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QUALITATIVE ANALYSIS ON REQUIREMENT OF IONS *POTASSIUM, NITROGEN, MAGNESIUM AND PHOSPHORUS* FOR GREEN GRAM GERMINATION BY HYDROPONICS.

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ABSTRACT

Seed is the most important part of any plant from which a new plantlet will emerge. This process of emergence of a plant from the seed is called Germination. Germination of a seed involves sprouting that takes place when water and nutrients are imbibed by the seeds from the surroundings. For any seed to germinate proper temperature, moisture, oxygen and darkness are required.

Apart from the above mentioned parameters proper ions are also required which are often present as nutrients in the surrounding soil in which the seeds are kept for germination. With advancement in the field of agriculture attempts are in progress for soilless cultivation which is termed as hydroponics.

Hydroponics involves the use of water and not soil for germination of seeds and growth of plantlets. For proper germination and growth there is an absolute requirement of basic ions in the water used for the purpose of hydroponics same as cultivation in soil enriched with basic nutrients.

In the present study to understand the requirement of the ions Potassium, Magnesium, Phosphorous and Nitrogen for germination of green gram seeds studies were conducted by using distilled water as control and distilled water supplemented with the individual ions in their salt forms.

KEYWORDS : Hydroponics, Seed germination, Ions, Green gram

INTRODUCTION:

Growth of anything and everything refers to the process of development throughout its life-span in different forms and phases. Recently I noticed a cyclical pattern in the process of growth of anything; whether it's an organism, a plant or a business venture. That the potential resources required throughout the life-span or growth stages of any of these seem to be the same but are utilized in different forms. For example: growth of an embryo requires nourishment of oxygen, glucose, energy etc. ("Stages Of Pregnancy & Fetal Development | Cleveland Clinic"). And again, in the growth phase of a new born child to an adult; the resources utilized for nourishment tend to be same but in different form, for instance the previous nutrients are no longer attained through the mother's umbilical cord but through vegetables, fruit, environment etc. ("Stages Of Pregnancy & Fetal Development | Cleveland Clinic"). This pattern in growth intrigued me to explore how this phenomenon presents itself in case of plants.

Alongside, the rapidly spreading idea of recycling by the global scientific community; I came across an often-overlooked method of recycling filtered out water in my locality i.e. reusing it for watering plants. I believe that reusing it for watering plants will be beneficial as it'll be rich of ions such as nitrogen, magnesium, phosphorus and potassium which are utilized by the plant for growing. Considering, all this I planned to investigate whether the plant requires all these ions even during its germination stage. To answer my query, I've designed an experiment: where I'll be observing the germination stage and initial growth phase of the green gram seeds. Hence, arriving at my research question:

Research Question: To what extent do the ions; potassium, nitrogen, magnesium and phosphorus influence the germination of green gram seeds?

Background information: Germination of seed is a basic growing skill that involves sprouting in the seed, the very first step in the development of new plant from the seed ("What Is Seed Germination? - Definition, Process, Steps & Factors - Video & Lesson Transcript | Study.Com"). During the process of germination, the seed imbibes water by picking moisture through the seed coat into the seed itself ("What Is Seed Germination? - Definition, Process, Steps & Factors - Video & Lesson Transcript | Study.Com").

The moisture brings life into the dormant seed by activating the enzymes in the seed that remained inactive over a long period when the seed remained in its dehydrated dry form ("Seed And Seedling Biology"). The enzyme hydrolyzes the stored proteins in the seed and help in the organization of new proteins needed for the development of new tissues necessary for the emergence of the two important organs i.e. shoot and root ("Gibberellin - An Overview | Sciencedirect Topics").

As moisture is absorbed by the seed the exterior of the seed cracks open and the radicle emerges from the seed to form the root. At the same time the hypocotyl, or stem of the germinating seed elongates and pushes the cotyledon above the ground. The cotyledon is the one which transforms into the first leaves of the seedling ("Seed And Seedling Biology").

During this process the seedling excretes essential hormone i.e. called gibberellin or gibberellin acid Gibberellin causes the production of amylase which hydrolyses starch into maltose ("Gibberellin - An Overview | Sciencedirect Topics"). Maltose is further hydrolyzed into glucose so that it can be used for cellular respiration. Some of the glucose may be converted into cellulose so that it can be used to produce new cells for cell walls. Thus, the formation of the shoot and the root of the seedling commence ("Gibberellin - An Overview | Sciencedirect Topics").

There are two types of seeds that exist; monocotyledon and dicotyledon. Monocotyledon seeds have a single cotyledon, leaf veins are usually parallel, the vascular bundles are complexly arranged with fibrous root system and the floral parts of the plant are often the multiples of three (Ersek). Whereas, dicotyledon seeds possess two cotyledons, netlike veins, ring arrangement vascular bundles with taproots and floral parts being in the multiples of four or five (Ersek).

As presented earlier I'll be using the ions: potassium, nitrogen, magnesium and phosphorus influence the germination of

green gram seeds. I've chosen these ions since they are essential macronutrients that the plant requires for growing and the absence of any one these ions could result in the deficiency in the plant growth. As shown in the table below: ("Plant Nutrition - Biology Encyclopedia - Cells, Body, Function, Cycle, Life, Membrane, Water, Molecules")

Table 1: Role of Macronutrients

Macronutrient	Role	Form absorbed	Deficiency
Nitrogen (N)	Formation of nucleic acids and chlorophyll (which is a green pigment that facilitates the process of photosynthesis by aiding in the absorption of sunlight)	NO_3^-, NH_4^+	Plants become light green with long slender roots,
Potassium (K)	Acts as an enzyme activator, is involved in the formation of starch and aids in the regulation osmotic balance by controlling the movement of guard cells.	K^+	Stems become slender and numerous small necrotic emerge near the margins of its leaves
Magnesium (Mg)	A key component in the formation of chlorophyll.	Mg^{2+}	Leaves tend to lose their rich green color and slowly become pale yellow in color.
Phosphorus (P)	A key component in the formation of nucleic acids, phospholipids and coenzymes.	$H_2PO_4^-$, HPO_4^{2-}	Plants become purple or dark green in color.

Methodology:

Present study aims at looking for the effect of different salts on the germination of seeds hence forth for such an analysis hydropic method of cultivation has been adopted.

Hydroponic method: is growing plants in the absence of soil directly on water by giving support for the roots to establish like a plastic net cup or anything with holes made in it for the seeds to rest upon and the roots to firmly adhere to. Theoretically the term "hydroponics" means growing plants in water without soil. Physiology of a plant shows that any plant grows through a process of photosynthesis (NUTRITION IN PLANTS – MINERAL NUTRITION). Photosynthesis is biological process operating in plants which facilitates the conversion of atmospheric carbon dioxide and water into carbohydrates in the presence of sunlight. Understanding the concept of photosynthesis, the main driving force in plants has made the plant cultivars across the world shift for hydroponic method of cultivation as the prime necessary things needed for plant growth are water, atmospheric carbon dioxide and the requisite metabolic pathways operating within the plant system for conversion of carbon dioxide to carbohydrates (NUTRITION IN PLANTS – MINERAL NUTRITION).

Following is the equation for photosynthesis: ("What Is The Photosynthesis Equation?")

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

The equation clearly justifies that there is not much role of soil in the whole process except for giving the anchoring support for the establishing root system and of course water and an array of macro and micro nutrients needed by plants for the metabolic pathways to operate and function. But if the required nutrients can directly be supplied in water itself than from soil by standing their roots in nutrient rich water than they can grow without soil. This is what is the concept or basis for hydroponics (NUTRITION IN PLANTS – MINERAL NUTRITION).

Hydroponics has its own advantages in the present investigation as it allows to investigate very precisely only one nutrient at a time as it is not involving the soil which is a nutrient support to the plants. Literature review and the experience of plant breeders have reviewed that hydroponics has many advantages over the conventional methods involving the soil. ("Pros And Cons Of Hydroponics - Easyponic")

- It resulted in high yields may times greater than conventional methods
- In hydroponics method of cultivation, the plants dip their roots directly in the nutrient rich solutions and get what they need more easily than the from soil.
- Plants can grow with minimum roots and can be accommodated in less available space as nutrients are easily available in water.
- Plants can be protected from many soils borne pests as soil is the abode of many disease-causing organisms resulting in the stunted growth of plants in general.

With this background knowledge on germination of seed and hydroponic method of cultivation the present study was designed taking proper care at every step to be in accordance with the research question and come to certain conclusion supporting the hypothesis.

Experimental Set up:

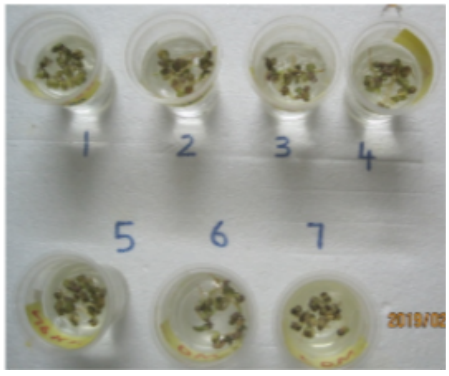


Figure 1: Experimental Set up

As discussed previously a simple hydroponic set up was utilized for this investigation. In which disposable transparent plastic cups and glasses were used. The salt solutions of nitrogen, potassium, phosphorus and magnesium were poured into the glass to acts as a water reservoir the green gram seeds to grow by taking up the water from below. Slightly above a small plastic cup with pores was partially submerged in the solution below. This cup helps up the green gram seeds to imbibe water, swell and through its tiny numerous equidistantly placed pores allowed its roots to pass down into the water reservoir, so that the water and mineral uptake can commence. Then the entire set up was placed in sunlight; so that the seeds can absorb diurnal sunlight.

Apparatus:

- Camera (for constantly recording your observations)
- 7 Disposable plastic cups
- 7 Disposable plastic glasses

Materials:

- Distilled Water
- Filter drain water (of my own water purifier)
- Potassium ion enriched fertilizer containing water
- Phosphorus ion enriched fertilizer containing water
- Nitrogen ion enriched fertilizer containing water
- Magnesium ion enriched fertilizer containing water
- Water solution containing all the four ions; Nitrogen, Phosphorus, Potassium, and magnesium
- Green Gram seeds

Variables	
Independent	Solutions made from varied ions (N, P, K, Mg)
Dependent	Germination of green gram seeds
Controlled	
• The relative mass of the green gram seeds selected for each solution • Same number of green gram seeds for each plastic cup • Room temperature and pressure • Distance between each pore in the plastic cup • The ideal concentration of different salts was mixed in fixed volume of distilled water (1 L) • Only tested viable seeds were used for hydroponics and proper aeration was given for the seeds to absorb enough atmospheric macronutrients such as oxygen and carbon dioxide.	

Results:

Legend:

1. Nitrogen (N)
2. Magnesium (Mg)
3. Phosphorus (P)
4. Potassium (K)
5. NPKMg (nitrogen, phosphorus, potassium and magnesium)
6. Distilled water
7. Filter drain water

Table2 : Results Day wise

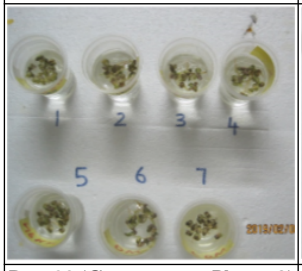
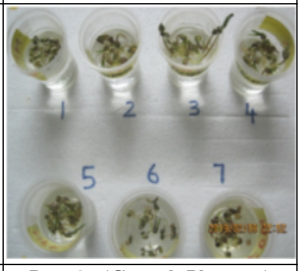
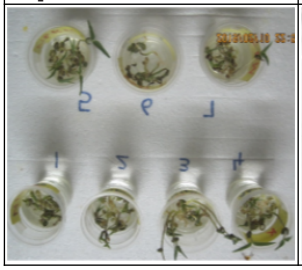
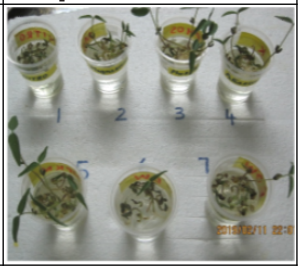
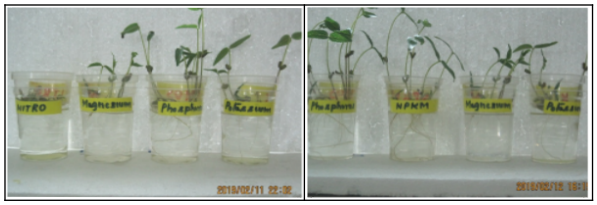
Day 01 (Sprouting period)	Day 02 (Germination Phase 1)
	
Day 03 (Germination Phase 2)	Day 04 (Growth Phase 1)
	

Table 3: Comparison of Day 04 and Day 05

Comparison between Day 04 and Day 05	
Day 04 (Growth Phase 1)	**Day 05 (Growth Phase 2)**
	



Discussion:

Throughout my investigation about finding out 'to what extent do the ions; potassium, nitrogen, magnesium and phosphorus influence the germination of green gram seeds?'. My observations recorded for five consecutive days indicated that seeds germinated with the aid of phosphorus ion enriched fertilizer containing water showcased the maximum germination in terms of number of seeds being germinated and growing healthily as shown in tables 2 & 3. Followed by seeds grown in water solution containing all the four ions; nitrogen, phosphorus, potassium and magnesium – this observation could potentially indicate that these four essential macronutrients do influence the germination of green gram seeds to an appreciable extent ("Plant Nutrition - Biology Encyclopedia - Cells, Body, Function, Cycle, Life, Membrane, Water, Molecules"). However, the control for this experiment i.e. growing moong seeds in distilled water (which displayed partial amount of germination but relatively slower in comparison). This unexpected phenomenon could have occurred because seeds in general are self-sufficient in terms of nutrients to support their process of germination and sprouting. They may only require enough supply of water to rehydrate the seed cotyledons, soften the outer seed coat and germinate ("Biology Of Plants: Starting To Grow").

Next up is magnesium and potassium which showed relatively same amount of germination; this could be because both Mg^{2+} and K^{+} are absorbed in their ionic form rather than being converted into another form before being absorbed by the roots ("A Plant Can Only Absorb Nutrients In The Form Of Ionic Salts"). The plants expressed relatively slow rate of growth in nutrient solution supplemented with nitrogen. This could be because of soil less culture, due to which the microbes which help the roots of the plants to take up nitrogen are missing. Moong belonging to a family of Leguminosae is dependent on bacteria for fixing nitrogen ("Fabaceae").

Another important observation is the effect of filter drain water on the rate of germination and growth of moong seeds where the growth was not up to the one observed in Mg, P and K salts supplemented waters. This can be attributed to the high concentration of various salts present in that water which slowed down the rate of germination, sprouting and growth ("Transport Of Water And Solutes In Plants | Boundless Biology").

Conclusion and Evaluation:

Seeds basically require water, oxygen and sunlight for germination which were provided in this experiment. Irrespective of the water sample used either the control distilled water or the distilled water enriched with the salts of the four different ions selected for the study there was a minimal germination process and growth seen in all. But it has been very clearly observed that the pace at which the seeds germinated and sprouted varied in different samples of water ("What Are The Requirements For Germinating Seeds? - Extension"). In the present study from the time of soaking to the stage of sprouting the distilled water used as control was enriched with different ions. In the analysis carried with different ion enriched distilled water, the water sample that contained phosphorous showed faster germination. As per the observations in the present analysis in germination of green gram seeds the ion phosphorus definitely showed a quicker germination and growth for the short period of time the study was designed.

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