Effect of Population Density and Water Substrate Interface of Growth and Yield Red Lettuce

by Susilawati Susilawati

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Effect of Population Density and Water Substrate Interface of Growth and Yield Red Lettuce

Muhammad Riyan Hidayah[1], Susilawati Susilawati*[2], Suwandi Suwandi[3], Benyamin Lakitan[2,4]

[1]*Master Program in Agriculture Science, Faculty of Agriculture, Sriwijaya University, Jalan Padang Selasa 524, Palembang, South Sumatra 30139, Indonesia.*
[2]*Department of Agronomy, Faculty of Agriculture, Sriwijaya University. Jalan Raya Palembang-Prabumulih km 32, Indralaya, Indonesia.*
[3]*Department of Plant Pests and Diseases, Faculty of Agriculture, Sriwijaya University. Jalan Raya Palembang-Prabumulih km 32, Indralaya, Indonesia.*
[4]*Research Center for Sub-optimal Lands (PUR-PLSO), Universitas Sriwijaya, Palembang, 30139, Indonesia*

*Corresponding author

E-mail address: susilawati@fp.unsri.ac.id (Susilawati Susilawati).
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Abstract

One of the green leafy vegetable plants that have good value and content for consumers is lettuce. Red lettuce (Lactuca sativa Var. Red rapids) is a type of leaf lettuce, this type of lettuce has leaves that are red, wide, thin, and clustered and look curly. Efforts to get maximum crop yields are by regulating plant populations so that they are efficient. This study aims to determine the effect of population and water level on the growth and yield of red lettuce. The method used in this study was a factorial randomized block design. The main factor was the population (P), which consisted of 3 treatments, namely 1 plant/pot (P1), 2 plants/pot (P2,) and 3 plants/pot (P3). The second factor was the water substrate interface (WSI), which consisted of 3 treatments, namely 1 cm (WSI1), 2 cm (WSI2), and 6 cm (WSI3). The results showed that red lettuce gave a different response to each population. (P2) produces the highest average number of plant leaves, this shows that plants with a population of 2 plants/pot are quite efficient in utilizing space so that plants grow well, characterized by a higher number and leaf area. The water interface contact area with a depth of 6 cm produces a root length value that is smaller than 1 cm and 3 cm. In a state of water saturation, roots cannot develop properly so that root growth becomes stunted.

Keywords: red lettuce, population, water substrate interface (WSI)

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1. Introduction

The global climate has a negative impact on fluctuations in water levels in wetlands. In the rainy season, the water level in the marshland increases so that it cannot be utilized optimally for agricultural production. Therefore, it is necessary to make relevant efforts to increase agricultural production in pond land during the rainy season [1]. One of the efforts that can be done is floating plant cultivation. Floating cultivation can be carried out using a raft made of plastic bottles so that the height of the water level can be adjusted in such a way as the needs of the plant [2].

In general, farmer's plant rice in the first season, then after harvest, there is an opportunity to plant a second rice or horticultural crop. Swamp pond farmers generally grow vegetables only to meet their own needs or for social purposes such as being distributed to neighbors. Only a small percentage of farmers sell their vegetable crops [3]. Choosing the right type of vegetable is one of the keys to creasing production yields. Currently, one type of plant that is quite popular with the public is lettuce. Lettuce is used as a complementary vegetable eaten raw, in salads, and served in a wide variety of dishes [4].

The red lettuce plant has benefits as a vegetable plant that has good nutritional content. Lettuce contains minerals such as calcium, iron, magnesium, phosphorus, potassium, and many others [5]. In addition, red lettuce also has benefits for the treatment of various types of diseases because it has anthocyanin pigments which are useful as antidotes to free radicals that damage body cells [6]. In addition to its fairly high selling price, lettuce plants have a fairly short life cycle between 40 - 60 day after transplanting.

One is an effort to get maximum crop yields, by regulating plant populations to a certain extent. Populations can make efficient use of their growing environment and also influence competition among plants in using nutrients [7].

Based on the description above, it is necessary to conduct research to improve the use of wetlands as optimal agricultural land. The research was conducted on the growth of red lettuce plants against different plant population settings and water substrate interface levels.

2. Materials and Methods

2.1 Materials

This study uses a pot (height of 20 cm, top diameter of 30 cm, and bottom diameter of 25 cm), a research pool with a size of 4x2 m ether, floating (raft 2x1 meters, plastic house, (SPAD), Soil Moisture meter, analytical balance sheet, and oven. The materials that will be used in the study are soil, NPK fertilizer, red lettuce seeds (Red rapid) kasgot fertilizer (pH 6.92, N total 1.86%, P2O5 3548.68 mg/100g, K2O 1674.05 mg/100g, Mg 1133.87 mg/100g, Cu 15.58 ppm, Zn 40.21 ppm, and Mn 23.10 ppm) [8] and manure.

2.2 Data Collection

Leaf width was conducted menggunakan sampel daun terlebar pada masing-masing tanaman per populasi. SPAD leaves were measured using a chlorophyll meter (Konika Minolta SPAD-502Plus). Leaf area was measured using LIA for Win32 by Kazukiyo Yamamoto (Nagoya University).

Measurement of the dry weight of plant materials was done after materials were dried in an oven at 70o C for 48 hours. At harvest, data on some important traits were recorded including root length, fresh and dry weight of root, and total fresh weight.

2.3 Experimental design and statistical analysis

This research uses a Factorial Group Randomized Design consisting of 2 factors, namely population and water level. The main factor is the population (P), which consists of 3 treatments i.e., 1 plant/pot (P 1), 2 plants/pot (P 2), and 3 plants/pots (P3). The second factor is the height of the water substrate interface level (WSI), which consists of 3 treatments, namely 1 cm (WSI 1), 2 cm (WSI 2), and 6 cm (WSI 3). Each combination of treatments consists of 5 repetitions so there are in total 45 experimental units.

Collected data were subjected to ANOVA using SAS 9.0 statistical analysis software (SAS Institute Inc., Cary, North Carolina, US). Significant differences between treatments were tested using the least significant difference (LSD) test at $P \leq 0.05$.

3. Results and Discussion

Based on the results of the study showed that the number of lettuce plant leaves continued to increase until 31 days after transplanting in all populations. However, a population of 2 plants per pot showed a higher number of leaves than populations 1 and 2. This shows that a population of 2 plants per pot is more efficient in the cultivation of lettuce plants. Furthermore, there was no significant difference in the high treatment of water substrate interface (WSI) level. But interestingly the number of leaves of lettuce plants with a water substrate interface (WSI) level of 5 cm indicates a higher number of leaves (**figure 1**). This shows that plants with a water susbtrate interface (WSI) level of 5 cm due to getting sufficient water are met.

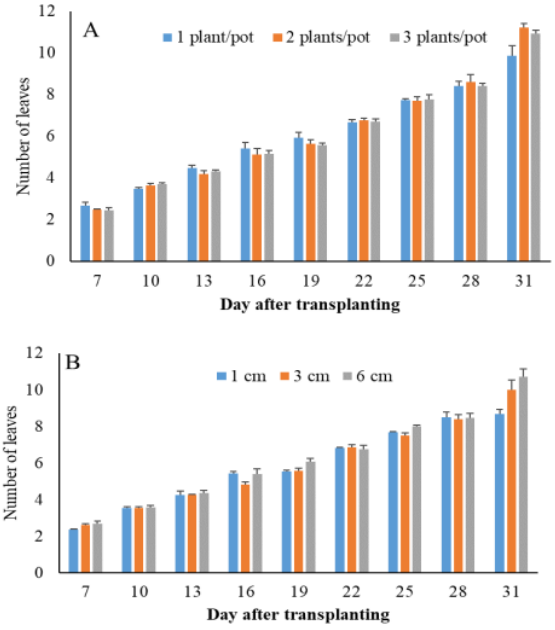

Figure 1. The number of red lettuce leaves influenced by different plant populations (A) and water levels (B).

Population density with 2 plants per pot results in longer leaves (figure 2) and width (figure 3). This suggests that plants planted with 2 plant populations per pot produce higher leaf area values than populations 1 and 3. Unlike population 3 which shows a

smaller leaf area, this is because leaf growth will be hampered if there is not enough space for growth.

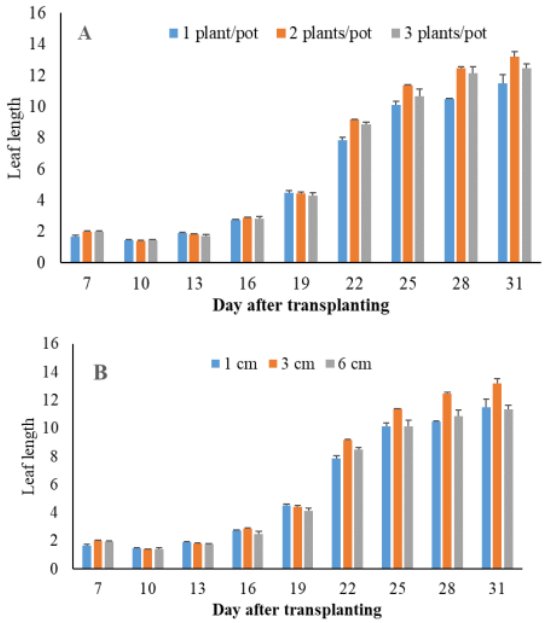

Figure 2. The length of red lettuce leaves is influenced by different plant populations (A) and water levels (B).

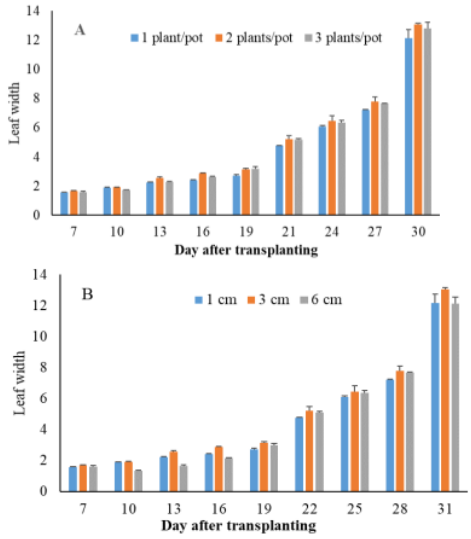

Figure 3. The width of red lettuce leaves is influenced by different plant populations (A) and water levels (B).

SPAD

Population density affects the SPAD value of red lettuce, this is indicated by the SPAD value in populations with 1 plant per pot higher (**figure 4**). This relates to the broad leaves of the lettuce plant. Plants that have wider leaves result in more capturing sunlight, this helps in the formation of chlorophyll in the leaves. Therefore, plants with a population of 1 plant per pot have a higher SPAD value.

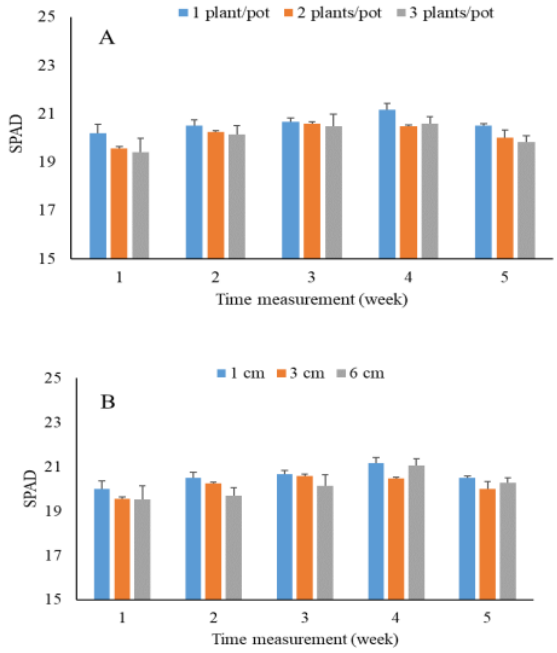

Figure 4. SPAD value of red lettuce is influenced by different plant populations (A) and water levels (B).

Yields

Based on the results of the 5% LSD advanced test, it shows that the influence of plant population treatment has a significant effect on the number of leaves, leaf length, leaf area, and SPAD value. Population regulation affects competition in the absorption of nutrients, water, and sunlight. Therefore, plants with a population of 3 plants per pot show low yields including the number of leaves (Table 1), fresh weight, and dry weight of the plant (Table 2), this is due to the little space for plants to grow.

Table 2. Effect of population and water level on the fresh and dried weight of plants, fresh weight, and root length

	Total weight of the population (g)		Average Fresh weight per plant(g)		Dry weight per plant (g)		Fresh weight of roots (g)		Root length (cm)	
1 plant/pot	36.82	a	30.85	b	2.23	b	6.35	b	22.00	a
2 plant/pot	40.97	a	29.28	b	2.21	b	7.97	b	20.56	ab
3 plant/pot	54.39	b	16.00	a	1.25	a	4.24	a	17.73	b
LSD	14.66		10.90		0.64		2.07		3.55	
WSI 1cm	42.15	a	29.20	a	2.16	a	6.80	a	22.37	a
WSI 3cm	50.60	a	23.51	a	1.72	a	5.78	a	18.15	b
WSI 6cm	39.43	a	23.42	a	1.81	a	5.98	a	19.77	ab
LSD	tn		tn		tn		tn		3.55	

Description: Average numbers with the same letter in the same column, indicating no noticeable difference based on 5% BNT

Discussion

The influence of population on the growth and yield of red lettuce plants

Plant density can be interpreted as the number of plants contained in units of land area [9]. Based on the results of the study showed that red lettuce plants gave different responses to each population. P2 produces the highest average number of plant leaves, this shows that plants with a population of 2 plants/pot are quite efficient in utilizing space so that plants grow well, characterized by a higher number and area of leaves. Purple pakchoi gives optimal results on a population of 1-2 plants per pot with a pot [10].

Plant population is closely related to crop yield. Each plant will compete for water or light, wide planting distances tend to spur plant vegetative growth [11]. The tighter the population of a plant, the higher the level of competition between plants to get sunlight, nutrients, and a good growing space for plants [12]. Plants that shade each other will affect the process of photosynthesis which results in the canopy growing small and the capacity to take nutrients and water being reduced. The optimal population can form a normal root system and maintain a good plant canopy shape by utilizing sunlight for the photosynthesis process so that the needs of lettuce life are met [13]. The higher density level makes it difficult for the canopy to develop and get sunlight [14]. Nascimento et al [15] mentioned row space of 0.20 increased the production of lettuce.

The components of the header include the stem and leaves. The population of 3 plants per pot results in the highest total plant weight. This is the result of the accumulation of each plant. But interestingly the average fresh weight per plant in population 3 is lower. This suggests that plants planted with 3 populations per pot tend to stunt growth. Whereas 1 population per pot is not significantly different from 2 populations/pots. This suggests that 2 plants are more effective if they are grown in one pot. This means that the accumulation of photosynthesis results and nutrient absorption is distributed to the plant canopy.

Root length is related to the root system's ability to absorb water and nutrients. The tighter the population causes the distance to grow the roots tighter, which makes the roots difficult to develop [16]. Inhibition of root growth also results in water absorption and nutrients being depleted. Limited root development results in stunted header growth. The value of the fresh weight of the root relates to the ability of the roots to absorb water. Roots that have a low fresh weight value indicate that root growth tends to be long and thin. Root development is good when supported by soil structure in good condition, and appropriate planting distances [17]. If the number of roots in the plant is large, it will support the growth of the plant itself, because basically, the root is one of the plant organs used to store water and biomass from the soil that is distributed to plants for metabolic processes [18].

Effect of high water level on the growth of red lettuce

The height of the water level is related to the availability of water in the growing medium. The availability of water in plants is very important because excess or less water will adversely affect plant growth [19].

The water substrate interface (WSI) or water surface contact area is a condition of water saturation that occurs in the lower layer of the substrate. In this study, the height of WSI used as a treatment was 1 cm, 3 cm, and 6 cm. Jaya et al. [2] mentioned in their research that although it only occupies a relatively shallow/thin layer of planting media, saturation conditions limit the oxygen diffusion of the plant root zone. In conditions of saturation, the pores of the water in the planting medium are partially filled with water which causes limited oxygen availability. Most vegetable crops are reported to be sensitive to hypoxic conditions, including lettuce plants[20], [21], [22].

WSI affects the growth of the roots of red lettuce plants. The water interchange touch-field with a depth of 6 cm produces a smaller root length value compared to 1 cm and 3 cm. This is a natural phenomenon carried out by the roots. In a water-saturated

state, the roots cannot develop completely so that root growth becomes stunted [23]. Inhibition of root growth will cause the growth of the header to also be inhibited. This is because the root is an organ that channels water and nutrients to canopy organs such as the stems and leaves of plants. Abundant rooting and being able to penetrate the deep soil layer will provide opportunities for plants to absorb more nutrient [24].

4. Conclusion

Red lettuce plants can survive water stress conditions for a certain period. Cultivating red lettuce plants with a population of 2 plants/pot is more efficient than 1 plant/pot and 3 plants/pot.

5. Acknowledgement

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