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Growth and Flowering Response of Cut Chrysanthemum under Root Restriction to Plant Density Grown in Soilless Culture

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ABSTRACT

The influence of plant density on the growthand flowering of cut chrysanthemum in soilless culture under root restricted condition was investigated. Two varieties of cut chrysanthemum "New White" and "New Yellow" were grown in seedling tray in coconut peat media. Plants were arrangedat three different plant densities namely 64, 81 and 99 plants m^2. There were no significant differences for leaf area, leaf length, number of internode and stem diameter between the three plant densities. However, 'New Yellow' had significantly more number of inter nodes than 'New White'.Plant density affected to leaf area index (LAI) and pedicel length. Plants grown at 81 plants m^{-2}had higher LAI of 2.76 than at 64 plants m^{-2} of 2.28.Pedicel length of plant density of 99 plants m^{-2} was longer than of 64 plants $m^{-2}$by 18.33%. There was interaction effect between variety and plant density on number of leaf. Number of leaf tended to decrease when plant densities increase for varieties 'New White'. No significant differences were observed between the two varieties and three plant densities on root length, root surface area, root diameter, root volume and root shoot ratio. Chlorophyll a, chlorophyll b and total chlorophyll were not significantly affected by varieties and plant densities. Stem fresh weight and total dry weight did not differ between the three plant densities. Plant densities did not significantly affect to photosynthesis, transpiration, stomatal conductance, Fv/Fm. Accumulation of proline was not significant difference between the three plant densities. Chrysanthemum grown at 99 m^{-2}had the tallest plant of 61.28 cm although it was not significantly different from the other two plant densities. Plant densities did not significantly affect to dayto flowering, number of flowers, flower diameter, inflorescence diameter,flowercolor and vase life. These results indicated that under root restriction, chrysanthemum can be grown up to99 plants m^2.

Keywords: Soilless culture, Hydoponics, ornamental.

INTRODUCTION

Chrysanthemum is one of the most popularcut flowers in the world. Commercial production of this plant is still predominantly in soil which faced many problems such as soil degradation and accumulation of soil born disease Cut chrysanthemum production in soilless system have been triedmore than three decades ago [17].However, the higher cost productionis a problem [18]. Manipulation plant density can be an option to decrease cost production of soilless culture by increasing the productivity. However, changing plant density affected to growth and flower qualityof chrysanthemum due to available light per plant [9]. Many studies were carried out and the results were varied. Huld and Andersson [6] reported that plant height and leaf area index of chrysanthemum grown at 83 plants $m^{-2}$was higher than at 125 plantsm^{-2}. In contrast, Kahar and Mahmud [7] found that plant height of chrysanthemum grown at 44 plant m^{-2} did not differ significantly from 104 plants m^{-2}. Langton *et al*., [9] also reported that chrysanthemum height did not increase with increasing plant density.Carvalho*et al*., [2] reported that number of flowers decreased from 33 flowers to 9 flowers when plant density increased from 32 plants m^{-2} to 80 plants m^{-2} with 45% light intensity. Spray diameter and number of flower bud

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decreased significantly when plant density increased from 44 plants m^{-2} to 104 plants m^{-2} while vase life was not affected [7].

Light intensity and light duration were the important factors that influence growth at different density. Carvalho*et al*., [3] reported that combinations of plant density and duration of long-day can offer similar total fresh mass of chrysanthemum without effect to flower size or number of flower. Accordingly, Lee *et al*., [10] reported that increased light level and plant density increased dry mass of chrysanthemum per square meter and final leaf area index. Chrysanthemum had variation response to plant density. The effect of plant density on growthof chrysanthemum in substrate culture has not been studied widely.

Objective:

This experiment investigated effect of plant density on growth and flowering response of chrysanthemum grown in restricted root condition.

Materials and Methods

The experiment was carried out at the Malaysia Agricultural Research and Development Station (MARDI), Cameron Highland, Pahang, Malaysia from August 2013 – January 2014 in a shade house with average temperature of 34° C and relative humidity of 47.08%. Rooted cuttings of chrysanthemumcv 'New White' and 'New yellow' were grown in seedling tray (Bumnong, Korea), each hole cancontain coconut peat of 140 ml. Six seedling trays were used for 1 m^2.Plants were arranged in seedling tray with three different densities at 64, 81, and 99 plants m^{-2} in a random complete block design with 4 replications.

Plants were irrigated by drip irrigation system via drip emitter 6 times per day with nutrient solution containing N 200, P 30, K 200, Ca 150, Mg 50, Fe 1.05, Mn 0.58, Zn 0.35, B 1, Cu 0.05 and Mo 0.05 mg/L. The electric conductivity (EC) was maintained at 1.3-1.5 mS $cm^{-1}$and pH was kept between 5.5 – 6.5. Night interruption from incandescent lamp (Phillip, 100 w) was given from 11.00 pm - 3.00 am after transplantinguntil 8 weeks.

Plant height,stem diameter, total leaf area and root lengthwere measuredevery two weeks. Total leaf area was measureby leaf area meter (Licor, USA). Fresh root samples were washed and root morphology was determined by WINRHIZO program. Leaf area index (LAI) was measured by plant canopy analyzer LAI-2200 (Licor, USA). Plant samples were separated and then dried in oven at 70°c for 48 hours. Dry weight of leaf, stem, root and flower were record.

Chlorophyll content was determined by method of Coombs [5].Four leaf discs 1 cm^2 from fully expand leaf were put in 10 ml of 80% acetone. Samples were kept in dark condition for 72 hours to extract chlorophyll from tissue. Absorbance of extraction were measured by spectrophotometer (Shimazu, Japan) at wavelength 664 and 647 nm. Chlorophyll a, b and total chlorophyll content were calculated from Coombs method (Coombs *et al.*, 1987) Chlorophyll a (mg cm^{-2}) = 13.19 A_{664} - 2.57 A_{647} , Chlorophyll b (mg cm^{-2}) = 22.10 A_{647} - 5.26 A_{664} and Total chlorophyll content (mg cm^{-2})

$$\frac{3.5 \times (ChlorophyllA + ChlorophyllB)}{4}$$

Ten fully expanded leaves from the apex of plant sample were dried in oven and grinded. Dried samples were digested. Nutrient concentration was determined by autoanalyzer (Quickchem, USA) and atomic absorption spectrophotometer (PerkinElmer,USA)

The time to produce flower bud was observed when bud diameter was larger than 0.3 cm. At harvesting, shoot fresh weight, number of flower, flower diameter, inflorescence diameter, number of petal and pedicel length were determined. The color of the petals were measured by Chromameter (Konica Minolta,Japan). Two plant samples per plot were cut at length 30 cm and putin distilled water 300 ml to observed vase life. The Analysis of variance was implemented by SAS statistical package at significance level $p<0.05$. Meanswere compared byTukey'stest.

Results:

As shown in Table 1, there were no significant differences for leaf area, leaf length, leaf thickness and leaf area index between two varieties of chrysanthemum. Chrysanthemum grown at 64 plant m^{-2} had highest leaf area of 258.12 cm^2, leaf length of 7.39 cm and leaf thickness of 33.33 μm but the differences were not significant. Plant density significantly affected to leaf area index. Increasing plant density tended to increase leaf area index (LAI). Plants grown at 81 plant m^{-2} had LAI of 2.76 which was significantly higher than 64 plant m^{-2} of 2.28.

The number of internode was significant affected by variety. Chrysanthemum 'New Yellow' had number of internode of 29.83 significantly higher than 'New White'of 26.25 (Table 2). However, number of internode and stem diameter of chrysanthemum in this experiment were not significantly different between the plant density. Plant density significantly affected to pedicle length, pedicle length of plants grown at 99 plant m^{-2} was longer than of 64 plant m^{-2} by 18.33%.

Table 1: Leaf area, leaf length, leaf thickness and leaf area index of chrysanthemum as affected by variety and plant density under soilless culture.

Treatments	Leaf area (cm^2)	Leaf length (cm)	Leaf thickness (μm)	Leaf area index
Variety				
New White	223.01 a	6.97 a	31.83 a	2.58 a
New Yellow	251.43 a	7.46 a	31.54 a	2.57 a
Plant density				
64 plant m^{-2}	258.12 a	7.39 a	33.44 a	2.28 b
81 plant m^{-2}	226.58 a	6.96 a	28.75 a	2.76 a
99 plant m^{-2}	226.96 a	7.30 a	32.88 a	2.69 ab
Variety (V)	ns	ns	ns	ns
Plant density (P)	ns	ns	ns	0.05
VxP	ns	ns	ns	ns

Means followed by the same letter are not significantly different at p≤0.05 by Tukey's test ns=nonsignificant

Table 2: Number of internode, stem diameter and pedicle length of chrysanthemum as affected by variety and plant density under soilless culture.

Treatments	Number of Internode	Stem diameter (cm)	Pedicle length (cm)
Variety			
New White	26.25 b	0.39 a	7.07 a
New Yellow	29.83 a	0.40 a	6.79 a
Plant density			
64 plant m^{-2}	27.38 a	0.40 a	6.15 b
81 plant m^{-2}	27.88 a	0.38 a	7.14 ab
99 plant m^{-2}	28.88 a	0.40 a	7.50 a
Variety (V)	0.05	ns	ns
Plant density (P)	ns	ns	0.05
VxP	ns	ns	ns

Means followed by the same letter are not significantly different at p≤0.05 by Tukey's test ns=nonsignificant

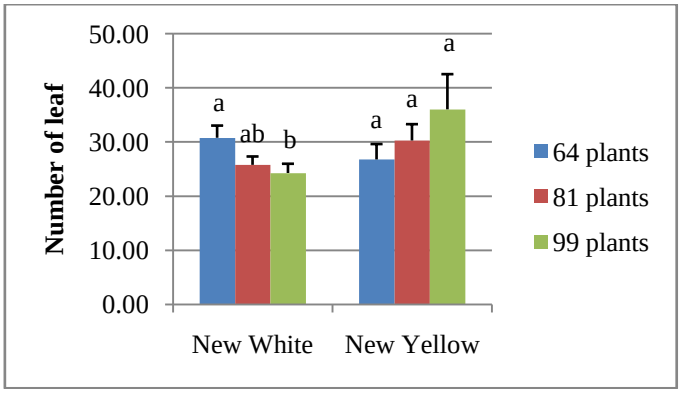

Fig. 1: Interaction effect of variety and plant density on number of leaf of chrysanthemum.

There was interaction effect between variety and plant density on number of leaf (Fig. 1). The number of leaf tended to decrease when plant density increased for variety 'New White'. In contrast to 'New Yellow', the number of leaf tended to increase with increasing plant density but there was no significant different. The highest number of leaf was recorded in chrysanthemum 'New Yellow' grown at 99 plant m^{-2} of 36 leaves.

No significant differences were observed between variety and plant density on root length, root surface area, root diameter, root volume and root shoot ratio (Table 3). The longest root length of 633.69 cm was observed in chrysanthemum grown at 99 plant m^{-2} and highest root surface area was exhibited in 81 plant m^{-2}. The highest root diameter was recorded at the plant density of 64 plant m^{-2}.

Root diameter, epidermis, cortex, and stele of root also did not show any differences between variety and plant density (Table 4). Chrysanthemum grown at 99 plant m^{-2} had highest root diameter of 65.75 μm, root cortex of 20 μm and stele of 19.50 μm. Plants grown at 64 plant m^{-2} showed highest root epidermis thickness of 2.75 μm.

Table 3: Root length, root surface area, root diameter root volume and root:shoot ratio of chrysanthemum as affected by variety and plant density under soilless culture.

Treatments	Root length (cm)	Root surface area (cm^2)	Root diameter (mm)	Root volume (cm^3)	Root: shoot
Variety					
New White	570.83 a	126.33 a	0.70 a	2.27 a	0.15 a
New Yellow	621.96 a	131.95 a	0.68 a	2.25 a	0.14 a
Plant density					
64 plant m^{-2}	540.27 a	124.83 a	0.73 a	2.32 a	0.14 a
81 plant m^{-2}	615.23 a	132.76 a	0.69 a	2.32 a	0.15 a
99 plant m^{-2}	633.69 a	129.84 a	0.66 a	2.15 a	0.14 a
Variety (V)	ns	ns	ns	ns	ns
Plant density (P)	ns	ns	ns	ns	ns
VxP	ns	ns	ns	ns	ns

Means followed by the same letter are not significantly different at p≤0.05 by Tukey's test ns=nonsignificant

Table 4: Root diameter, epidermis, cortex and stele of chrysanthemum as affected by variety and plant density under soilless culture.

Treatments	Root diameter	Epidermis	Cortex	Stele
	(μm)	(μm)	(μm)	(μm)
Variety				
New White	60.75 a	2.58 a	17.42 a	18.33 a
New Yellow	66.58 a	2.33 a	21.33 a	18.83 a
Plant density				
64 plant m^{-2}	60.50 a	2.75 a	19.50 a	17.25 a
81 plant m^{-2}	64.75 a	2.13 a	18.63 a	19.00 a
99 plant m^{-2}	65.75 a	2.50 a	20.00 a	19.50 a
Variety (V)	ns	ns	ns	ns
Plant density (P)	ns	ns	ns	ns
VxP	ns	ns	ns	ns

Means followed by the same letter are not significantly different at p≤0.05 by Tukey's test ns=nonsignificant

Chrysanthemum 'New Yellow, had higher chlorophyll a, chlorophyll b and total chlorophyll than 'New White' but the differences were not significantly(Table 5). Plant density had no significant effect on chlorophyll a, chlorophyll b and total chlorophyll of chrysanthemum but plants grown at 99 plant m^{-2} exhibited the highest chlorophyll a, chlorophyll b and total chlorophyll of 8.13, 3.48 and 10.16 mg cm^{-2} respectively.

Table 5. Chlorophyll content of chrysanthemum leaves as affected by variety and plant density under soilless culture.

Treatments	Chlorophyll a (mg cm^{-2})	Chlorophyll b (mg cm^{-2})	Total chlorophyll (mg cm^{-2})
Variety			
New White	7.39 a	3.17 a	9.24 a
New Yellow	8.14 a	3.38 a	10.08 a
Plant density			
64 plant m^{-2}	7.60 a	3.12 a	9.37 a
81 plant m^{-2}	7.57 a	3.22 a	9.44 a
99 plant m^{-2}	8.13 a	3.48 a	10.16 a
Variety (V)	ns	ns	ns
Plant density (P)	ns	ns	ns
VxP	ns	ns	ns

Means followed by the same letter are not significantly different at p≤0.05 by Tukey's test ns=nonsignificant

Stem fresh weight and total dry weight of chrysanthemum 'New Yellow' were higher than 'New White' but the difference was not significant (Table 6). There was no difference between fresh weight means of chrysanthemum grown at different plant density Maximum fresh weight was 27.91 g obtained from the plant density of 99 plants m^{-2}. Leaf, stem, root, flower and total dry weight of chrysanthemum did not show significantly difference between variety or plant density. However, at a plant density of 64 plants m^2 produced the highest dry weight of 5.91 g.

Results from leaf nutrient analysis at 6 weeks after transplanting indicated that there were no significantly differences of nitrogen, phosphorus, potassium, calcium and magnesium level between variety and plant density (Table 7). While, result from nutrient analysis at fourteenth week after transplanting showed that chrysanthemum 'New yellow' had higher potassium than 'New White' significantly but there were no significant differences between other nutrients (Table 8).

Table 6: Fresh weight and dry weight of chrysanthemum as affected by variety and plant density under soilless culture.

Treatments	Stem fresh weight			Dry weight (g)		
	(g)	Leaf	Stem	Root	Flower	Total
Variety						
New White	23.31 a	1.12 a	2.45 a	0.65 a	0.84 a	5.06 a
New Yellow	29.08 a	1.23 a	2.92 a	0.69 a	1.03 a	5.87 a
Plant density						
64 plant m^{-2}	27.16 a	1.27 a	2.95 a	0.68 a	1.01 a	5.91 a
81 plant m^{-2}	23.53 a	1.19 a	2.66 a	0.71 a	0.84 a	5.40 a
99 plant m^{-2}	27.91 a	1.06 a	2.44 a	0.62 a	0.96 a	5.08 a
Variety (V)	ns	ns	ns	ns	ns	ns
Plant density (P)	ns	ns	ns	ns	ns	ns
VxP	ns	ns	ns	ns	ns	ns

Means followed by the same letter are not significantly different at p≤0.05 by Tukey's test ns=nonsignificant

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Table 7: Nutrient concentrations of chrysanthemum as affected by variety and plant density at sixth week after transplanting.

Treatments	N	P	K	Ca	Mg
			%		
Variety					
New White	1.78 a	0.18 a	4.11 a	1.29 a	0.44 a
New Yellow	1.74 a	0.16 a	3.38 a	1.23 a	0.39 a
Plant density					
64 plant m^{-2}	1.47 a	0.15 a	3.49 a	1.07 a	0.35 a
81 plant m^{-2}	1.77 a	0.17 a	3.65 a	1.38 a	0.44 a
99 plant m^{-2}	2.04 a	0.20 a	4.10 a	1.32 a	0.45 a
Variety (V)	ns	ns	ns	ns	ns
Plant density (P)	ns	ns	ns	ns	ns
VxP	ns	ns	ns	ns	ns

Means followed by the same letter are not significantly different at p≤0.05 by Tukey's test ns=nonsignificant

Table 8. Nutrient concentrations of chrysanthemum as affected by variety and plant density at fourteenth week after transplanting

Treatments	N	P	K	Ca	Mg
			%		
Variety					
New White	3.33 a	1.04 a	4.94 b	0.30 a	3.33 a
New Yellow	3.91 a	1.15 a	5.54 a	0.35 a	3.91 a
Plant density					
64 plant m^{-2}	3.60 a	0.27 a	5.06 a	1.04 a	0.35 a
81 plant m^{-2}	3.28 a	0.34 a	5.21 a	1.09 a	0.38 a
99 plant m^{-2}	3.98 a	0.37a	5.46 a	1.15 a	0.40 a
Variety (V)	ns	ns	0.05	ns	ns
Plant density (P)	ns	ns	ns	ns	ns
VxP	ns	ns	ns	ns	ns

Means followed by the same letter are not significantly different at p≤0.05 by Tukey's test ns=nonsignificant

There were no significant differences of photosynthesis rate, stomatalconductant, transpiration rate, between variety and plant density even at six week or fourteenth week after transplanting (Table 9 and Table 10). Chlorophyll fluorescence efficiency (Fv/Fm) of chrysanthemum 'New White' and 'New Yellow' did not differ significantly. Even plants grown at 64 plant m^{-2} had highest Fv/Fm value of 0.85 but it was not significant difference from other plant density. Water potential significantly affected by variety, chrysanthemum 'New Yellow' was significantly higher than 'New White' both at six week and fourteenth week. There was no significant difference of water potential among plant density.

Maximum plant height of 61.28 cm was recorded from the density of 99 plants m^{-2}. However, there were no significant differences for the plant height between variety or plant density as shown in Table 11. Day to flowering was not affected by variety and plant density. Chrysanthemum took 76 - 77 days after transplanting to start flowering. Number of flowers was not difference between variety and plant density but chrysanthemum grown at 64 plant m^{-2} had highest average number of flower of 5.69. Flower diameter and inflorescence diameter also did not show significant differences between variety or plant density. From measurement of flower color, lightness and hue angle value of chrysanthemum 'New White' did not significantly differ from 'New Yellow', except the chroma value (Table 11). While there were no differences of flower color between plant density.Vase life of chrysanthemum 'New white' was 14.79 day, a few longer than 'New Yellow of 13.83 day. No significant differences were observed for vase life among plant density treatments.

Table 9: Photosynthesis, stomatalconductant, transpiration rate, Fv/Fm, proline, water potential of chrysanthemum at 6 weeks as affected by variety and plant density.

Treatments	Photosynthesis ($\mu mol\ m^{-2}s^{-1}$)	Stomatal conductant ($cm\ s^{-1}$)	Transpiration ($mol\ m^{-2}s^{-1}$)	Fv/Fm	Proline (μg)	Water potential (bar)
Variety						
New White	15.49 a	0.17 a	1.58 a	0.81 a	6.25 a	-3.35 b
New Yellow	16.32 a	0.17 a	1.59 a	0.83 a	6.84 a	-4.80 a
Plant density						
64 plant m^{-2}	16.79 a	0.14 a	1.39 a	0.85 a	7.08 a	-3.50 a
81 plant m^{-2}	15.61 a	0.20 a	1.85 a	0.82 a	6.27 a	-4.13 a
99 plant m^{-2}	15.32 a	0.16 a	1.51 a	0.81 a	6.29 a	-4.59 a
Variety (V)	ns	Ns	ns	ns	ns	ns
Plant density (P)	ns	ns	ns	ns	ns	ns
VxP	ns	ns	ns	ns	ns	ns

Means followed by the same letter are not significantly different at p≤0.05 by Tukey's test ns=nonsignificant

Table 10: Photosynthesis, stomatalconductant, transpiration rate, Fv/Fm, proline, water potential of chrysanthemum at 6 weeks as affected by variety and plant density.

Treatments	Photosynthesis ($\mu molm^{-2}s^{-1}$)	Stomatal conductant ($cm\ s^{-1}$)	Transpiration ($mol\ m^{-2}s^{-1}$)	Fv/Fm	Proline (μg)	Water potential (bar)
Variety						
New White	15.23 a	0.12 a	1.18 a	0.79 a	4.13 a	-2.80 b
New Yellow	12.21 a	0.09 a	0.98 a	0.75 a	4.00 a	-3.70 a
Plant density						
64 plant m^{-2}	11.19 a	0.09 a	1.02 a	0.85 a	3.62 a	-3.35 a
81 plant m^{-2}	17.14 a	0.11 a	1.10 a	0.82 a	4.35 a	-2.99 a
99 plant m^{-2}	12.82 a	0.11 a	1.12 a	0.81 a	4.22 a	-3.41 a
Variety (V)	ns	ns	ns	ns	ns	0.05
Plant density (P)	ns	ns	ns	ns	ns	ns
VxP	ns	ns	ns	ns	ns	ns

Means followed by the same letter are not significantly different at p≤0.05 by Tukey's test ns=nonsignificant

Table 11: Plant height, number of flowers, flower diameter, inflorescence diameter of chrysanthemum as affected by variety and plant density.

Treatments	Plant Height (cm)	Day to flowering	Number of flowers	Flower diameter (cm)	Inflorescence diameter (cm)
Variety					
New White	55.38 a	76.67 a	5.00 a	6.64 a	13.55 a
New Yellow	60.85 a	76.58 a	5.83 a	6.76 a	13.87 a
Plant density					
64 plant m^{-2}	55.94 a	77.00 a	5.69 a	6.45 a	13.14 a
81 plant m^{-2}	57.13 a	76.50 a	5.06 a	6.86 a	13.98 a
99 plant m^{-2}	61.28 a	76.38 a	5.50 a	6.80 a	14.02 a
Variety (V)	ns	ns	ns	ns	ns
Plant density (P)	ns	ns	ns	ns	ns
VxP	ns	ns	ns	ns	ns

Means followed by the same letter are not significantly different at p≤0.05 by Tukey's test ns=nonsignificant

Table 12: Vase life lightness, chroma, hue value of chrysanthemumof chrysanthemum as affected by variety and plant density.

Treatments	Lightness	Chroma	Hue	Vase life (day)
Variety				
New White	57.30 a	1.61 b	91.05 a	14.79 a
New Yellow	60.46 a	38.54 a	100.45 a	13.83 b
Plant density				
64 plant m^{-2}	57.62 a	21.22 a	93.57 a	14.56 a
81 plant m^{-2}	58.96 a	18.27 a	94.91 a	13.94 a
99 plant m^{-2}	60.06 a	20.73 a	98.77 a	14.44 a
Variety (V)	ns	0.01	ns	0.05
Plant density (P)	ns	ns	ns	ns
VxP	ns	ns	ns	ns

Means followed by the same letter are not significantly different at p≤0.05 by Tukey's test ns=nonsignificant

Discussion:

Plant density altered the light intensity at the plant canopy. This influenced to morphology and physiology of plants. Carvalho and Heuvelink [3], informed that increasing plant density reduced leaf area, leaf number, leaf size, and leaf thickness of chrysanthemum. Khattak*et al*., [8] also reported that leaf area of chrysanthemum decreased with the

increasing of plant density.But, there were no significant differences between leaf area and leaf length of chrysanthemum at different plant density in this experiment.Increasing plant density tended to increase leaf area index (LAI). LAI of chrysanthemum grown at 81 and 99 plant m^{-2} were higher than 64 plant m^{-2}. This result agreed with report of Lee *et al*., [10] who stated that leaf area index increased with increasing plant density. In contrary, Huld and Anderson [6] reported that leaf area index of chrysanthemum grown at 83 plant m^{-2} was higher than at 125 plant m^{-2}**.** Number of internode was significant affected by variety, chrysanthemum 'New Yellow' had number of internode significantly higher than 'New White'.This may be due to chrysanthemum cultivar had variation response to plant density due to the ability of inherent [11,10].

In this experiment, plant density did not clearly affect to stem fresh weight and total dry weight. There were no significant differences between stem fresh weight and total dry weight of chrysanthemum between different plant density. This result varied from finding of Lee *et al*., [11] who reported that fresh and dry matter of chrysanthemum was decreased with increasing plant density. While Lee *et al*., [10] reported that fresh weight and dry weight of chrysanthemum increased with increasing plant density.

Plant density did not affected to root morphology of chrysanthemum, root length, root surface area, root diameter, root volume and root shoot ratio did not differ between plant density. This result contrasted with report of Panahandeh*et et al*., [14] who stated that root length and root diameter of chichory grown in hydroponic were significant differences with plant density.

There were no significant differences on nutrient level between plant density at 6 week or 14 week after transplanting. These results can be concluded that plant density did not affect to nutrient level which similar to Russo [15], who reported that element concentration in plant tissues were not affected by plant density.Chlorophyll A, chlorophyll B and total chlorophyll did not affect by plant density. This finding agreed with finding of Arouiee*et al*., who reported that plant density did not significantly affect on leaf chlorophyll of sweet pepper**.**

Carvalho and Heuvelink noted that increasing plant density decreased photosynthesis rate. However, there were no significantly differences of photosynthesis, stomatalconductant, transpiration rate and Fv/Fm among plant density at six week or fourteenth week after transplanting. This result corresponded with the report in corn of Xiuming [19] who said that photosynthesis and transpiration were not affected by plant density. This may be the density was not so high until it influenced to the photosynthesis. Because Li *et al*., [13] informed that when maize was grown at density exceeded 82,500 plants per hm^2, photosynthesis and Fv/Fm decreased significantly.

Plant height of chrysanthemum had strongly response to plant density [11]. However, there was no significant difference for the plant height between variety either or plant density This result corresponded with report of Kahar and Mahmud, [7] who found that plant height of chrysanthemum grown at 104 plant m^{-2} did not differ significantly from 44 plants m^{-2}. Lee *et al*., [11] also indicated that chrysanthemum stem length hardly responded to plant density.

Significantly differences of day to flowering was not observed between different plant density of chrysanthemum. This result contrasted with finding of Langton *et al*., [9] who reported that increasing plant density related to slow flowering of chrysanthemum. Number of flower also was not difference between plant density. In contrast with other findings [11,3,16] which reported that increasing plant density decreased number of flower. Inflorescence diameter did not show significant differences between variety or plant density. In contrast, Kahar and Mahmud [7] reported that spray diameter of chrysanthemum decreased significantly when plant density increased from 44 plant $m^{-2}$to 104 plant m^{-2}. This might because of the assimilation was not difference obviously between plant density. Plant density did not affect to vase life as report of Kahar and Mahmud [7] who informed that vase life of chrysanthemum grown at 44 plant m^{-2} did not differ from 104 plant m^{-2}.

Conclusion:

Chrysanthemum grown under root restriction at high density of 81 and 99 plants m^{-2} did not show significant differences on growth and flowering with 64 plants m^{-2} except pedicle length. An increasing in plant density increased number of stem per area which can utilize greenhouse space. Considering the yield per square meter, growing chrysanthemum at 99 plants m^{-2}appeared to be recommendable for the cultivation under root restriction.

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