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Effect of pH on Hydroponically Grown Bush Beans (*phaseolus vulgaris*)

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***Abstract*— *Numerous environmental factors can influence the viability of plants. Several studies have shown that acidic and basic pHs have a noticeable effect on different types of plants when grown directly in soils. However not too many studies have been done on hydroponically grown plants with respect to pH. This study was conducted at the Botany laboratory and Green house at Alabama A & M University with bush beans.*

Five nutrient solutions with pH values ranging from 5 - 9 were used. Observations on plant height and number of leaves were done for six weeks after nutrient solutions with the different pH values were introduced to the plants 7 days after the seed germinated.

Plants grown in nutrient solutions with high alkalinity levels (8 & 9) were significantly shorter compared to those grown in nutrient solutions with pH 5, 6 and 7. Leaf number and size strongly correlated in a manner expected with plant height, plants in high alkalinity nutrient solutions had fewer and smaller leaves. Plants grown in neutral or near neutral nutrient solutions appear healthier with green leaves and strong stems.

Keywords*— *Effect, hydroponically, pH, bush beans.

I. INTRODUCTION

Hydroponics was derived from two Greek terms, Hydro (water) and Ponos (labor). In 1929, a plant physiologist by the name of William Gericke used nutrient solution formulae to grow crops and called the process "aquaculture". However, that term was used for another process, so Gericke instead coined the word "hydroponics" (Welch, 1990). Hydroponic systems have been utilized as one of the standard methods for plant biology research and also used in commercial production for several crops (Nguyen et al.). Hydroponics is the practices of growing plants using only water as a substrate with the addition of essential nutrients and is one of many methods used in nutrient- delivery systems (Kane et al, 2006). Most modern hydroponic solutions are based on the work of Hoagland and Arnon and have been adapted to numerous crops (Kane et al, 2006, Wheeler et al., 2008). Since the 1980s, hydroponic units have been commercialize for vegetable and flower production, and today more than 60,000 Ha of vegetables are grown hydroponically in green houses worldwide (Kane et al, 2006). Since hydroponic plants have access to unlimited nutrients and water, this specific environment helps to improve crop growth and yield (Paradiso et al,.2017) and they are able to grow up to ten times faster and healthier than soil grown plants (Ficks and Mitchell, 1993). Root zone pH is most importantly considered in hydroponic culture (Hyun-Ju Kim et al). The pH of a hydroponic solution influences the solubility and availability of nutrients for root uptake, especially iron and other micronutrients such as manganese and boron. A high pH decreases iron solubility and uptake by roots, which can result in deficiency symptoms. For most crops, keeping pH within a target range of 5.6 and 6.2 ensures adequate nutrient solubility and availability for plant uptake

(Dickson and Fisher, 2017).Plants grown in a hydroponic system have the perfect balance of nutrients and water freely available to their roots. Because plants are not forced to expand their limited energy searching for water and food, they are able to grow faster and healthier.

Plants must have certain nutrients in order to survive and function properly. Plants get their nutrients from air, water, or soil in which they grow. Of these three sources, the soil is often the greatest source for plant nutrients, but whether or not these nutrients are actually available for plant uptake, depends largely on the acidity or basicity of the soil (Huett, 1994). When growing plants without soil, or hydroponically, the pH of the nutrient solution is critical for proper development. If the pH of the nutrient solution is within the appropriate range for a particular plant, that plant will be able to utilize all the proper nutrients and thrive. If the pH of the solution is not within the appropriate range for a particular

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plant, then that plant will not be able to utilize an adequate amount of nutrients and will begin to show signs of poor health such as fragile stems, yellowish, and slow stunted growth. If the plant environment in which it is grown is too acidic then some nutrients can't be absorbed; likewise if too basic, then other nutrients cannot be absorbed. Ideally its environment should have a good balance, such that it is neither very acidic nor very basic. The pH number lets you know how soluble the nutrients in the water mixture are. It determines the mobility of these nutrients, and hence the plant uptake ability of these nutrients Green and Vibrant, 2017}Scientists have found that the ideal overall pH for optimum absorption of most nutrients is 6.8, slightly acidic. Any soil that has a pH range within 6.3 to 7.3 is considered good (Jett, 1999).

A simple hydroponic system comprising of plastic planting containers, planting medium, a reservoir, a wick, air space and a light source was used. The objective of this study is to show how altering the pH of a nutrient solution will affect the growth and health of bush bean plants.

II. MATERIALS AND METHODS

The study was conducted at the Botany Laboratory and Green House at Alabama Agricultural and Mechanical University. Bush beans grown in hydroponic nutrient solutions (contents: N 7.0%, P_2 O_5 4.0%, K_2 O10.%, Ca 4.0%, Mg 1.5%, S 2.0% and Fe 0.1%) with adjusted pH values of five, six, seven, eight and nine used in this experiment. Each treatment was replicated three times.

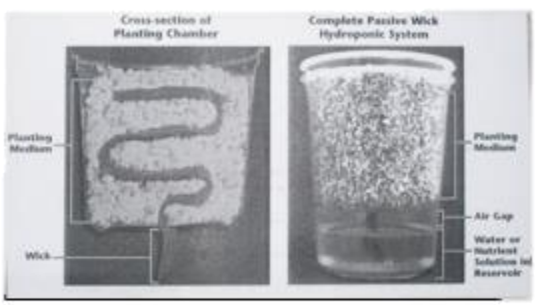

Figure 1: Hydroponic Set-Up System

The hydroponic system was assembled using two different sizes transparent plastic containers. One small sized container was used for the inert planting medium [perlite {70%} and vermiculite {30%}] and absorbent felt wick. The other size was used as a reservoir for the nutrient solution. The felt wick was weaved in an "S" shape through the container with the planting medium with at least 2 inches protruding through a slit at the bottom. The container was then placed in the other container with the nutrient solution, making sure an air gap was seen and the wick was immersed in the solution.

Figure 2: Bush Bean Plants seven (7) days after germination (grown with only water: no nutrient solution applies

Initially approximately 200 ml of water was placed in the reservoir container to allow the bush bean seeds to germinate, the seedlings were grown for one week and their heights measured before they were introduced to the different adjusted pH nutrient solutions. Plants were measured and number of leaves counted weekly. Other observations made were based on the general appearance of the plants (e.g. color, size and lost of leaves and color, strength of stem).

Using a pH strip and the pH up and pH down solutions, the nutrient solutions were maintained at their respective PHs. Reservoir containers were emptied, cleaned and refilled with newly mixed adjusted pH nutrient solutions every two weeks. At the end of the six weeks observational period the data for plant height and number of leaves per plant were compiled and graphical charts used to indicate correlations and trends. Plants were exposed to eighteen hours of light and six hours of darkness per 24- hour period. During the germination period light was kept on for 24-hours per day.

III. RESULTS AND DISCUSSION

Figure 3: Differences in growth/development of Bush Bean Plants Thirty-five (35) days after being fed with nutrient solutions. A= Nutrient solution at pH 5, B= Nutrient solution at pH 7, C= Nutrient solution at pH 6, D= Nutrient solution at pH 8, E= Nutrient solution at pH 9.

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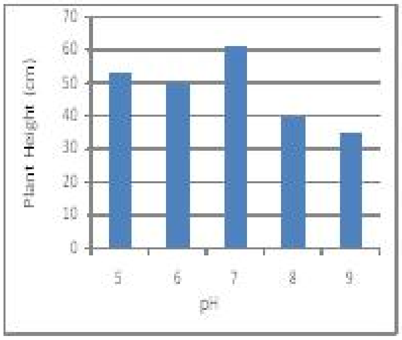

Figure 4: Effect of nutrient solutions at different pH levels on plant (*Phaseolus vulgaris*) height.

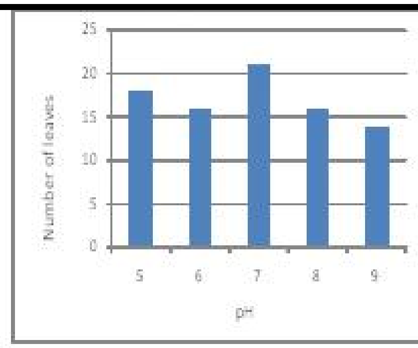

Figure 5: Effect of nutrient solutions at different pH levels on number of leaves/plant (*Phaseolus vulgaris*)

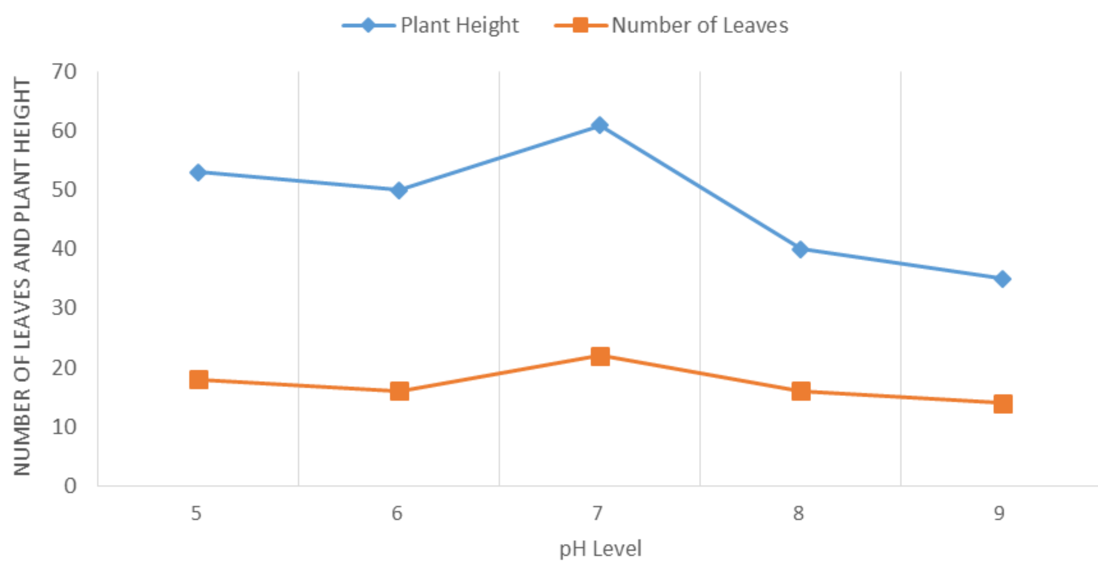

Figure 6: Correlation between Plant Height and Number of Leaves

The data of six week of observation on the effect of pH on hydroponically Bush Bean *(phaseolus vulgaris*) are illustrated in figures 4 and 5. Nutrient solutions with Very basic pH (8and 9) contributed to the stunted growth of bush bean, the data (Fig. 4) indicated that heights decreased when plants were grown in nutrient solutions at pH levels 8 (40cm) and 9 (35cm) when compared to nutrient solution with pH levels of 5 (53 cm), 6(50cm) and 7(61cm). This variation in growth was due to an observed decrease in internode length at both alkalinic nutrients solution levels (pH 8 & 9). This finding supports that of Green and Vibrant (2017) who indicated that each element has a specific tolerance to a respective pH level and main macronutrients (NPK) are hard to move in too high pH environment. Which makes it difficult for plants to absorb them, which results in deficiencies (Sedimentation occurred in nutrient solutions with pH levels of 8 and 9, indicating nutrients did not dissolve completely at those pH levels. **Ruano (1987)** and Heutt (1994) said pH values below 6 and above 7.5 cause the inhibition of phosphoric, calcium, magnesium, iron, manganese, copper, zinc and boron **ions** to be less available to plants. According to him extremes in pH, especially above 7 can result in precipitation of certain nutrients, for plant roots to be able to absorb nutrients, the nutrient must be dissolved in solution. The process of precipitation (the reverse of dissolving) results in the formation of solids in the nutrient solution, making nutrients unavailable to plants. These factors must have contributed to the deficiency in internode length, hence the height of the plant.

Data in Figure 5 indicated that less leaves were produced when plants were grown in nutrient solutions with pH levels of 8 & 9. Leaves were also observed to be smaller on plants grown in nutrient solution with pH levels of 5, 8 and 9. Lack of vital nutrients could be the contributing factor for these deficiencies. These results seem to support Huett (1994) finding that at extreme pH (very acid/very basic) essential elements become less available due some form of precipitation.

Based on general observations after the conclusion of the experimental period (Fig. 3), plants grown with nutrient solutions of pH 5, 8 and 9 show signs and symptoms that would eventually lead to their mortality. Plants grown with nutrient solutions of pH 5and 6, especially those with neutral (pH7) looked healthier. Excessive drying and falling of leaves, discoloration and fragile stems were indications that these plants would not survive. Similar trends in Figure 4 and 5 show a strong correlation between plant height and number of leaves per plant (Fig. 6) in this investigation.

IV. CONCLUSION

Plants grown in neutral or near neutral nutrient solutions (pH 6-7) appear healthier with green leaves and strong stems. This finding agrees with Kane et al. (2006)that biomass was greatest for plants grown at pH 6.5. According to Azad et al. (2009), plant growth is related to media pH and nutrient components.

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