 (0.32)
Tap water	13.55 (0.67)	0.08 (0.01)	2.90 (0.12)	7.49 (0.31)
Deep well	14.31 (0.98)	0.07 (0.00)	2.90 (0.12)	7.58 (0.45)
shallow well	10.83 (0.64)	0.06 (0.00)	3.23 (0.13)	7.97 (0.31)

Table 2: Descriptive statistics of mean values (μ (S.E), n=16) of agronomic parameters (leaf area, girth area, number of mature leaves and height) in the four treatments (waste water, tap water, borehole and shallow well) at T_1: 15 days

Treatment	Leaf area (S.E)	Girth area (S.E)	Number of mature leaves (SE)	Height (S.E)
Wastewater	30.92 (0.76)	0.19 (0.01)	4.58 (0.19)	11.39 (0.66)
Tap water	34.05 (6.46)	0.17 (0.01)	4.68 (0.24)	11.58 (0.60)
Deep well	29.8 (2.20)	0.20 (0.02)	5.23 (0.24)	12.40 (0.67)
Shallow well	22.30 (1.79)	0.16 (0.01)	5.93 (0.23)	13.12 (0.57)

Table 3: Descriptive statistics of mean values (μ ± S.E, n=16) of agronomic parameters (leaf area, girth area, number of mature leaves and height) in the four treatments (waste water, tap water, borehole and shallow well) at T_2: 30 days

Treatment	Leaf area (S.E)	Girth area (S.E)	Number of mature leaves (SE)	Height (S.E)
Waste water	70.03 (5.42)	0.34 (0.02)	6.03 (0.23)	18.83 (0.90)
Tap water	64.0 (5.82)	0.3 (0.03)	6.37 (0.30)	19.22 (0.96)
Deep well	65.7 (6.15)	0.3 (0.03)	7.20 (0.35)	20.15(0.92)
Shallow well	58.38 (4.00)	0.38 (0.02)	9.53 (0.37)	22.81 (0.85)

Table 4: P-value of agronomic parameters (leaf area, girth area, number of mature leaves and height) of various treatments (wastewater, borehole and shallow well) as compared that of tap water using Wilcoxon signed-rank test

Tap water	**Treatment**	**Z - Test**	**P-value**
Leaf area	wastewater	-1.586	0.11
	deep well	-0.591	0.83
	shallow well	0.215	0.05
Girth area	wastewater	-0.141	0.89
	deep well	-0.753	0.45
	shallow well	-1.492	0.14
Number of mature leaves	wastewater	0.536	0.59
	deep well	-1.998	0.05

	shallow well	-4.974	0.00
Height	wastewater	-0.249	0.80
	deep well	-1.367	0.17
	shallow well	-2.588	0.01

3.1 Leaf Area

From figure 2 it is notable that crop samples grown using wastewater had the highest leaf area at the time of harvest (T_2). However, those grown using shallow well recorded the lowest area of the leaves throughout the growth period. It is also clear that increase in the mean value of the leaf area for all the treatments was highest between T_1 and T_2. For instance there was 226 and 220% increase in leaf area from T_1 and T_2 for crop samples grown using wastewater and borehole respectively. At 220%, wastewater had the highest increase. High amount of iron, crucial in nitrogen fixation, and manganese responsible for stimulating enzymatic activity as well as the production of chloroplast may be responsibe for the leaf area increase in wastewater. This is an indication that *S. Scabrum* is more vegetative between week 2 and 4 at the time of complete harvest.

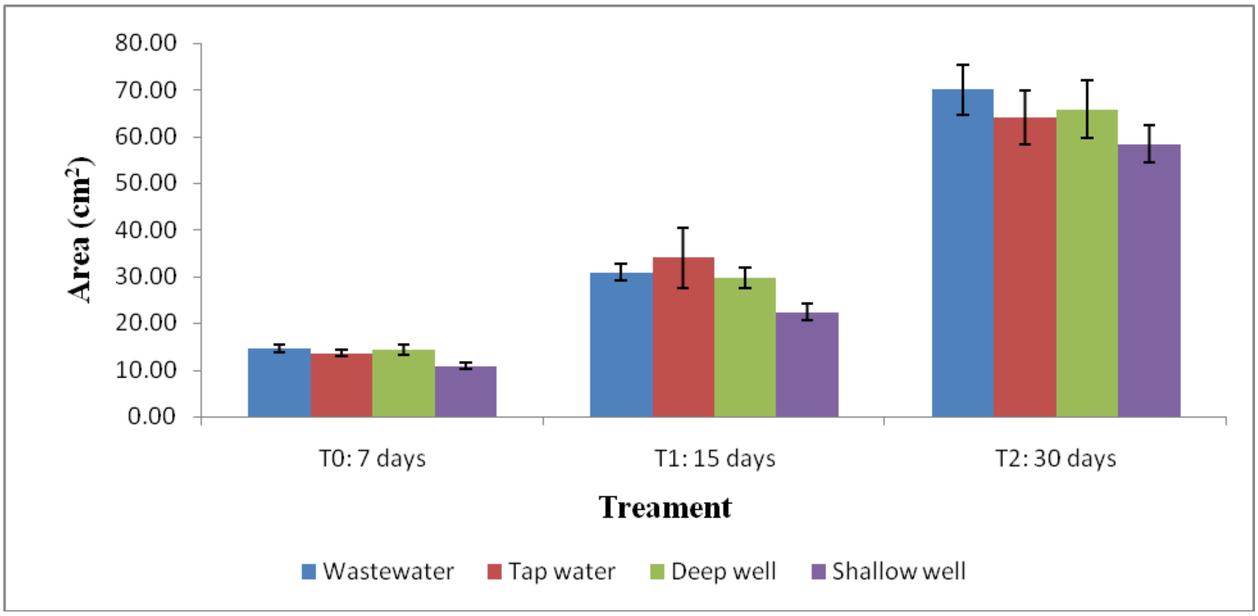

Figure 1: Graph showing the leaf area in the four water treatments (wastewater, tap water,borehole and shallow well) at different periods (T_0: 7 days, T_1: 15 days and T_2: 30 days).

3.2 Girth Area

From figure 3 it is clear that the highest girth area at T_2 was recorded by crop samples grown using shallow well. Further, as compared to crop crop samples also recorded the highest increase in the mean value from T_0 and T_1 at 268 % and 236% between T_1 and T_2. Wastewater recorded the lowest percentage increase 179% between T1 and T2 at as compared to the other treatments. High amount of calcium in the shallow wells due to leaching may be responsible for the above results as calcium helps in cell wall construction, cell growth and root development.

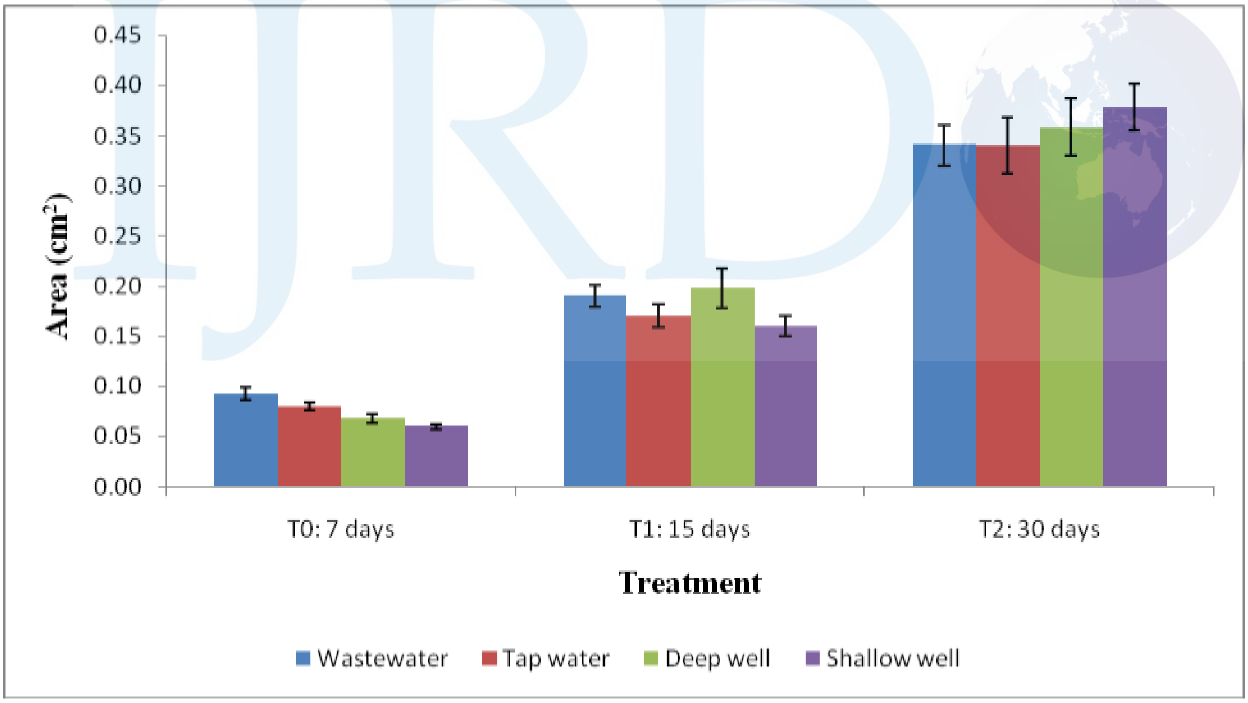

Figure 2: Graph showing the girth area in the four water treatments (wastewater, tap water,borehole and shallow well) at different periods (T_0: 7 days, T_1: 15 days and T_2: 30 days).

3.3 The leaf numbers

Just like the girth area, crop samples grown using water from shallow wells recorded the highest mean value of 9.53 (1.79) in term of the number of mature leaves T_2 as seen in figure 4.2.3.

The mean value was the highest among all other treatments, and 158% higher as compared to that of wastewater at week 4 which was the lowest. This can be attributed to the fact that strong stems in crop samples from shallow wells were able to offer support to increased number of leaves. Further, since stem conducts water, nutrients and the products of photosynthesis to and from roots and leaves, then it is clear that crop samples grown using water from the shallow wells were well supplied with nutrients, thus more number of leaves (Arteca, 2014).

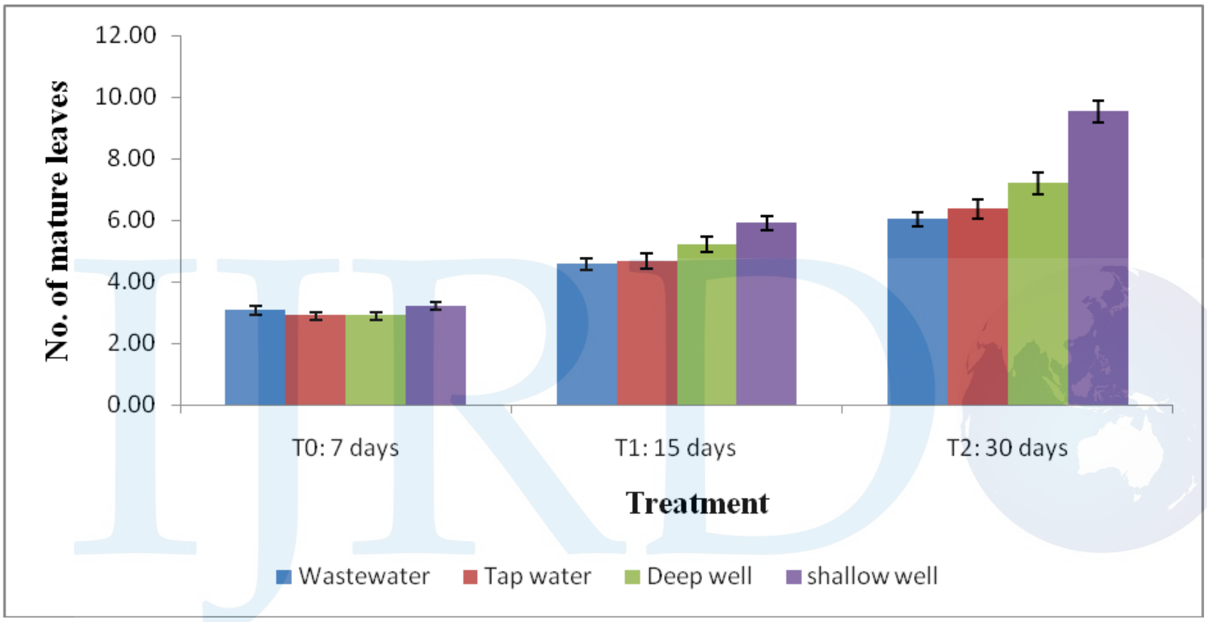

Figure 3: Graph showing the number of mature leaves in the four water treatments (wastewater, tap water,borehole and shallow well) at different periods (T_0: 7 days, T_1: 15 days and T_2: 30 days).

3.4 Plant Height

Figure 5 shows that the crop samples grown using water from shallow wells recorded the highest mean value of 13.12 (0.57) in term of plant height at T_2. Highest height for crop samples grown using water from shallow wells was also recorded at T_0 and T_1 as compared to the other teartments. Strong stems and high number of leaves are responsible for the increased height of the crop samples due to availability of more nutrients. Further, strong stem results to increased plant height (Mikulecky, Gilman & Peterson, 2016).

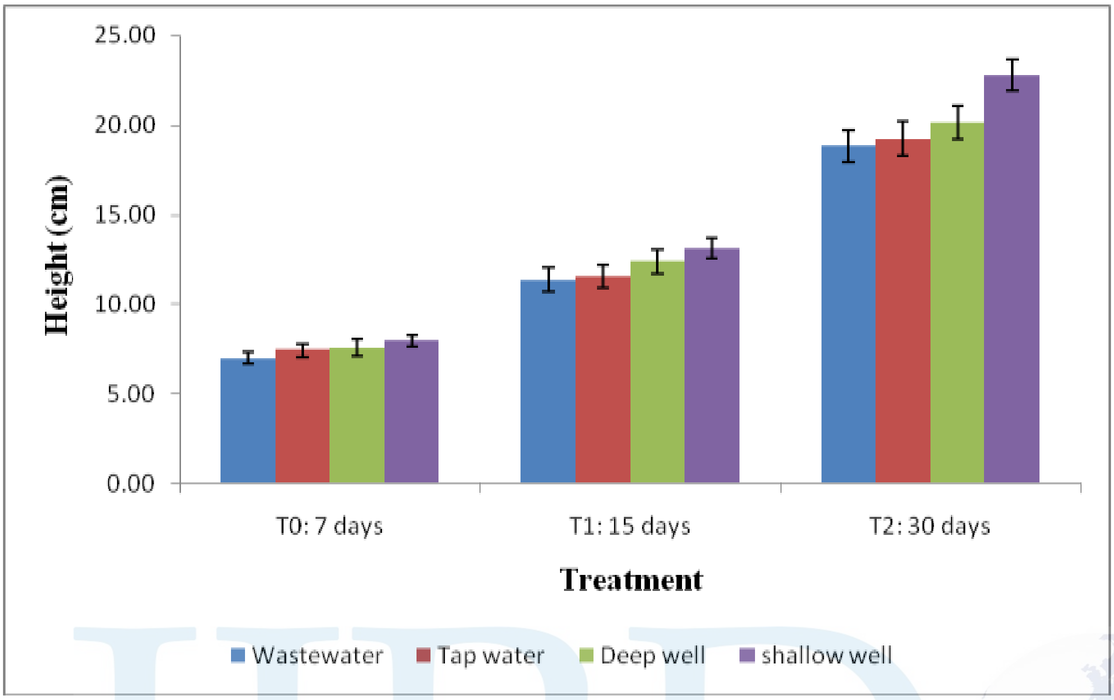

Figure 4: Graph showing the height in the four water treatments (wastewater, tap water,borehole and shallow well) at different periods (T_0: 7 days, T_1: 15 days and T_2: 30 days).

4.0 CONCLUSION

From the study, it can be concluded that the agronomic properties of *S. Scabrum* vary significantly depending on the type of irrigation water used. The number of mature leaves ($p \leq 0.00$) and height ($p \leq 0.01$) varied significantly between the plant samples grown using tap water as compared to that of shallow well. Further, there was a significant difference ($p \leq 0.05$) between the height of the plant samples grown by the use of water from the borehole with that of the tap water. This is owing to the fact that water from the borehole is rich in sodium and other useful minerals such as fluoride that may be useful to plants though in small quantities. Overall it is clear that in regard to agronomic parameters, crop samples grown using water from the shallow well were the best, recording the highest mean values as far as the girth area, number of mature leaves, and height. This can be attributed to the high level of nitrogen and phosphates in surficial aquifers due to leaching. As a result, farmers in this area should be encouraged to grow *S. Scabrum* as well as other leafy vegetables using water from shallow for maximum benefit.

5.0 RECOMMEDATION

Further research need to be carried out to determine the biological quality of *S. Scabrum* irrigated using various types of water.

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