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Response of hydroponic curly endive to applications of macronutrients via drip irrigation

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Abstract

Hydroponic technique is currently becoming popular for vegetable production due to efficient resources management and quality food production. The objective of this study was to determine plant growth and development of hydroponic curly endive responding to applications of macronutrients (N, K, Ca, Mg and S) via drip irrigation. The experiment was conducted in a net house, with three different macronutrient concentrations (low: N1, medium: N2 and high: N3). Endive lettuce seedings with 2–3 leave were grown in mixed substrate of sand and coconut filer (1:1 v/v), and fed by N1, N2 and N3 concentrations for 25 days via drip irrigation. The curly endive achieved the highest yield in N2 treatment, providing sufficient level for plant growth, whereas the lower concentration of macronutrient provided longer leave, but less leaf number per plant. The optimize macronutrient concentration provides a better productivity.

Keywords: hydroponics, drip irrigation, lettuce, soilless culture and vegetable.

Introduction

Hydroponic technique is currently becoming popular for vegetable production because of efficient resources management and quality food production (Sonneveld and Voogt 2009). It is also applied to avoid some challenges of soil based agriculture such as urbanization, natural disaster, climate change, indiscriminate use of chemicals and pesticides which is depleting the soil fertility (Sonneveld and Voogt 2009; Sharma et al. 2018).

There are 16 elements are carbon (C), hydrogen (H), oxygen (O), phosphorus (P), potassium (K), nitrogen (N), sulfur (S), calcium (Ca), iron (Fe), magnesium (Mg), boron (B), manganese (Mn), copper (Cu), zinc (Zn), molybdenum (Mo), and chlorine (Cl) are required by plants for growth, and these nutrients can be supplied from air, water, and fertilizers. In hydroponic crops, nutrients play an important role in the quality and productivity of leafy vegetables (Sublett et al. 2018). High nutrient concentrations cause ion toxicity, nutrient imbalance and osmotic stress, and low nutrient concentrations lead to nutrient deficiencies (Fallovo et al. 2009). Thus, providing all the nutrients to the plant needs is one of the basic principles for vegetable production in hydroponic system (Sonneveld and Voogt 2009; Nozzi et al. 2018). There are different fertilizers can be mixed to make hydroponics nutrients solution (e.g. Coston 1983; Parks and Murray 2011).

Previous studies have focused on nitrogen (N) (Schenk 1996; Gent 2002; Shariffi and Zebarth 2006; Cometti et al. 2011) with less consideration on other macronutrients such as phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S).

The objective of this study was to determine plant growth and development of hydroponic curly endive responding to applications of macronutrients (i.e. N, K, S, Ca and Mg) via drip irrigation.

When fertilizers are applied to meet crop needs, benefits in terms of productivity and profitability may result (Mattson and Van Iersel. 2011).

Methods

Plant materials and culture condition

The experiment took place in the University of Battambang, Cambodia (13° 5' 6.95" N, 103° 13' 15.25" E), inside a net house (size – length: 20 m, wide: 10 m, high: 4 m) from May 14th to June 27th , 2012. The net house was full covered by sun shad nets (green net, shad rate: ≅50%); and transparent plastic was sub-covered at 2 m high to control rain (Fig. 2). Seeds of Curly Endive were produced by Choke Kasikorn Seed Co. Ltd, Thailand (purity: 98%, germination rate: 80%, moisture: 8%), were sown on trays containing mixed soil and manure (2:1) then kept them under the net house and watering twice a day. Gravel (particle size: 2 – 4 mm) and coconut fiber were mixed and used as a substrate (1:1, v/v) and filled into 72 plastic bags (diameter: 12 cm * high: 18 cm). Endive seedlings were transplanted in the bags when seedlings were 15 days old.

Light and temperature during growing condition were measured at 08:00, 12:00 and 17:00 (Table 1). The drip system was selected for this experiment because it is suitable for almost all varieties of vegetable crops, three drip systems were manipulated for the experiment; (Srean, 2009). The drip system was installed by three main pipes (diameter: 4.9 cm) connecting to a solution tank and micro pipes (Ø: 2mm) connecting to the main pipes to feed the plants (Fig. 1).

Table 1: Light intensity and temperature during the experiment (mean ± SD).

Time	Light intensity (Lux)	Temperature (ºC)
08:00	16,055 ± 550	27.0 ± 1.00
12:00	21,252 ± 1951	36.2 ± 0.84
17:00	16,634 ± 1660	30.4 ± 1.14

Experimental design and data analysis

The experiment followed a completely randomized design, with three treatments of macronutrients and representative by thirty-six plants for each treatment (Fig. 1). A nutrient solution containing 0.20‰ P2O5, 0.50 ppm Zn, 0.25 ppm Fe, 0.50 ppm Cu, 0.25 ppm Mn, and 0.20 ppm B, and plus three different rates of macronutrients (i.e. N, K, S, Ca and Mg) were determined for the treatments; the detail nutrient solution of each treatment are present in Table 2. Chemicals such as K2SO4, CaSO4, Mg(NO3)2 were used to make the three different macronutrient concentrations for each treatment, i.e. N1, N2 and N3. The nutrient solution were made and put in the nutrient tanks separately (Fig. 1); the solution was stirred before fed plants via drip irrigation for 15 minutes triple a day at 08:00, 12:00 or 17:00.

Table 2: Detail of the macronutrient concentrations of the three different concentrations.

Macronutrients	Treatment		
	N1 (‰)	N2 (‰)	N3 (‰)
N	17	34	51
K	25	50	75
Ca	23	46	69
Mg	14	28	42
S	38	76	114

Leaf numbers and leaf length were measured at every five days after transplanting. At the end of the experiment at 25 days of culture period, ten out of the thirty-six plants were selected randomly from each treatment to determine the leaf numbers, leaf length, root and shoot fresh-weight. The root and shoot of the plants were dried at 85 °C in a hot air oven (Model 500; Memmert, Buchenbach, Germany) for 48 h then incubated in desiccators before measurement of their dry-weight.

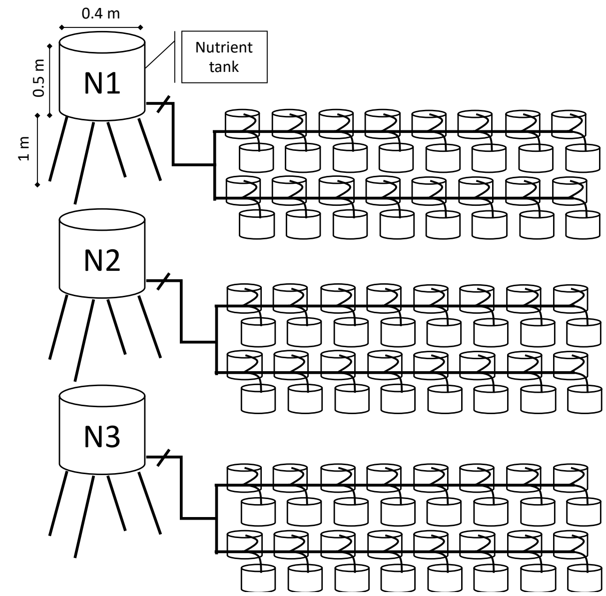

Fig. 1: Layout of experimental design for hydroponic curly endive, with drip systems of three different nutrient concentrations, N1, N2 and N3 are nutrient tanks.

For comparison of means of multiple groups or treatments, the analysis of variance (ANOVA), the Kruskal–Wallis test, or the multiple comparison test of Tukey's least significant difference ($\alpha = 0.05$) was used. All statistical analyses were performed with the R statistical software, version 3.3.3 (R Core Team 2017).

Results

All the plants in each treatment no one death was observed within 25 days of the experiment (Fig. 2).

Fig. 2: The response of hydroponic curly endive to applications of macronutrients (N, K, S, Ca and Mg) via drip irrigation at day 18 after transplanting.

ANOVA indicated that: the number of leave per plant in the N3 treatment was significantly greater the others over the last 15 days of the experiment period, whereas leaf length in the N1 treatment was longer than the other treatments (Fig. 3). Both the dry and fresh weights of plant shoot in N2 and N3 were better than those in N1 (Fig. 4a & c). For the root per plant, fresh weight was better in N2 and N3 treatments, the dry weight was the greatest in N2 treatment (Fig. 4b & d).

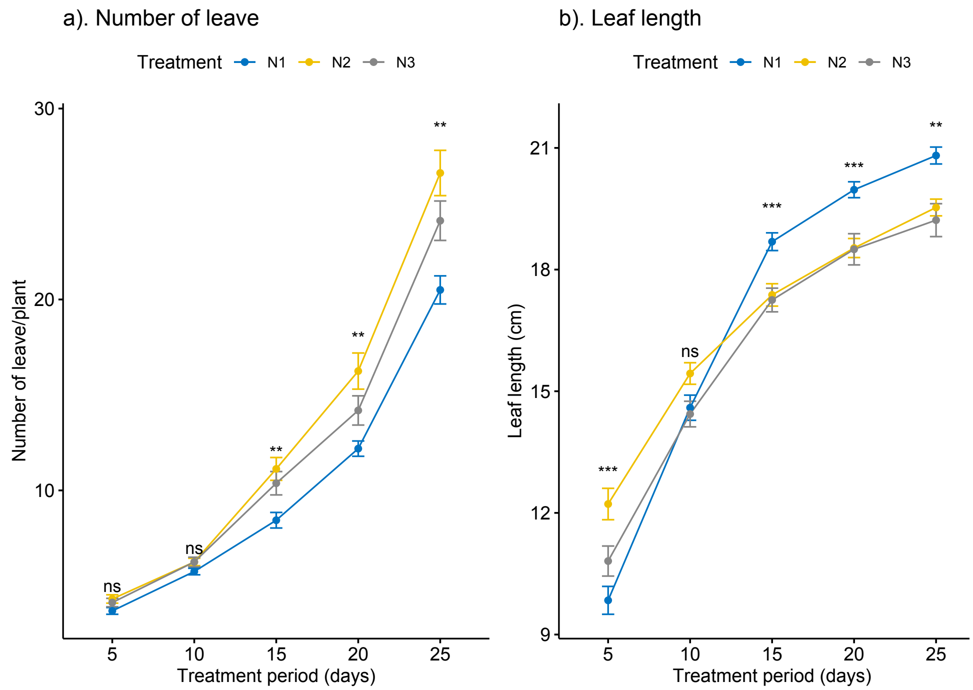

Fig. 3: Effect of macronutrient concentration rates on leaf development (a) and leaf growth (b) in hydroponically grown endives (n = 10; $\bar{X} \pm$ SE).

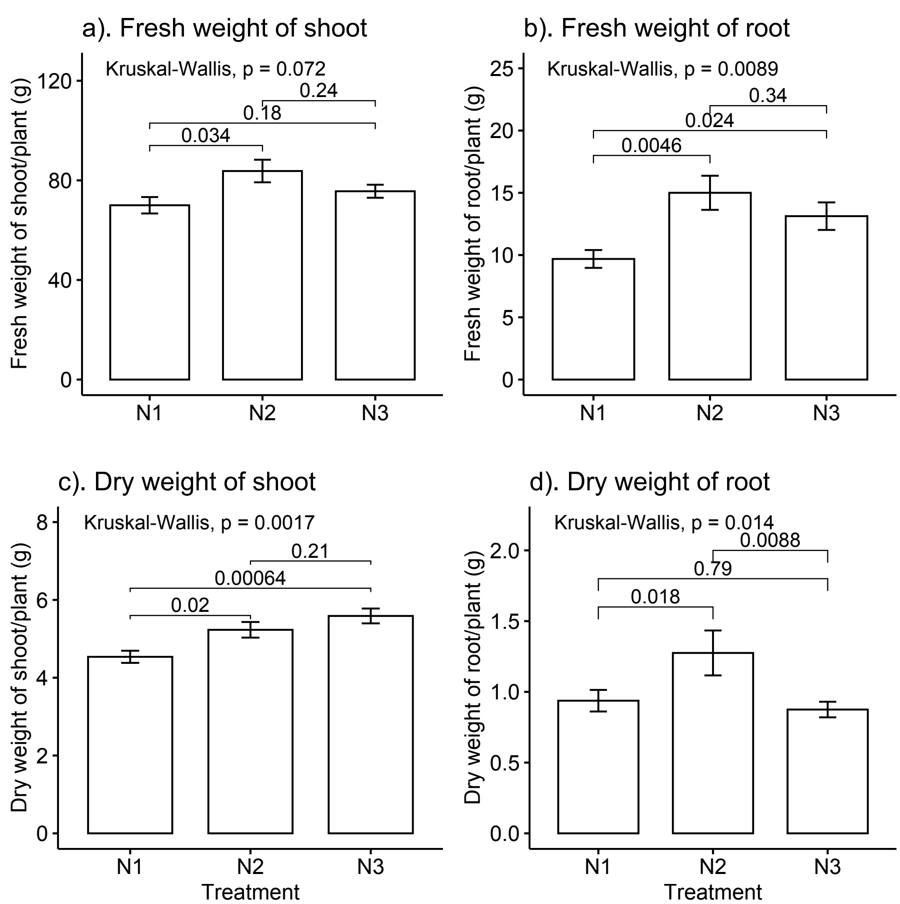

Fig. 4: Effect of macronutrient concentration rates on plant growth and development of hydroponic curly endive at 25 days after transplanting (n = 10; $\bar{X} \pm$ SE).

Discussion

Our measurements suggests that the leaf growth is better in lower concentration of the macronutrient, whereas leaf development was best in neither low nor high concentration. Eighter low or high concentrations of macronutrients restrict the growth and development of plant shoot and root. The main abiotic stresses affecting plant growth and development is salinity (Choi and Lee 2001; Tzortzakis 2010). Salinity affects carbon fixation reduction due to specific ions toxicity (Niu et al. 1995); and photosynthesis restriction due to partial stomata closure, waste of energy in the processes of osmotic adaptation and ion exclusion (Pasternak 1987). In hydroponic lettuce, the demand for N, P and K declines with plant age, whereas Ca, Mg and S were absorbed at constant rates throughout the crop cycle (Albornoz and Lieth 2016). Plant growth and ultimately quality and yield can be reduced, when nutrient supply is not sufficient to meet demand; or economic losses when nutrient applications in excess of plant demand (Grattan and Grieve 1999; Mattson and Van Iersel. 2011).

Overall, these findings suggest that a proper management of the optimize macronutrient concentration provides a better growth condition to improve plant growth and development in hydroponically grown endives.

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