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Determination of Optimization of Nutritional Deficiencies in Plant Physiology Practicum in Hydroponic Laboratories (Axis and No-Axis System)

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Background: Hydroponics is a method of agriculture that utilizes water as a planting medium. The purpose of the study was to find out reasonable working procedures and nutrient solution formulas capable of showing symptoms of morphological nutritional deficiencies in plants. **Methods:** The plants used are the seeds of kale plants that are sown within 1 - 2 weeks (until roots, stems, and leaves grow). The design used is Random Group using three formulas with nine kinds of treatment on each formula and three repeats. Experiments were conducted on two hydroponic systems, the axis and without the axis. The parameters observed are the number of leaves, the leaves' length, the leaves' width, the plant's height, and the plant's size. **Results:** Observational data in the analysis using SPSS 25. The effect of treatment with test parameters is seen using ANOVA analysis and BNT advanced tests. Visual observations showed the formula of nutrient solutions 1, 2 and 3 using both the axis system and without the axis showed symptoms of nutritional deficiencies in kale plants. The axis less system experiment gave more significant results on all parameters except leaf length than the axis system based on the average results of BNT advanced tests. **Conclusion**: Nutrient solutions 1, 2 and 3 have a real effect on all test parameters.

Penentuan Optimalisasi Defisiensi Nutrisi Pada Praktikum Fisiologi Tumbuhan di Laboratorium Secara Hidroponik (Sistem Sumbu Dan Tanpa Sumbu)

Kata kunci:
Defisiensi nutrisi;
Kangkung;
Prosedur kerja;

A B S T R A K

Background: Hidroponik merupakan metode pertanian dengan memanfaatkan air sebagai media tanam. Tujuan penelitian adalah untuk mengetahui prosedur kerja yang baik dan formula larutan hara yang mampu menunjukkan gejala defisiensi nutrisi secara morfologi pada tanaman. **Metode:** Tanaman yang digunakan adalah benih tanaman kangkung yang disemai dalam waktu 1 - 2 minggu (sampai tumbuh akar, batang dan daun). Rancangan yang digunakan yaitu Acak Kelompok menggunakan 3 formula dengan 9 macam perlakuan pada masing-masing formula dan 3 kali ulangan. Percobaan dilakukan pada 2 sistem hidroponik yaitu sumbu dan tanpa sumbu. Parameter yang diamati adalah jumlah daun, panjang daun, lebar daun, petambahan tinggi tanaman, dan tinggi tanaman. **Hasil**: Data hasil pengamatan di analisis menggunakan SPSS 25. Pengaruh perlakuan dengan parameter uji dilihat menggunakan analisis ANOVA dan uji lanjut BNT. Hasil pengamatan visual menunjukan formula larutan hara 1, 2 dan 3 baik menggunakan sistem sumbu maupun tanpa sumbu menunjukkan gejala defisiensi nutrisi pada tanaman kangkung. Percobaan sistem tanpa sumbu memberikan hasil yang lebih signifikan pada semua parameter kecuali PD (panjang daun) dibandingkan sistem sumbu berdasarkan hasil rata-rata uji lanjut BNT. **Kesimpulan**: larutan hara 1, 2 dan 3 berpengaruh nyata terhadap seluruh parameter pengujian.

Introduction

The growth and development of plants are greatly influenced by the availability of nutrients and minerals in the soil. Improper provision of fertilizers or nutrients results in the growth and reproduction of not optimal crops and waste energy and cost (Ruhnayat, 2007).

Plant nutrients are distinguished into macronutrients, micronutrients, and trace elements based on nutrient needs. Macronutrient elements consist of N, K, S, Ca, Mg, and P (Jeyalakshmi and Radha, 2017). Micronutrient elements include Na, K, B, Mn, Zn, Cu, and Mo and trace elements, namely Al, Si, Au, Ni (Mc Cauley et al., 2011).

Mineral and nutrient deficiency disorders in plants can be diagnosed through plant analysis by determining CTL (critical deficiency level), CDL value (basic levels of deficiency), and CTL values (basic levels of toxicity) in plant tissues. CDL and CTL values are not a point of value but a range of values. (Marschner, 1995).

Practicum is a debriefing activity for students to understand theory and practice (Nisa, 2017). In addition, according to Susanti (2013), practicums can 1) practice skills, 2) prove something scientifically, and 3) allow students to integrate knowledge and skills that are owned in actual practice. So that it takes a clear and systematic standard of artistry or methods so that practicum activities can provide benefits as desired.

Formulation of deficiency solution in practicum plant physiology has been carried out by Kusrinah *et al*., (2019) with nutritional deficiency solution formula namely KNO3 (10 ml), MgSO4 (4 ml), Ca(No3)2 (10 ml), KH2PO4 (2 ml), FeDTA (2 ml), Micronutrients (2 ml), NaNo3 (20 ml), Mgcl2 (4), Na2SO4 (2 ml), NaHPO4 (2), CaCl2 (10 ml), KCl (10 ml) on 9 treatments that are complete, -P, -K, -N, -Mg, -Ca, -S, -Fe, -Micronutrients against kale (*Ipomoea aquatic*). But still not able to visualize the symptoms of nutritional deficiency in each treatment.

Harijati *et al*., (2019) formulated the following nutritional deficiency solutions Ca (1.5 ml), KNO3 (1.5 ml), MgSO4 (0.6 ml), KH2PO4 (0.03 ml), FeDTA (0.3 ml), Micronutrients (0.0.03 ml). 3 ml), NaNo3 (1.5 ml), Mgcl2 (0.6), Na2SO4 (0.6 ml), NaHPO4 (0.3), CaCl2 (1.5 ml), KCl (1.5) in 9 treatments i.e. complete, -K, -P, -N, -Ca, -S, -Fe, -Mg -Micronutrients against corn crops (*Zea mays*).

To get good results related to the conformity of theory and facts in the field on practicum activities of nutritional deficiency ingredients, research "Determination of Optimization of Malnutrition in Plant Physiology Practicum in Hydroponic Laboratory (Axis System and Without Axes)" needs to be done.

The research was conducted in the hope of a nutritional optimization procedure that can visualize symptoms and know the composition of nutrient solutions that can show signs of nutritional deficiencies in test plants.

Metode

Scope of Research

The plant used is the seed of a kale plant that is sown within 1 - 2 weeks (until the roots, stems and leaves grow. The test treatment uses three different formulas with nine treatments in each procedure and three repeats using an axis and no-axis hydroponic system. The parameters observed are leaf length, leaf width, number of leaves, plant height, and plant height (Jayasinghe, 2014).

The materials used in this study were poly tex brand sponges, net pots, flannel, aluminium foil, cling wrapping, filter paper, weigh paper, label paper, equates, KNO3, MgSO4, KCl, 7H2O, KH2PO4, Ca(NO3)2, NaNO3, MgCl2, NaH2PO4, CaCl2, H3BO3, MnCl2, 4H2O, ZnCl, CuCl2, 2H2O, Na2MoO4.2H2O, Na2SO, FeSO4.7H2O, Na2EDTA, four and water (Hardoyo et al., 2017). The kale seeds used are Bangkok kale seeds LP-1 brand red arrow stamp. Equipment used in the study included: sprayer, pH meter, lux meter, hygrometer, analytical scales, TDS meter, plastic tub, small tray, jam bottle, reagent bottle, beaker glass, spatula, measuring pipette, pi-pump, drop pipette, measuring glass, measuring gourd (Calbo and Ferreira, 2011).

Research Methods

The method used in this study is an experimental method, with the Group Random Design model using three formulas with nine kinds of treatments in each formula and three repeats. The study was conducted in July-September 2021.

Research Procedure

This research was conducted in several stages: 1) Preparation of kale seeds. 2) Setup of planting media. 3) The seedling stage. 4) Simple hydroponic manufacture of axis systems. 5) Simple hydroponic manufacture without axes. 6) Manufacture of macronutrient solution. 7) Manufacture of micronutrient solution. 8) Manufacture of Fe-EDTA solution. 9) How to treat formulas to kale plants using the axis system. 11) Treating formulas to kale plants using axis systems and 12) Data analysis techniques.

Data Collection and Data Analysis

The data were analyzed with SPSS 25 to see the effect of treatment with test parameters using ANOVA analysis and BNT advanced tests.

Results

Result of BNT/LSD test

The results of BNT further tests showed that all the formulas given had a real effect on all parameters, namely the number of leaves, leaf length, leaf width, plant height and plant height. This is indicated by the average results of the BNT test as follows the axis system, namely The Number of Leaves (8.10), Leaf Length (5.20), Leaf Width (0.77), Plant Height Increase (9.10), and Plant Height (15.20) and axis more minor system namely Number of Leaves (8.20), Leaf Length (5.03), Leaf Width (0.83), Plant Height Increase (9.97), and Plant Height (17.07). This shows that the experiment of a system without axes gave more significant results on all parameters except leaf length than the axis system.

The difference in significance level between the axis system and without the axis is influenced by the axis intermediary as a treatment solution transfer medium in each given formula. The axis system uses flannel that has a pretty good absorption. While in a system without the root-axis of the plant is submerged by the solution of the treatment given. This makes the transfer speed of the test solution different and is at the speed of metabolic processes in the axis and without axis system experiments. The results of the BNT test on formulas 1,2 and 3 trial one and trial two can be seen in table 5. The number followed by different letters in each column showed a fundamental difference according to the BNT/LSD test at the rate of 5%.

Deficiency in Kale Plants

Nutritional deficiencies in kale plants using three different formulas showed that all formulas have a deficiency impact on test plants. Experiment 2 uses a hydroponic system without axes to provide visual deficiency results and more real analysis than the 1st experiment using the axis system.

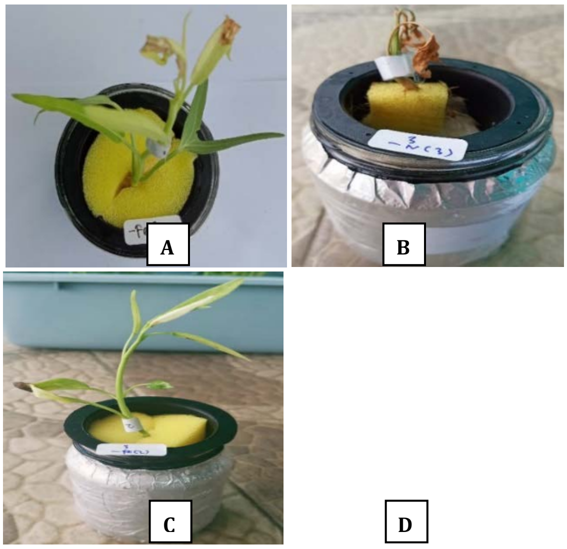

Figure 1. Symptoms of nutritional deficiency in def-fe treatment (A) Trial 1, Def-N(B) Trial 1, Def-fe(C) trial 2, Def-N(D) Trial 2

Table 1. BNT/LSD test results

Formula	Experiment	Number of Leaves	Leaf Length	Leaf Width	Increase im Plant Height	Plant Height
1		8,6 a	5,8 a	0,9 b	11,0 ac	17,3 d
2	1	8,0 a	5,0 b	0,8 c	9,0 a	14,6 d
3		7,7 a	4,8 b	0,6 c	7,3 a	13,7 d
1		9,0 a	5,6 a	0,9 b	12,2 c	19,4 d
2	2	8,2 a	5,1 a	0,9 b	10,2 c	17,4 d
3		7,4 a	4,4 b	0,7 c	7,5 a	14,4 d

Table 2. Nutrient Solution Formula 1

Solution (ml)	Treatment								
	Complete	Def-Ca	Def-S	Def-Mg	Def-K	Def-N	Def-P	Def-Fe	Micronutrient
$Ca(NO_3)_2$	1,5	-	1,5	1,5	1,5	-	1,5	1,5	1,5
KNO_3	1,5	1,5	1,5	1,5	-	-	1,5	1,5	1,5
MgSO4	0,6	0,6	-	-	0,6	0,6	0,6	0,6	0,6
KH_2PO_4	0,3	0,3	0,3	0,3	-	0,3	-	0,3	0,3
Fe EDTA	0,3	0,3	0,3	0,3	0,3	0,3	0,3	-	0,3
Mikronutrien	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	-
$NaNO_3$	-	3	-	-	1,5	-	-	-	-
$MgCl_2$	-	-	0,6	-	-	-	-	-	-
Na_2SO_4	-	-	-	0,6	-	-	-	-	-
NaH_2PO_4	-	-	-	-	0,3	-	-	-	-
$CaCl_2$	-	-	-	-	-	1,5	-	-	-
KCl	-	-	-	-	-	1,5	0,3	-	-

Table 3. Hara Solution Formula 2

Solution (ml)	Treatment								
	Complete	Def-Ca	Def-S	Def-Mg	Def-K	Def-N	Def-P	Def-Fe	Micronutrient
$Ca(NO_3)_2$	3	-	3	3	3	-	3	3	3
KNO_3	3	3	3	3	-	-	3	3	3
MgSO4	1,2	1,2	-	-	1,2	1,2	1,2	1,2	1,2
KH_2PO_4	0,6	0,6	0,6	0,6	-	0,6	-	0,6	0,6
Fe EDTA	0,6	0,6	0,6	0,6	0,6	0,6	0,6	-	0,6
Mikronutrien	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	-
$NaNO_3$	-	6	-	-	3	-	-	-	-
$MgCl_2$	-	-	1,2	-	-	-	-	-	-
Na_2SO_4	-	-	-	1,2	-	-	-	-	-
NaH_2PO_4	-	-	-	-	0,6	-	-	-	-
$CaCl_2$	-	-	-	-	-	3	-	-	-
KCl	-	-	-	-	-	3	0,6	-	-

Tabel 4. The formula of Nutrient Solution 3

Solution (ml)	Treatment								
	Complete	Def-Ca	Def-S	Def-Mg	Def-K	Def-N	Def-P	Def-Fe	Micronutrient
$Ca(NO_3)_2$	6	-	6	6	6	-	6	6	6
KNO_3	6	6	6	6	-	-	6	6	6
MgSO4	2,4	2,4	-	-	2,4	2,4	2,4	2,4	2,4
KH_2PO_4	1,2	1,2	1,2	1,2	-	1,2	-	1,2	1,2
Fe EDTA	1,2	1,2	1,2	1,2	1,2	1,2	1,2	-	1,2
Mikronutrien	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	-
$NaNO_3$	-	12	-	-	6	-	-	-	-
$MgCl_2$	-	-	2,4	-	-	-	-	-	-
Na_2SO_4	-	-	-	2,4	-	-	-	-	-
NaH_2PO_4	-	-	-	-	1,2	-	-	-	-
$CaCl_2$	-	-	-	-	-	6	-	-	-
KCl	-	-	-	-	-	6	1,2	-	-

Table 5. Light Intensity, Humidity, and Environmental Temperature Data

Day	Morning (06.30-07.00 WIB)			Afternoon (16.30 -17.00 WIB)		
	Temperature (°C)	Humidity (%)	Light Intensity (Lux)	Temperature (°C)	Moisture (%)	Light Intensity (Lux)
1	28	66	2300	31	64	900
2	29	70	2500	30	75	200
3	28	77	7400	31	72	300
4	33	67	15600	30	68	900
5	29	60	6400	30	75	200
6	29	74	5800	31	66	1500
7	35	52	7900	32	62	2500
8	28	72	7400	30	75	300
9	29	64	6400	30	59	2200
10	29	73	4600	31	64	890
11	30	65	7900	30	70	320
12	27	78	2200	29	78	1000
13	29	74	7000	30	68	800
14	30	70	2600	32	60	2200

Discussion

Nutritional deficiency is when plants lack the nutrients needed for plant growth. Each plant has its uniqueness in nutritional optimization (Silva and Uchida, 2000). The first step in identifying dietary deficiencies in plants is to describe the symptoms that arise in the plant (McCauley *et al.*, 2011). Visual observations on kale plants given formula one, formula two, and Formula three treatment using simple hydroponic methods of axis systems and simple hydroponic methods without axes show the most easily observed symptoms of leaf discolouration. This follows Wiraatmaja (2017), which explains that visual symptoms of nutritional deficiency can be seen in old leaves and young leaves (old and mature leaf blades) because leaves are the most accessible organs to observe in dietary deficiencies.

The visual symptoms of Def-Fe, Def-N, Def-Mg, aquades showed the most striking of nutritional deficiency, among other test treatments. In Def-Fe treatment, experiment one

Showed the following symptoms: a) young leaves are yellowish-green. b) on the second week, the young leaves are yellowing and pale. c) chlorosis. These symptoms follow what the hero conveys that in plants that lack the element Fe (iron), there will be chlorosis on the sidelines of young leaves and will turn yellow in severe cases. The element Fe has an essential role in plants' respiration and photosynthetic reactions. Yellow to white discolouration is caused by a decrease in chlorophyll levels in the leaves caused by Fe deficiency (McCauley *et al.*, 2011).

While in def-N treatment appears the following symptoms: a) dwarf and thin plants. b) Young and old leaves are brownish-yellow. c) Severe chlorosis to dry and die Wulandhari *et al.* (2019) Explained that plants that experience deficiency of element N experience discolouration in the leaves, namely brightly coloured young leaves and old leaves turn yellow. This is because Element N is a mobile element that can move from the old or young leaf part and provide effects to other parts of the plant when nutritional needs are not met (McCauley *et al.*, 2011). Nitrogen is an element that must be available enough in plants as a condition of plant growth and development. The availability of nutrient elements is the structure of protein-forming components, chlorophyll, eco enzyme, purines, pyrimidines, and nucleic acids. Nitrogen is available in soil in the form of elemental nitrate (NO3-) or ammonium (NH4+) (Ahanger *et al.*, 2016).

As for the def-mg treatment appears symptoms of nutritional deficiency as follows: a) plants look withered and limp. b) Plants grow elongated because the segment is elongated. c) the leaves of the bawar part are yellowed, brown and fall off. This follows Wulandhari *et al.*, (2019), which explains that the symptoms of mg elemental deficiency are yellow leaves and eventually fall. One of the main functions of Magnesium (Mg) is its involvement in photosynthesis, as Mg is the element that makes up chlorophyll (Ahanger *et al.*, 2016). Magnesium is a mobile element forming chlorophyll molecules (Silva and Uchida, 2000).

Aquades treatment is a control treatment on a series of tests. The plant is not given any nutrients in the control solution, so the plant grows dwarf, pale leaf colour. This is due to the absence of nutrients in the solution media. Plants that do not get nutrients will experience nutritional deficiencies or deficiencies.

Based on the results of observations, the three test solutions (formulas 1, 2, and 3) were able to display symptoms of nutritional deficiency in the treatment -Ca, -Mg, -S, -K, -N, -P, -Fe and - Micronutrients. But based on the BNT recap results table, experiment 2 using a hydroponic system without axes gave a higher calculation rate than experiment 1 on leaf number, leaf width, plant height, and plant height. While on the length of the leaves of experiment 1 using a higher axis hydroponic system. This is due to the absorption of nutrient deficiencies in systems without axis more than axis system, through the intermediary of the axis assistance for the transfer of nutrients from solution media. Roots in plant systems without axes will absorb directly the deficiency nutrients that exist so that it more quickly gives rise to visual symptoms of deficiency.

The comparison of formula 1 test parameter measurements showed that the parameters of leaf count, plant height, and plant height without axes gave more significant effects. While on the leaves' length and the leaves' width. While in formula two, the hydroponic system without axes gave effective results compared to the axis system in all test parameters, including the number of leaves, leaf length, leaf width, plant height accretion, and plant height.

The measurement results showed that the axis system showed significant leaf width, plant height, and plant height in formula three. While in both parameters, namely the number of leaves and the length of the leaves, the measurements using the axis system are more significant. The experiments showed that the three formulas given were able to show the results of nutritional deficiencies. Nevertheless, several points must be considered in the working procedure of practicum nutritional deficiency in kale plants.

Before implementing the practicum, the thing that must be considered is that the kale plant used must be taken entirely from the seeds/seeds, then sown first, so that kale plants have a uniform age and the same treatment. The problem/failure experienced by the previous practicum is because the sample of kale plants does not come from seeds. Still, the practice of bringing kale plants is ready to harvest and comes from different places so that the condition of kale plants has a treatment and age is not uniform. This causes symptoms of nutrient defiance in kale plants not seen in previous practices.

Conclusion

The results of different accurate tests showed that the formula of nutrient solutions 1, 2 and 3 had a natural effect on all test parameters. The parameters, namely, leaf length, leaf width, plant height, plant height, and several leaves, while based on visual symptoms that appeared, hydroponic systems without axes were better able to display symptoms than axis systems.

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Declaration Statement

The authors reported no potential conflict of interest.

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