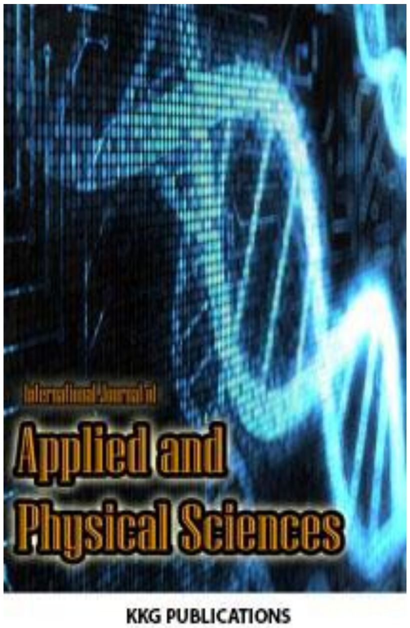

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THE EFFECT OF DIFFERENT TYPES OF SOILS ON THE GERMINATION RATE OF THE WATERCRESS SEEDS (NASTURTIUM OFFICINAL)

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Abstract. In this research, we investigated the effect of different types of soil on plant growth. We wanted to study the effects of soil on plant growth to see how different soil content can affect plant growth. The experiment was held by planting watercress seeds in three different soils; Qatari soil, Egyptian soil, and American soil. Fifteen seeds were planted in each soil. The reason for choosing watercress seeds specifically is their fast growth rate and the fact that they grow in sunny conditions [1], which matches Qatar's atmosphere. The experiment was done for 21 days based on an investigational study by [2]. The plants were watered with 150 ml in equal time intervals, and they have placed 2 cm away from the window. After three weeks, the average seeds plumule of the seeds planted in the American soil were 18.14, and the average height of the radical was 3.04. The seeds planted in the Egyptian soil had an average shoot length of 11.38 cm, and 1. 93 cm root length; While the seeds planted in the Qatari soil had shown an average height of 1.6cm for the radical and 9.97 cm for the plumule. Those results indicated that American soil was most fertile in comparison to Egyptian or Qatari soil.

INTRODUCTION

Watercress (Nasturtium officinale) is a fast-growing, aquatic or semi-aquatic, perennial plants. It grows in rich, fertile soil with a pH range between 6.5 and 7.5. It prefers full sun but tolerates some shade. The seed germination: i.e. the process at which plant embryo grows into seedling ,for watercress is very short and it varies between 7 to 14 days. As any other plant, watercress's embryo needs some essential elements in order for it to grow [3]. According to [4] criteria for defining elements that are essential for plant growth, there are 17 essential elements for a plant to grow. Those include: Carbon dioxide, oxygen, water and other elements obtained from soil. Presence of those indispensable elements would lead to efficient growth of any plant. However, in case a soil lacks any necessary element for the growth of a plant, it'll be unproductive [5] resulting in a slow rate of germination or no germination at all. Different soils, i.e soils from different regions, contain different types and percentages of plant nutrients and thus the growth of watercress would differ in each soil.

The Aim

The aim of this investigation is to determine the best conditions and nutrients needed for growing watercress by identifying the best soil (American, Qatari or Egyptian soil) for growing it. Then, examining and analyzing the soil content for the different types of soil.

Research Question

How does the nutrient content for different soils; collected from Qatar, Egypt and America, affect the rate of germination of watercress seeds.

Hypothesis

As California soil is known for its fertility and high nutrient content [6], we predict that watercress seeds will be best germinated in the soil collected from America, California. Thus it'll provide a better soil than that of Qatar or Egypt. In other word, American soil will provide the best conditions for the gibberellins (plant hormones that regulate growth and influence various developmental processes, including germination) in the plant.

Variables

Independent Variable

- The type of soil: They were brought from the ground soil from different countries in America, Egypt and Qatar. Hence they each contained different type of nutrition.

Dependent Variable

- The length of the embryonic shoot: Measured by a ruler of 30 cm
- The length of the embryonic root: Measured by the same ruler with the same length,
- The number of grown plants in each group.

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Constants

- 45 seeds from the same kind of the water cress seeds were used in the experiment, because according to some previous resources the different species result in flowers with varying lengths and sizes, it is going to be constant by using 15 seeds for each pot from the same package of the seeds.
- The room temperature was fixed, as the pots were placed near the window in a room with a temperature nearly between 22^0c-25^0c, the distance between the window and the pots was approximately 2cm measured by using a ruler.
- The water that was provided for the seeds for the germination process was filtered water from the same tap and the amount was 150 ml for each pot.
- The quantity of soil added and constant mineral content as well: As the pots are all of the same size, they have a diameter of 14 cm, the depth measurement is 13.5cm, the circumference is 42cm and the pots were provided with 8 big holes and 4 small holes in order to allow the oxygen gas to pass through them, so 900g of the soil was used for each pot .The weight of the soil is directly proportional to the nutrients provided in it. So as a result by providing equal quantity of the same soil for all the water cress seeds, they will be provided by equal amount of the minerals and nutrients.
- The depth of the seeds sowed: the ruler was used to measure or to sow the seeds into a depth of 6cms.
- The Distance between the seeds: To avoid any competition between the seeds, 3cm was left between the seeds as a constant distance.
- The no. of seeds per pot; 15 seeds were placed in each pot, as it is the maximum no. of seeds that could be placed in the pots. The seeds were clustered in 3 groups 5 seeds each, in order to facilitate the process of counting (decreasing the uncertainty) and also to avoid the competition factor between the plants.

Uncontrolled Variables

1. The intensity of light that is going to be received by the seeds in each pot.
2. The intensity of light cannot be controlled, however, all the pots are going to be placed approximately 2 cm away from the window.

Materials Required

- 15 seeds from water cress seeds for each pot (The same package was used).
- 900g of different types of soil (in this experiment the soils were collected from America, Egypt, and Qatar)
- 3 small pots with the same size and shape.
- 30 cm Ruler (the quantity: 3).
- Labels and permanent pen.
- Measuring cup(150 ml),Graduated cylinders could be used

METHOD

- I added 900g from the first type of the soil to the first pot, but I left 1cm of space from the edge of the pot, in order to avoid the water flow when I water the plants.
- I repeated step one for the other 2 soils ,and then I placed the three pots 2cm away from the window, by using a ruler to measure the distance.
- I sowed in each pot 15seeds (divided in 3 groups, 5 seeds each); but before that, I plotted 3 cm between the seeds to indicate the place where they were sowed into a depth of 6cms and I measured the depth by using a ruler.
- I labeled each pot according to the type of soil that was added inside the pots.
- Relevant measuring cup were used and filled with a specific volume of filtered tap water (150ml) and then each plant in the pots was watered.
- The seeds were watered once a day according to the instructions paper that was attached to the seeds and the same watering method was used through the rest of the 21days.
- The growth of the seeds should be observed and realized after maximum 5days as written in the instructions paper.
- The lengths and the no. of the plants were measured per week, for a period of 3 weeks, and the lengths were measured by using a ruler that was placed from the beginning in the three pots.

Data collection and Presentation

Observations

When the 21 days finished, I observed that the water cress seeds had germinated and transformed from seeds to mature plants, although of this, some seeds did not germinate at all, since no plants had appeared instead of the seeds that have been germinated. The lengths of the radical and the plumule were measured and the results were recorded for the 15 seeds that were planted in the three pots as follow in the tables.

TABLE 1A
THE LENGTHS OF THE RADICAL AND THE PLUMULE OF THE WATER CRESS SEEDLING IN EACH POT AFTER 21 DAYS OF THE GERMINATION PROCESS; FOR AMERICAN SOIL

The no. of the seed(Sn)	The length of the embryonic radical (±0.1cm)	The length of the embryonic plumule (±0.1cm)
S1	3.5	18.0
S2	-	-
S3	3.0	17.6
S4	3.6	18.3
S5	3.7	18.5
S6	3.6	18.2
S7	2.9	17.4
S8	3.6	18.3
S9	3.5	17.9
S10	3.6	18.2
S11	3.8	19.0
S12	-	-
S13	3.7	18.4
S14	3.6	18.2
S15	3.5	18.0

TABLE 1B
THE LENGTHS OF THE RADICAL AND THE PLUMULE OF THE WATER CRESS SEEDLING IN EACH POT AFTER 21 DAYS OF THE GERMINATION PROCESS; FOR EGYPTIAN SOIL

The no. of the seed(SN)	The length of the embryonic radical (±0.1cm)	The length of the embryonic plumule (±0.1cm)
S1	2.9	17.2
S2	-	-
S3	2.6	16.5
S4	2.6	16.8
S5	-	-
S6	3.0	17.0
S7	-	-
S8	3.5	17.8
S9	2.8	16.9
S10	2.5	16.4
S11	-	-
S12	2.7	16.9
S13	3.0	17.7
S14	-	-
S15	3.3	17.6

TABLE 1C
THE LENGTHS OF THE RADICAL AND THE PLUMULE OF THE WATER CRESS SEEDLING IN EACH POT AFTER 21 DAYS OF THE GERMINATION PROCESS; FOR QATARI SOIL

The no. of the seed(S_n)	The length of the embryonic radical (±0.1cm)	The length of the embryonic plumule (±0.1cm)
S1	3.0	16.9
S2	2.4	16.5
S3	-	-
S4	2.5	16.7
S5	-	-
S6	-	-
S7	2.9	16.8
S8	-	-
S9	2.7	16.5
S10	-	-
S11	2.5	16.6
S12	2.0	15.9
S13	-	-
S14	3.0	17.0
S15	2.9	16.7

TABLE 2
PERCENTAGE OF THE WATER CRESS' SEEDS GERMINATED; AND THE AVERAGE LENGTH OF THE PLUMULE AND RADICAL FOR EACH TYPE OF THE SOIL

Type of soil	Average lengths of the embryonic radical (cm)	Percentage of seeds germinated (%)	The average of the lengths of the embryonic plumule (cm)
American soil	3.0cm	86.7%	18.14Cm
Qatari Soil	1.6cm	60.0%	9.97Cm
Egyptian Soil	1.9cm	66.7%	11.38Cm

The calculations in Table 2 have taken place as the following:
To calculate the average length of both the plumule and the radical:

Average length = $\frac{\text{Sumofall the lengths}}{\text{Numberofmeasure}}$

Example: 0020

To calculate the average length of the embryonic plumule of the American seed:

$\frac{(18.0+ 17.6+ 18.3+ 18.5 +18.2\ 17.4 +18.3+ 17.9+ 18.2+ 19.0+ 18.4 +18.2+18.0)}{15}$=18 .14cm

The same method is used to calculate the average lengths of the embryonic radical of any type of soil, but by using the lengths of the radical not the plumule.

To calculate the percentage of the seed germinated:

Percentage = $\frac{\text{Numberofseedstransformedintoplants}}{\text{Numberofseedsgerminatedatthebeginigoftheexperiment}} \times$ 100%

Example:
To calculate the percentage of the seed germinated in the American soil:
No. of seed germinated=13
Original no. of seeds=15
∴13/15*100=86.7%

The observations for the water cress were majorly different from the soil of one country to the other. To explain the difference I've analyzed the soil to identify its Cation-Exchange Capacity (CEC), which is the degree to which soil can absorb and exchange cations (such as NH^{4+}, K^+, Ca^{2+}, Fe^{2+}) and here are the results obtained:

TABLE 3A
CEC VALUE FOR AMERICAN SOIL USING DIFFERENT 8, 14 AND 20 DROPS OF BCL2

CEC for the 8 drops of BCl_2 solution	CEC for the 14 drops of BCl_2 solution	CEC for the 20 drops of BCl_2 solution
39.04%	29.28%	14.64%

TABLE 3B
CEC VALUE FOR EGYPTIAN SOIL USING DIFFERENT 8,14 AND 20 DROPS OF BCL2

CEC for the 8 drops of BCl_2 solution	CEC for the 14 drops of BCl_2 solution	CEC for the 20 drops of BCl_2 solution
19.52%	9.76%	4.88%

TABLE 3C
CEC VALUE FOR QATARI SOIL USING DIFFERENT 8, 14 AND 20 DROPS OF BCL2

CEC for the 8 drops of BCl_2 solution	CEC for the 14 drops of BCl_2 solution	CEC for the 20 drops of BCl_2 solution
97.6%	48.8%	0%

TABLE 3D
PH VALUES FOR THE THREE TYPES OF SOILS (AMERICAN –EGYPTIAN-QATARI)

American soil	Egyptian soil	Qatari soil
7.00	5.5	4.0

The Calculations at Table 3a, B And C Have Taken Place as The Following:

To Calculate CEC:

CEC=$\frac{(No.of Barum Chloride drps - 2)\times(N)}{5}\times 100\%$

Where N s the normality of the 0.2BCl_2 and it is calculated by:

$N = \frac{Molar mass of barium Chlorde}{2}\times 0.2$

So, for example, to calculate the CEC value for the American soil when 8drops were added during the analysis:
No. of barium chloride drops added = 8

N=$\left(\frac{Molar mass of barium Chlorde}{2}\times 0.2\right) = 0.244$

CEC=$\frac{(8-2)\times(24.4)}{5}\times 100\%$=29.28%

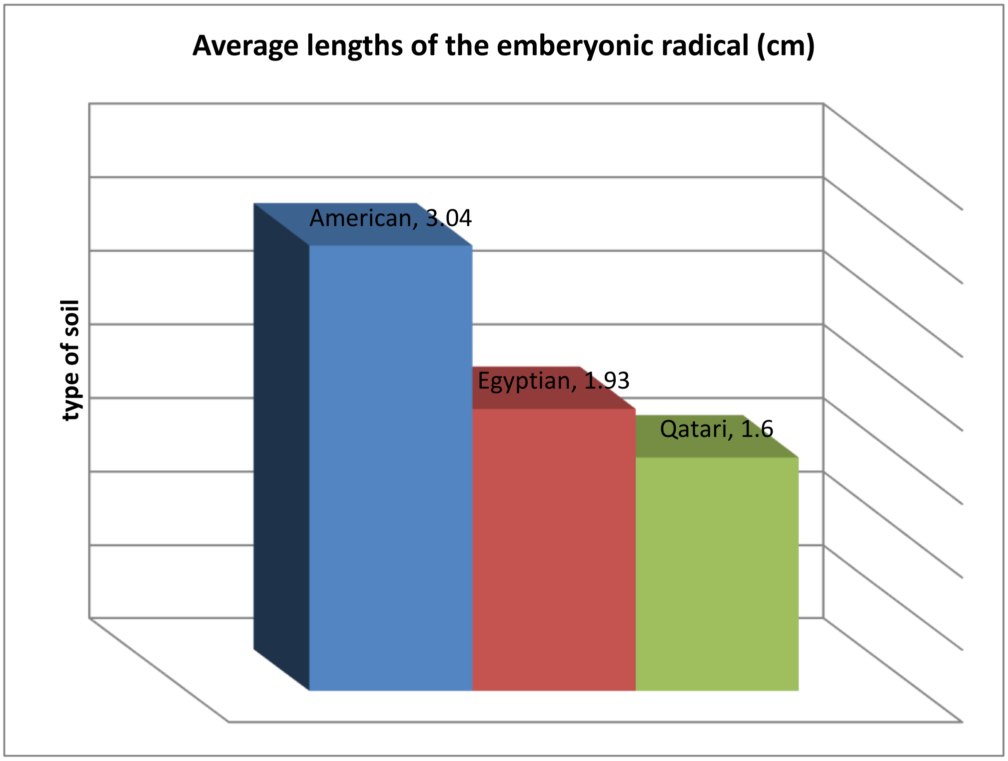
Further Investigation on the Issue; Through an Interview:

An interview was conducted with one of the best farmers in Qatar (In the national vegetables market) and the answers were as follow:

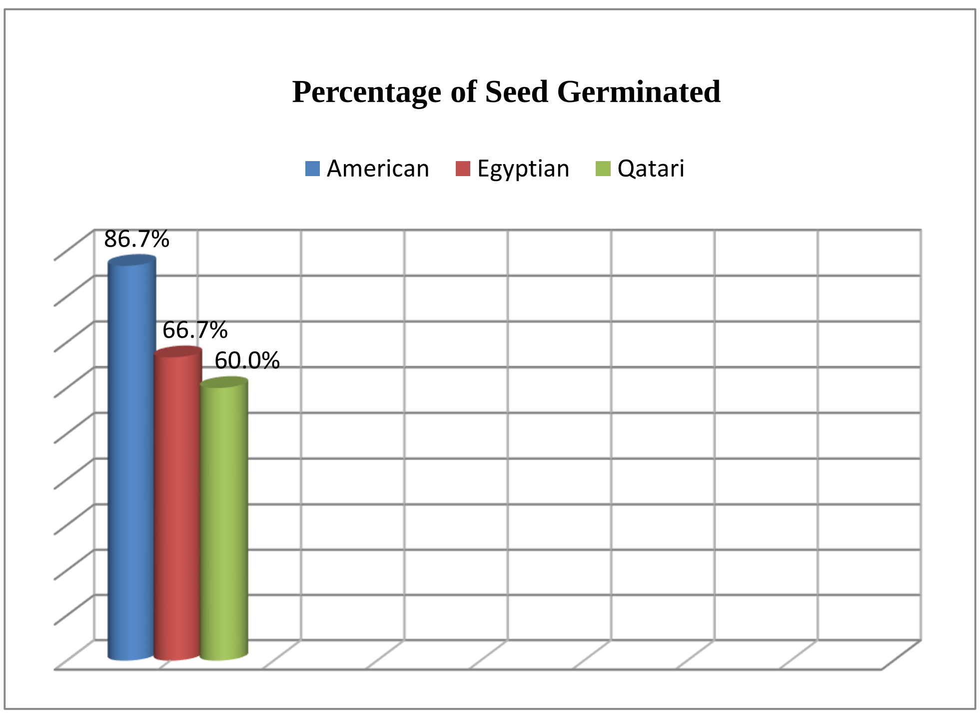
Q: Can you tell me a little bit about the nature of Qatar soil?
A: Qatar soil is a very dry soil, lack of nutrients and this is mainly the obstacle that we face in our work, and also the lack or at least the limited availability of organic matter (Soil fertility, structure, stability, nutrient retention, and available water capacity).

Q: What about the Physical Characteristics?
A: The physical characteristics depends mainly on the depth, texture, and structure of the soil and all these affects other things like for example: the transport of water and nutrients, but at his point exactly ,we cannot actually generalize ,since there are some areas here in Qatar which satisfy all the required standards for effective germination like in the (Rowdat) which have a very (sweety) soil.

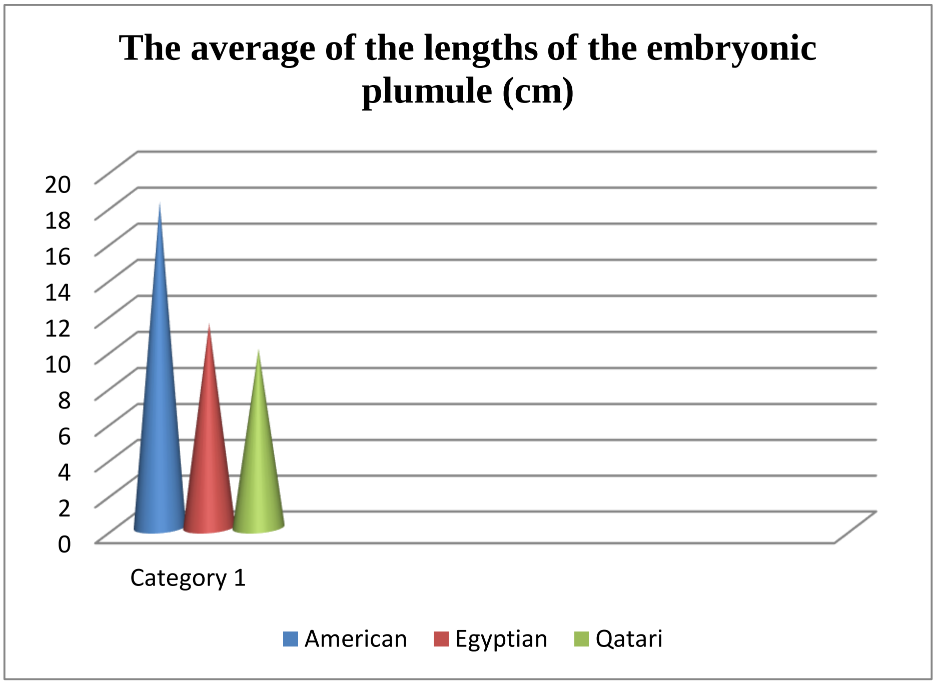
Q: What about the nutrients and the ions in the soil?
A: The soil here in Qatar is mainly lack of phosphorus, sodium and nitrogen and these three ions are very important for any plant and this is the main reason behind using fertilizers with high content of these nutrients in order to balance or compensate the loss of these crucial ions in the soil.



Graph A



Graph B



Graph C

Fig. 1. Average lengths of the emberyonic radical

DISCUSSION AND CONCLUSION

As the data and graphs show, the seeds that were planted on the American soil had the best rate of germination in compared to those planted in the Qatari or Egyptian soil. This is clear as the average height of the seed plumule was 18.14 and the average height of the radical was 3.04. In addition to that, 86.7 % of the seeds had germinated; however, this percentage isn't enough to support the conclusion since some of these seeds might contain dead embryos, so they could not germinate. On the other hand, the seeds planted in the Qatari soil had shown an average height of 1.6cm for the radical and 9.97 cm for the plumule. The Egyptian soil had shown an average shoot length of 11.38 cm, and 1. 93 cm root Length and this shows exactly the difference between the three types of soils, and this difference could be shown clearly in Graph A and C.

Moreover, If we looked really deeply in the CEC values [7], we would find that the results prove both the hypothesis and the results collected for the lengths of the plumule and the radical for all the plants ,as the results indicates that the American soil contains the highest amount of clay and organic nutrient since the ratio recorded the highest amount among the three types of the soils and as shown above in the results table the American soil indicated and recorded the highest fertility followed by the Egyptian soil and finally the Qatari soil, and also as the no. of Barium chloride drops increase the CEC value decrease for all the three types which means that the % of the ions decrease with increasing barium chloride, in addition to this the results are supported by the no. of drops added to get the same color as the reference color that was used in the other experiment that analyze the soils and the results were almost the same and also the amount of the ppts. The highest percentage of the CEC reached is 3904 for the American soil while it reached 1952 for the Egyptian one, and finally the Qatari soil indicated a very low percentage as it reached 976.

Another supporter for the results is the PH values that were recorded by using the same kit for analyzing the three types of soils. As the most suitable soil was the American chosen by comparing the values of the PH for all the three types as it was the only neutral soil according to the PH scale and the PH value is a very important indicator as for example: The nitrogen (nutrient) could be found only in the soil which has a pH value of about 5-5.5(at 5.5 is rare). Similarly, phosphorous could be found ina soil with a pH value between 6 and 7 [8]. And If any seed is planted, into the wrong type of soil ,there will be a lack of nutrients that any seed or plant needs and as a result this will cause disease. In general the best pH value range for any soil is approximately recorded between 6 or 7 as this is the range in which most important nutrients can be readily found, and this exactly matches the American soil first and then the Egyptian soil in a way or another and finally the least nearer one is the Qatari soil which indicates that there is lack of nutrients in the soil.

From this we could conclude that ,the American soil was full of important minerals and this is why the seed grew efficiently. Those results also show that the water cress seeds cannot really germinate well in the dry soil, as Qatari soil, or at least, not as good as when put in the wet, high mineral content American soil.

The bad rate of growth at dry soil could easily be explained due to the low mineral content soil, as this means that the embryo is not going to be provided with the essential nutrition and this is important especially at these stages of the development. On the other hand, the mineral rich soil was more fertile and hence, the germination process is occurred in a faster rate and in a higher rate.

All in all, this conclusion have supported my hypothesis, as the seed in the American soil grown better than in the other soils and had the highest amount of ions within it ,which means that it has natural nutrients ,organic matter, and ions unlike the Qatari and Egyptian soil as the farmer said and explained previously. And all these features explain the differences between the percentages of the seed germinated shown in graph B which compares between the three types of soil.

Evaluation

The experiment was done in a good manner, however some errors might of have altered the results. As a start, the watering time of the plants was not the same during the whole 21 days of the experiment, which might lead to some uncertainties in the results. Moreover, the viability of the seeds was not known before they were sown, and so this might have affected the percentage of the seed that have been germinated. If the experiment was held again, those errors could be avoided by fixing the watering timing for all during the whole period of the experiment, also the viability of the embryo in the seeds should be checked before germinating them. This would be an indication that they contain dead embryo, so they could be excluded from the experiment.

Another uncertainty that could have occurred is in finding the PH values, as there is more accurate methods to find the values of the PH rather than using the colors as indicators according to the graph provided with the soil kit, as human uncertainties could have been occurred due to the eye limitations.

In order to improve the fertility of the Qatari soil which indicated and showed a very low rate of the nutrients and clay which is very important for any type of the soil, I suggest that further analysis should be done to indicate which nutrients are exactly missed from the soil and so based on the results, the nutrients should be added as this experiment show that the problem is in the lack of certain nutrients. In addition to this the value of the PH was very high and this could be improved by using basic nutrients to decrease the high acidity that was very clear from the PH value and also another suggestion is the mixing between 2 different types of soils.

From the observed differences of plant growth in different soil mediums and measured differences in ion concentration of the soil mediums, this can be further used for studies to enhance the soil of Qatar to allow sustainable agricultural development and agricultural growth. The data could also create basis for experiments of the same manner with further studies on other factors affecting plant growth such as other mineral concentrations, water concentration and PH.

FUTURE PLANS

The conclusion of our findings seems to be consistent with the fact that plants can grow in Qatar's soil contrary to common belief. With a little bit of research to find out how to add minerals to optimize crops, Qatar's soil will be sustainable agriculturally.

We acknowledge the limitations set forth by our research, as only on type of plant has been tested and under a few conditions, what can be fortified.

We plan to further extend our research from the small scale school lab work it is, to a bigger scale national research in cooperation with, the Ministry of Municipality and Urban planning along with Qatar unvisited, to test more plants and figure out a mineral concentration which coincides with optimum soil potential.

REFERENCES

[1] J. Tullock, *The New American Homestead: Sustainable, Self-sufficient Living in the Country or in the City*. Hoboken, NJ: Wiley, 2012.

[2] C. Robertson, B. Clothier, S. Sivakumarana, A. McLachlan, I. McIvor and H. Meikle, Nitrogen Management by Watercress (Nasturtium Officinale) in Hydroponic Conditions, [Online], Available at http://goo.gl/Kpv5XB, 2012.

[3] A. V. Barker and D. J. Pilbeam, *Handbook of Plant Nutrition*. Boca Raton, FL: CRC/Taylor & Francis, 2007.

[4] M. Hoefnagels, *E-Study Guide for Biology: Concepts and Investigations*. Kindle ed. Cram101, 2014.

[5] W. G. Hopkins and C. M. Évrard. *Plant Physiology*. Bruxelles: De Boeck, 2003.

[6] M. Gaskell, R. Smith, J. Mitchell, S. T. Koike, C. Fouche, T. Hartz and W. Horwath,. "Soil fertility and the nutritive value of crops," *Nutrition Reviews*, vol. 34, no. 10, pp. 316-317, 2009.

[7] D. L. Rowell, *Soil Science: Methods & Applications*, New York: John Wiley & Sons, 1994.

[8] L. Busman, *The Nature of Phosphorus in Soils*. Minnesota Extension Service, University of Minnesota, 2002.

APPENDIX

Some Pictures taken during the experiment:





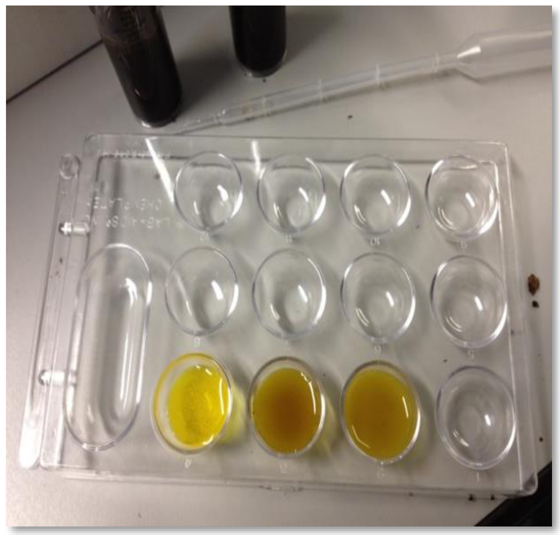

The three types of soils:

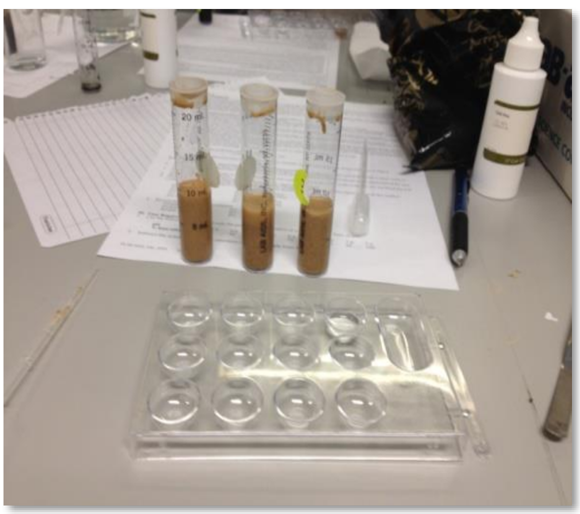
Qatari Soil

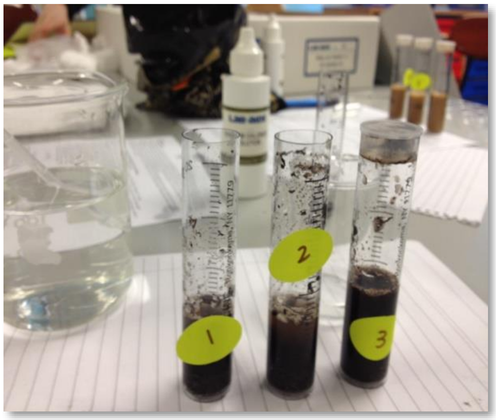
Egyptian Soil

American Soil

Pictures taken during the soil analysis process and measuring the PH values:



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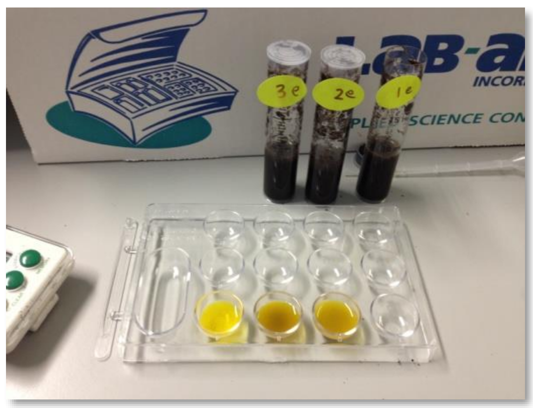
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