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Artificial Shade Adaptation and Population Density on Swiss Chard (*Beta vulgaris* subsp. Cicla (L) W.D.J Koch) in Urban Area

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Abstract

Swiss chard is a leafy vegetable that is high in nutrients, vitamins, minerals, protein, and antioxidants that are beneficial to human health. Swiss chard. Swiss chard is generally cultivated in the Mediterranean climate, grows well in full sunlight, air temperatures 14-21oC, and can still survive at temperatures close to light frost. The aim of this study to evaluate efficient plant densi-ties in urban limited land area and looking at the response of Swiss chard plant to reduc-ing the intensity of sunligt of 45%, 55% and 80%.in urban tropic area. This research was used 4 different artificial shading i.e 0% (control, shade 45%, shade 55% and shade 80%. Microclimate was measured per each shade for 14 days i.e., air temperatur, soil temperature, air humidity, and soil moisture using a data logger meter. Shade with intensity 80% is proven to reduce air temperate and soil temperature, but also inhibits the growth and development of Swiss chard plants. Population 1plant/pot gives the best growth and yield of Swiss chard per plant, 3 plants/pot increased total fresh weight per cultivation area, thereby maximize the use of limited urban land.

Keywords: Colorful vegetable, subtropis, micro climate, urban area

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1. Introduction

Availability of land in urban areas is limited, land size is narrow, and land conditions are classified as sub-optimal; it is more likely to be managed only to meet the needs of the household itself. Strengthen this statement and believe that agriculture in the center and on the out-skirts of urban areas has different characteristics and abili-ties to meet the food needs of urban communities [1]. Cul-tivating vegetables in urban areas is an efficient way to use production facilities, provide fresh produce, and help meet household needs [2].

Swiss chard is a plant that has the potential to be de-veloped in urban areas. Swiss chard has a high nutritional content and aesthetic value of its own. Swiss chard is gen-erally cultivated in the Mediterranean climate, grows well in full sunlight, air temperatures 14-21oC, and can still survive at tempera-tures close to light frost [3]. The air tempera-ture reaches > 30°C during the day in low-land areas, and limited open land conditions, tall buildings, and trees that shade each oth-er are obstacles to cultivating this plant. High temperatures will increase respiration, conse-quently reducing production [4]. Plants that grow at tem-peratures above the opti-mum will result in an imbalance between the amounts of photosynthetic processes pro-duced resulting in reduced carbohydrates due to respira-tion.

Therefore, this study to evaluate efficient plant densi-ties in urban limited land area and looking at the response of Swiss chard plant to reducing the intensity of sunligt of 45%, 55% and 80%. Population control can be done to in-crease the efficiency of vacant land so that it can be used optimally in the same area but provides more profitable re-sults. Plant population is defined as the number of plants found in a unit area of land [5]. The use of artificial shading aims to modify the microclimate with the aim of lowering the temperature, but on the other hand it is also to test the adaptability of Swiss chard plants to shaded environments such as urban areas. [6] Reported that the use of shade reduces air temperature by 2.3-2.5°C, reduces evapotranspiration 17.4-50%, solar radiation 15-39%, and air velocity 50-87%.

2. Materials and Methods

The study was carried out in a tropical cli-mate at an aoutdoor research facility at Jakabaring (104o46'44"E; 3o01'35"S), Pa-lembang, Indonesia. The study was conducted during June to September 2022. The plant material used was seeds of three Swiss chard cultivars, i.e, Red ruby, pink passion and Yellow cannary. This study used split plot design with 2 factors. The first factor is artificial shading consisting of 0% shading (N0), 45% artificial shading (N1), 55% artifi-cial shading (N2), 80% artificial shading (N3). The second factor was the plant popu-lation consisting of P1: 1 plant/pot (Yellow cannary), P2: 2 plants/pot (Red ruby and Pink passion), P3: 3 plants/pot (Red ruby, Yellow cannary and Pink passion). The plas-tic pot used is a pot with a size (27.5 cm in top diameter, 19.8 cm in bottom diameter, and 20 cm in height). Before planting the seeds are sown for up to 14 days. The planting medium used was a mixture of soil: ma-nure: sand (4:2:1 v/v). A week before trans-planting, the planting medium was given biofungicide (Decoprima) at a dose of 2g/l (200 ml/pot) for sterilization purposes. The pot is placed in the shadow house according to the treatment. The shade used is an artifi-cial shade made of plastic.

Data collection

Growth variables observed i.e., number of leaves, length and width of leaves, leaf thickness, stalk length and SPAD. Leaf thickness was measured using a digital caliper. Leaf SPAD was measured using a chlo-rophyll meter (Konica Minolta SPAD-502 Plus). Additional data measured to support primary data included soil moisture, soil temperature and electrical conductance (EC), measured using a Datalogger Meter for 14 days to see differences in each shade. Air temperature and humidity were meas-ured using the Wireless Thermo Recorder RTR 502. Leaf temperature was measured using the FLIR Thermal C3-X camera twice a week at 10.00 WIB, 12.00 WIB and 14.00 WIB. The results of leaf temperature meas-urements were analyzed using the FLIR Thermal Studio application. The harvest var-iables observed were total plant fresh weight, fresh weight of leaves and stalks, dry weight of leaves and stalks. Variables for growth analysis i.e., leaf growth rate measured daily to maximum area, leaf length/width ratio, leaf length/stalk length ratio, specific leaf area (LDS), total leaf area, leaf moisture content and petiole. Drying the destructive results of plants using an oven with a temperature of 100°C for 24 hours.

3. Results and Discussion

The difference in each shade tested causes differences in microclimates including air temperature, soil temperature, leaf tempera-ture and air humidity. There are fluctuations between soil temperature in the morning, afternoon and evening. The increase in soil temperature is affected by the amount of radiation absorption from the sun on the soil surface. During the day the soil temperature will increase due to the sun's heating of the soil surface, so that the air around the soil surface gets a high temperature. Further-more, at night until the morning, the soil temperature tends to be lower. Evapotranspi-ration during the day causes an increase in soil temperature resulting in a decrease in the availability of water in the soil. The height of the measurement results is influenced by air temperature, sunlight and rain intensity at two different measurement times (Figure 1). Shade can control plant growth, reduce light intensity and modify microclimates such as air temperature, soil temperature, air humidi-ty, carbon dioxide concentration and air ve-locity [7], [8], [9]. Xu et al. [10] also report-ed that shading reduced daily air tempera-ture, soil temperature, and light intensity by 2.31%, 2.67% and 18.45% in 2014, and 2.47%, 2.44% and 21.34% in 2015; RH in shade was higher than without shade.

Soil temperature, soil moisture, and carbon supply regulate the respiration process in the soil [11]. The results showed that each shade had a different decrease in soil temperature, air temperature and plant temperature. The main source of soil temperature is solar radi-ation which is absorbed by the soil and plants. The lower the intensity of the sun received due to the shade, the temperature on the ground will be lower. Soil temperature changes every time due to changes in radiation energy and energy changes take place through the soil surface. Changes in soil temperature are affected by solar radia-tion, vegetative cover and evapora-tion/evapotranspiration. As the shading in-tensity increases, the evapotranspiration pro-cess will decrease. Shade reduces evapotran-spiration by 30–50% in pepper cultivation and 34% in grape cultivation with 10% shade [12]. The evapotranspiration process is also closely related to soil moisture and air temperature [13]

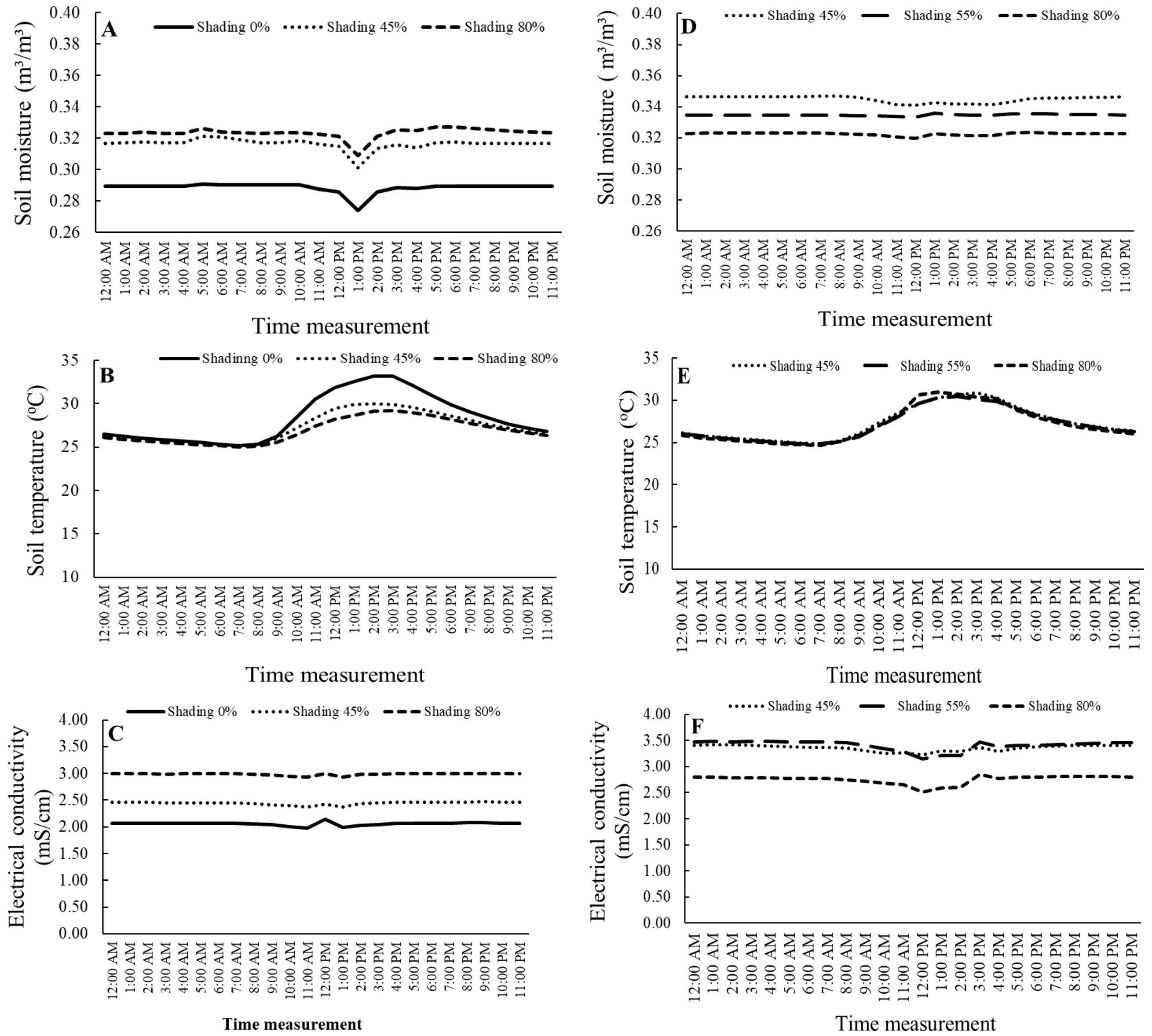

Figure 1. Micro climate (soil moisture, soil temperature, EC) in 2 measurement periods with different intensity levels, first 14 days (A=0%, B=45%, C=80%) and second 14 days (D=45%, E=55%, F=80%).

This study showed that at 12.00 and 14.00 the air temperature, leaf temperature and soil temperature increased. This is shown in plants without shade (0%) showing higher temperatures and low soil moisture. This is because sunlight shines directly on plants so that more light is absorbed by plants and soil, causing soil and leaf temperatures to increase. An increase in temperature that is too high accelerates the evapotranspiration process and consequently decreases soil moisture (Figure 2).

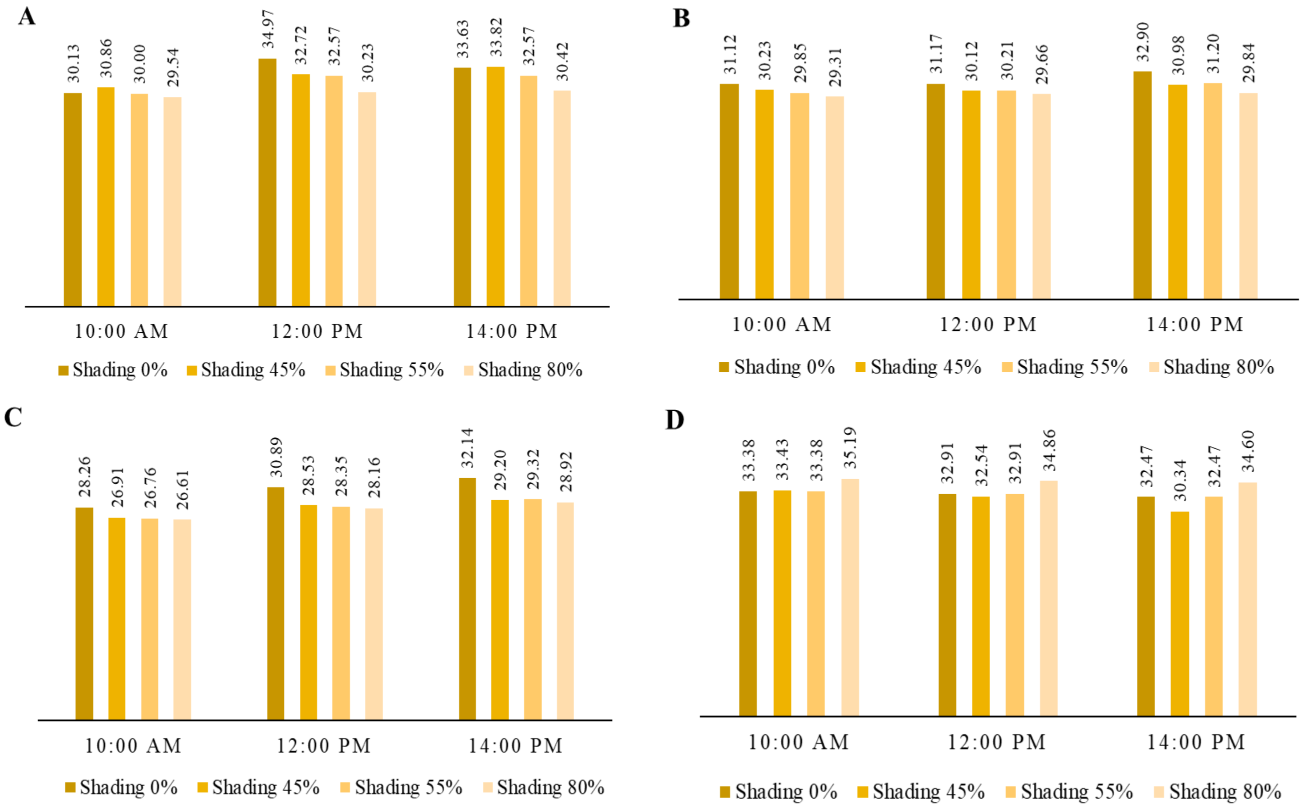

Figure 2. Comparison of air temperature (A), leaf temperature (B), soil temperature (C) and soil moisture (D) at a decrease in shade intensity of 0%, 45%, 55% and 80%

Plants that were given shade treatment with an intensity of 80% had higher soil moisture and lower air temperature. This is due to the shade reducing the amount of incoming radiation energy so that it has the potential to reduce air temperature. Conversely, at 0% shade the soil moisture is lower. Reduction of soil moisture occurs when air temperature and soil temperature increase, decreasing the viscosity of water, allowing more water to evaporate and partially seep through the soil profile [14].

Absorption of water by the soil decreases at low temperatures. This is due to the increased viscosity and decreased water absorption rate at low temperatures, decreased water absorption reduces the rate of photosynthesis [15]. However, an increase in light intensity does not affect the rate of photosynthesis, but an increase in temperature due to light intensity can accelerate the rate of photosynthesis. The higher the intensity of the shading the lower the light received. The light absorbed by the shade is partially absorbed and partially reflected. The absorbed light is rushed to the ground surface and some is used for photosynthesis. Moist soil conducts heat better than dry soil, dry soil heats up faster during the day than at night [16]. Water's high temperature capacity and thermal conductivity compared to air, wetter soil cools faster than dry soil [17].

Swiss chard response to various shading intensities

The ratio measurements described the individual growth of the leaf blade and petiole of Swiss chard for 16 consecutive days (Figure 3). Under unshaded conditions (0%), Swiss chard has longer leaves than its petiole. However, increasing the intensity of shading causes a decrease in the value of this ratio. Swiss chard under 80% shade intensity had a ratio value < 1. Over time, Swiss chard elongated the petioles compared to its leaves until the 16th day of observation. This proves that an increase in the intensity of the shade causes Swiss chard plants to experience etiolation and stunted growth. Increasing shading intensity was also shown to reduce Swiss chard leaf area. Swiss chard under 80% artificial shade experienced stunted growth. This is due to the low intensity of light received by plants, causing delays in the process of photosynthesis and cell division (Figure 12). Shade can inhibit leaf growth and increase auxin content, where this substance functions to regulate the development, growth, expansion and elongation of leaves [18, 19]

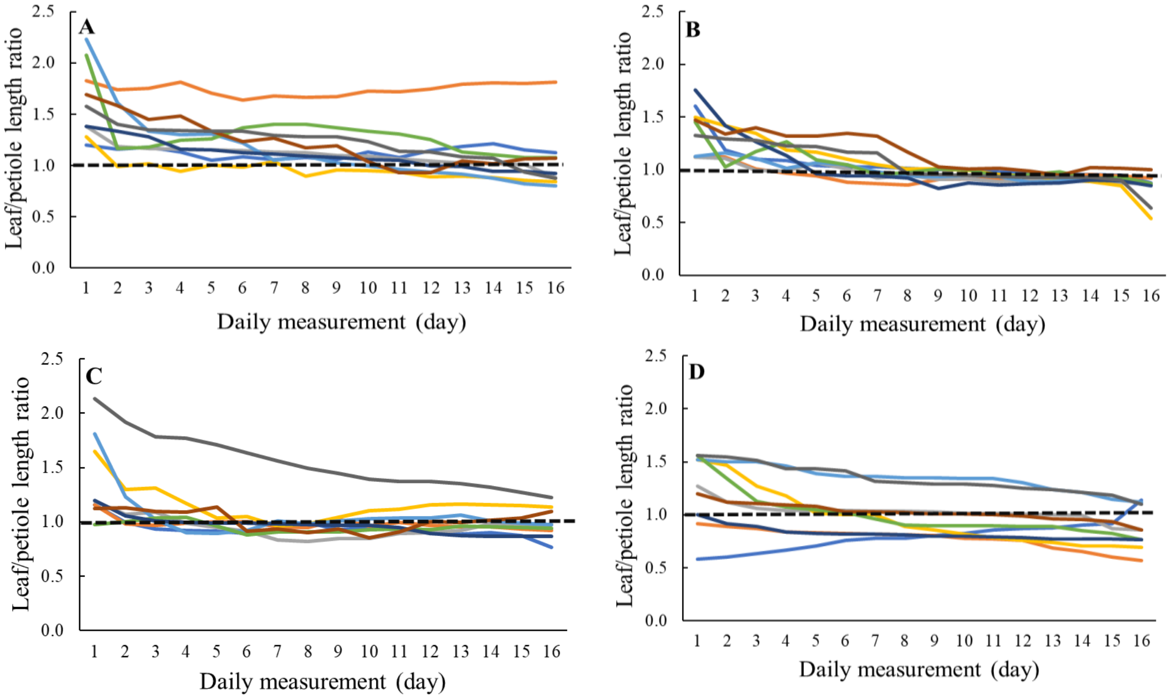

Figure 3. Differences in leaf blade:petiole length ration at shading intensity 0% (A), 45% (B), 55% (C) and 80% (D)

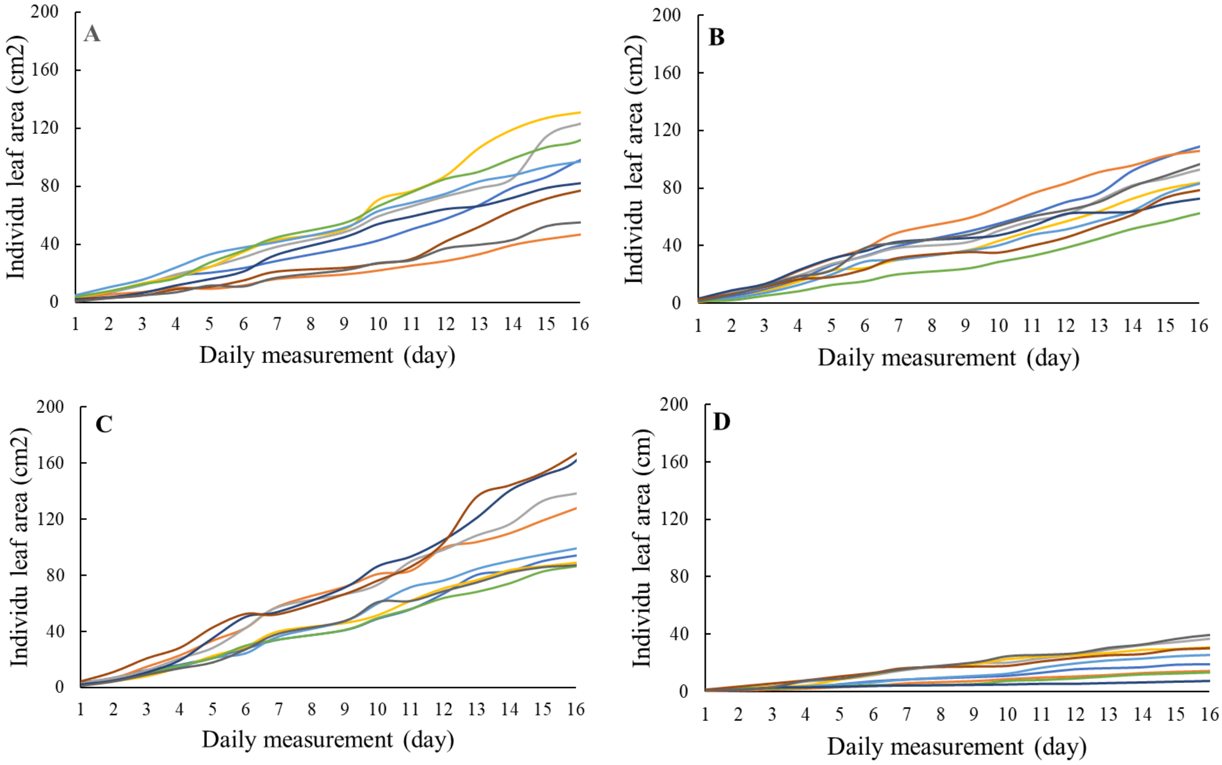

Figure 4. Shading effect of 0% (A), 45% (B), 55% (C) and 80% (D) on the expansion of individual leaves.

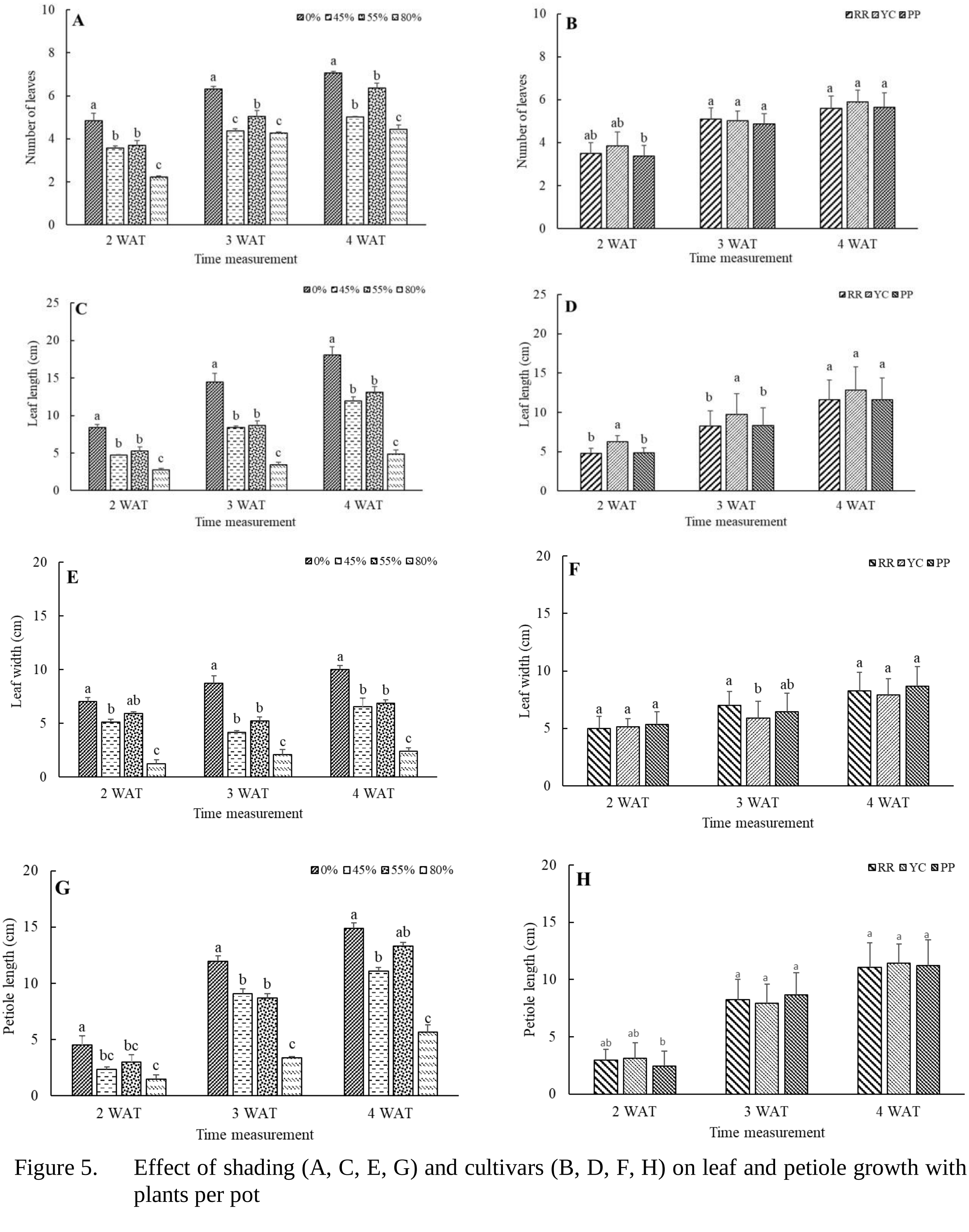

Figure 5. Effect of shading (A, C, E, G) and cultivars (B, D, F, H) on leaf and petiole growth with 3 plants per pot

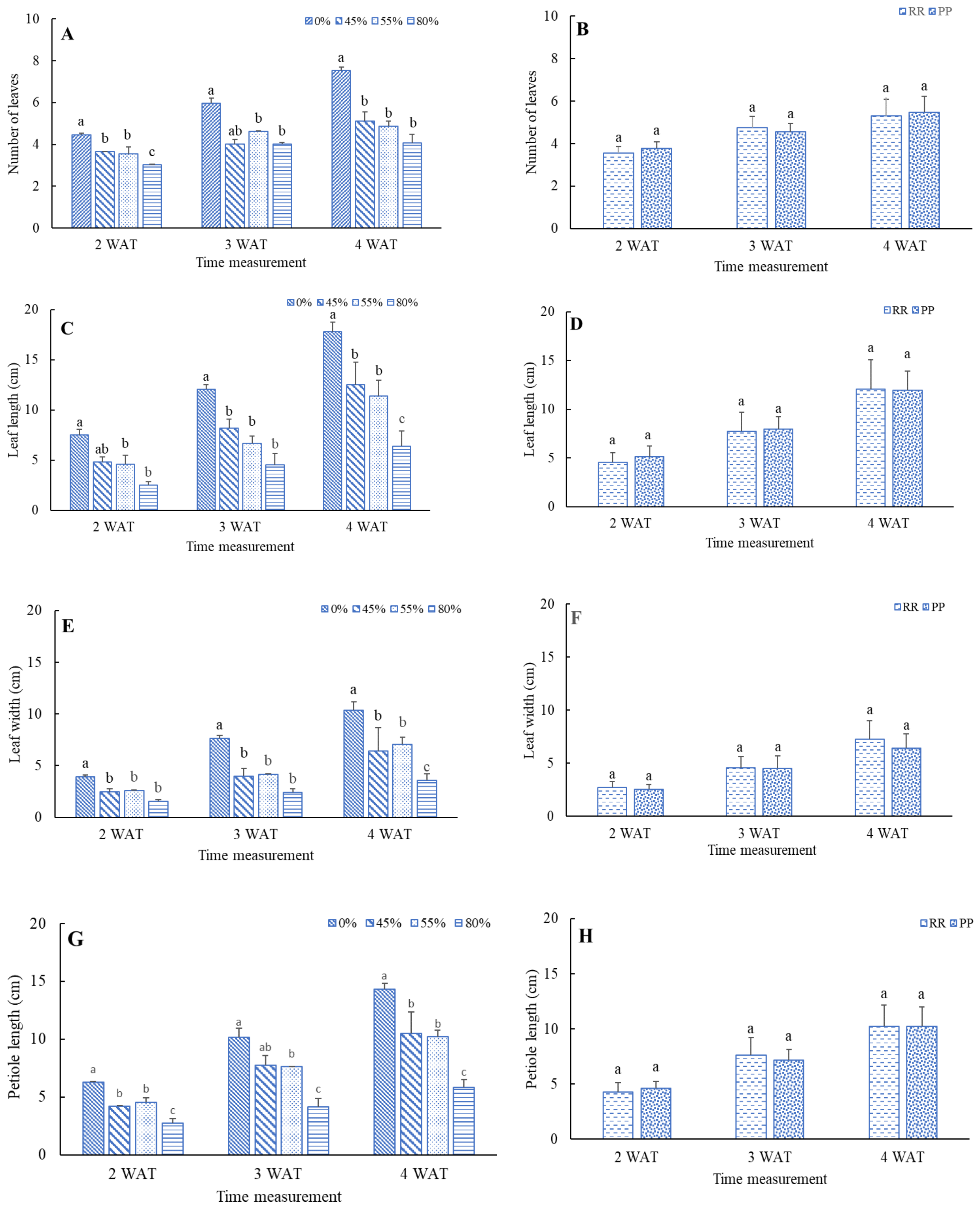

Figure 6. Effect of shading (A, C, E, G) and cultivars (B, D, F, H) on leaf and petiole growth with 2 plants per pot

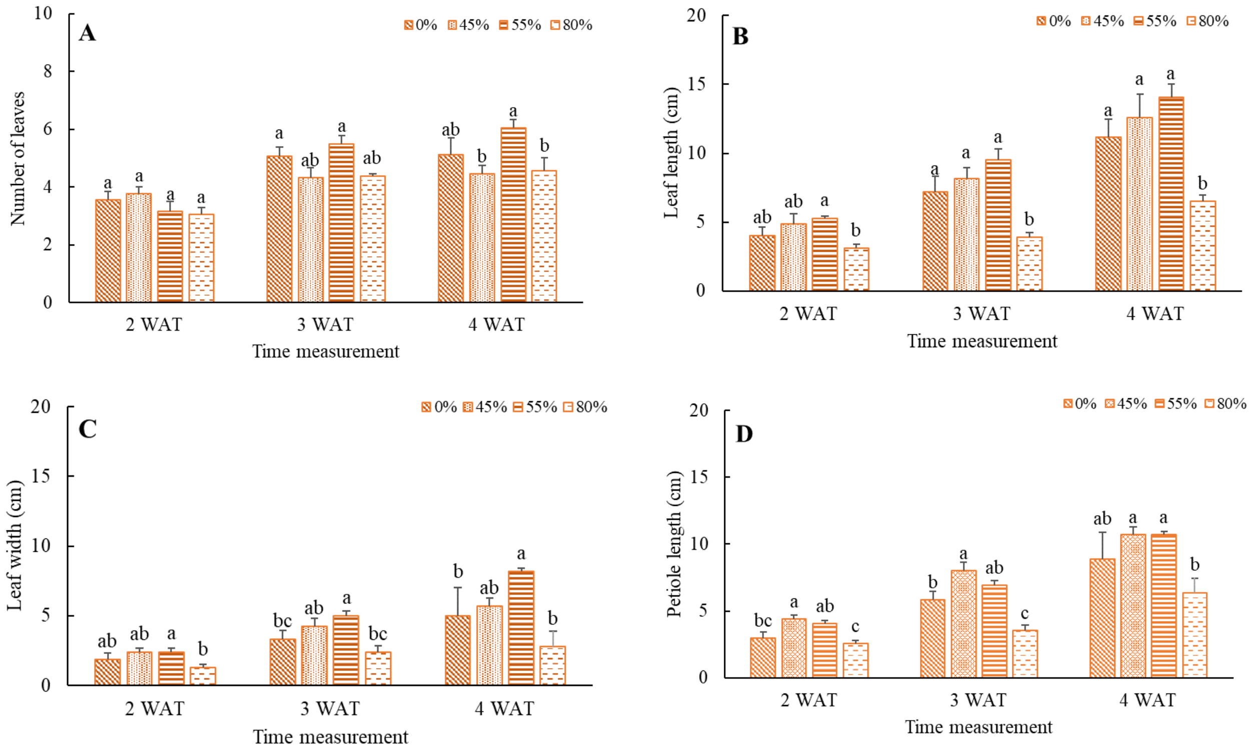

Figure 7. Effect of shading (A, C) and cultivars (B, D) on leaf and petiole growth with 2 plants per pot.

Increasing the intensity of shading decreased the value of the growth variables (Figs. 5, 6 and 7) and yields (Tables 1, 2 and 3) in each population. In addition, it also reduces fresh weight. Differences in shading intensity also affect leaf thickness and SPAD values. Plants in open/no shade conditions tend to have thicker leaves and higher SPAD values. On the other hand, under shading conditions with high intensity, leaf thickness and SPAD values were very low. Lack of sunlight in plants causes etiolation in plants, resulting in leaves experiencing etioplasts. When the levels of etioplas in the leaves increase, it causes the leaves to become thin and yellow. This decrease in leaf thickness and SPAD values occurred in all three types of populations (Table 4).

[20] reported that shade inhibits cell division, reduces the number and size of cells, so that plants under shade tend to be stunted, have smaller and thinner leaves.

The effect of shade also has a significant effect on crop yields, namely the total fresh weight and dry weight of shoots. A decrease in light intensity is strongly related to a decrease in fresh shoot weight and fresh weight of purple pakchoi roots and lettuce [21, 22, 23]. Full sun at any given quality of light improves the nutritional quality and yield of vegetables. Because light affects the metabolic system, the most sensitive response is the formation of sugar (the main photosynthetic product) and its accumulation in the leaves [24]. Disturbed metabolism will actually reduce the yield of biomass on Swiss chard. This is shown by Swiss chard under 80% shade has a very low biomass. Tereshima et al. [25] reported that thinner leaves have lower leaf dry times per unit area. This is evidenced by the results of this study showing that Swiss chard under 80% shade has a high moisture content and a low dry weight.

Abdel et al. [26] the increase in leaf area and leaf thickness occurs depending on the light received and absorbed by plants. The little light that plants receive inhibits the rate of anticlinal cell expansion, the effect on the cells of this expansion is preceded by cell division, causing a reduction of one layer of palisade cells [26]. Thin leaves have thinner palisade tissue and fewer chloroplasts, so they don't have strong photosynthesis and low biomass accumulation [20]. This is related to the chlorophyll content in Swiss chard leaves. SPAD decreased with increasing shading intensity used. It was reported that the use of shading also reduced SPAD values in soybean, wheat and maize leaves [20, 28, 29, 30]. Conversely, for plants that like shade, the SPAD values and leaf area are larger for konjac plants [31].

Tabel 1. Effect of shading on Swiss chard yields one plant per pot

Variabel	Shading intensity	Time harvested									
		6 WAT		8 WAT		10 WAT		12 WAT		Total	
Number of leaves	0%	2.00	a	3.00	a	5.00	a	9.00	ab	19.00	a
	45%	2.00	a	2.50	a	2.83	a	7.00	bc	14.33	b
	55%	3.05	a	2.94	a	3.33	a	9.66	a	19.00	a
	80%	-		2.66	a	3.33	a	5.83	c	11.83	b
	LSD	1.96		1.75		7.06		2.03		4.61	
Total leaf area (cm2)	0%	172.88	ab	313.34	ab	512.29	a	900.56	b	1899.07	ab
	45%	195.93	ab	188.29	b	262.22	b	425.72	c	1072.18	bc
	55%	345.45	a	475.71	a	451.02	a	1025.04	a	2306.24	a
	80%	-		2.44	b	270.34	b	174.84	d	615.03	c
	LSD	225.84		206.26		176.78		227.23		1045.02	
Leaf fresh weight (g)	0%	7.06	a	11.85	b	23.15	a	24.12	ab	66.20	ab
	45%	7.37	a	7.77	bc	10.18	b	13.20	ab	38.35	bc
	55%	13.56	a	18.84	a	18.93	ab	35.02	a	86.36	a
	80%	-		5.11	c	9.24	b	6.10	b	20.45	c
	LSD	10.04		5.15		2.44		26.96		26.71	
Leaf dry weight (g)	0%	0.54	ab	0.61	b	0.61	b	1.43	ab	4.47	ab
	45%	0.27	ab	0.76	b	0.76	b	1.01	b	2.61	bc
	55%	0.75	a	1.73	a	1.73	a	2.66	a	6.21	a
	80%	-		0.31	b	0.31	b	0.34	b	1.02	c
	LSD	0.71		0.53		0.53		1.58		2.35	
Petiole fresh weight (g)	0%	4.98	a	3.90	b	15.14	a	16.18	ab	40.30	ab
	45%	3.91	a	9.50	a	7.36	b	11.27	b	32.14	b
	55%	5.92	a	12.26	a	14.88	a	26.79	a	59.86	a
	80%	-		4.58	b	5.71	b	3.30	b	11.60	c
	LSD	2.77		5.18		6.39		13.94		20.13	
Petiole dry weight (g)	0%	0.26	a	0.35	b	1.61	a	1.87	ab	4.53	a
	45%	0.27	a	0.35	b	0.47	b	0.63	bc	1.74	b
	55%	0.40	a	0.80	a	1.18	a	2.30	a	4.26	a
	80%	-		0.07	b	0.34	b	0.23	c	0.64	b
	LSD	0.54		0.32		0.62		1.56		2.19	
Leaf water content (%)	0%	91.15	b	93.95	a	91.86	c	93.10	a	93.19	ab
	45%	96.27	a	89.85	a	94.28	b	91.10	a	93.00	b
	55%	94.45	a	90.85	a	94.28	b	92.29	a	92.81	b
	80%	-		93.67	a	96.11	a	94.06	a	95.07	a
	LSD	2.31		6.55		1.49		4.02		1.93	
Petiole water content (%)	0%	94.06	a	91.51	c	89.27	b	85.63	b	88.34	b
	45%	2.07	a	85.77	ab	93.42	a	94.43	a	94.67	a
	55%	93.07	a	93.51	bc	91.86	ab	93.07	a	92.88	ab
	80%	-		97.34	a	94.12	a	94.43	a	94.50	a
	LSD	2.61		2.48		2.74		5.81		4.66	

Mean followed by the same letters within each column were significantly different based on LSD at $P \leq 0.05$ for each treatment and week of data measurement; WAT – week after transplanting

Table 2. Effect of shading on Swiss chard yields two plants per pot

Variables	Cultivars	Time harvested									
		6 WAT		8 WAT		10 WAT		12 WAT		Total	
Number of leaves	Red ruby	2.48	a	3.01	a	2.83	b	6.19	a	14.51	a
	Pink passion	2.16	a	2.27	b	3.27	a	5.44	a	13.14	a
	BNT	0.8		0.73		0.42		1.88		2.36	
Total leaf area (cm2)	Red ruby	324.05	a	462.31	a	342.60	a	526.68	a	1655.64	a
	Pink passion	216.32	b	238.54	b	279.31	a	277.28	b	1011.45	b
	BNT	84.54		61.95		77.72		183.97		206.06	
Leaf fresh weight (g)	Red ruby	15.28	a	19.85	a	16.50	a	13.86	a	65.49	a
	Pink passion	8.74	b	6.53	b	8.80	b	6.86	b	30.93	b
	BNT	3.81		4.79		5.61		2.68		8.69	
Leaf dry weight (g))	Red ruby	1.23	a	1.911	a	1.34	a	1.35	a	5.831	a
	Pink passion	0.66	b	0.69	b	0.41	b	0.60	b	2.36	b
	BNT	0.29		0.54		0.50		0.36		0.96	
Petiole fresh weight (g)	Red ruby	5.59	a	12.72	a	12.52	a	21.21	a	52.04	a
	Pink passion	5.21	a	5.84	b	14.78	a	7.99	b	33.82	b
	BNT	3.48		3.05		6.44		5.73		8.69	
Petiole dry weight (g)	Red ruby	0.39	a	0.91	a	1.11	a	2.35	a	4.76	a
	Pink passion	0.27	a	0.34	b	1.19	a	0.86	b	2.66	b
	BNT	0.2		0.29		0.54		0.45		0.96	
Leaf water content (%)	Red ruby	91.93	a	90.65	a	91.98	b	76.39	a	76.14	a
	Pink passion	92.12	a	88.81	a	94.89	a	85.00	a	85.28	a
	BNT	1.85		2.48		1.30		18.90		18.84	
Petiole water content (%)	Red ruby	93.29	b	93.12	a	91.20	a	89.12	a	90.79	b
	Pink passion	94.58	a	94	a	92.05	a	89.66	a	92.40	a
	BNT	0.72		1.23		0.94		1.93		1.51	

Mean followed by the same letters within each column were significantly different based on LSD at $P \leq 0.05$ for each treatment and week of data measurement; WAT – week after transplanting

Growth response of Swiss chard in three different types of populations

In this study, plants grown with a total of three plants per pot produced growth values including leaf growth, total leaf area and lower yields (Table 5).

Gebremedhin and Awgchew [32] reported that the longest leaves of Swiss chard were produced with an intra-space spacing of 20 cm. Swiss chard grown one plant and two plants per pot resulted in a higher total leaf area. Shading swiss chard leaves will affect the process of photosynthesis, as a result the crown grows smaller, the capacity to absorb light and nutrients decreases. In a large space, the plant canopy grows and utilizes sunlight for the photosynthesis process, conversely the denser the plants, the lower the canopy gets less sunlight [33, 34]. Wide spacing stimulates the vegetative growth of lettuce plants and produces the longest leaves, otherwise the plants will compete for water, nutrients and light which causes reduced growth [35, 36, 37].

Less plant density has an impact on plant vegetative plasticity so it is stronger [38]. The impact of dense plant populations is to inhibit plant growth but increase total yield per hectar. This occurs in kale plants, individual yields tend to be better in low populations, but the total yield per pot is higher when planted in high populations [39]. Optimal spacing increases the fresh weight of lettuce, beet and spinach leaves [35, 37, 40]. In kailan plants, dense spacing inhibits leaf growth [41].

Tabel 3. Effect of shading on Swiss chard yield three plants per pot

Variables	Cultivars	Time harvested									
		6 WAT		8 WAT		10 WAT		12 WAT		Total	
Number of leaves	Red ruby	2.37	a	1.92	a	2.57	a	5.68	a	9.08	a
	Yellow canary	2.14	a	1.92	a	2.50	a	5.70	a	7.88	a
	Pink passion	2.33	a	2.07	a	2.50	a	6.06	a	8.90	a
	BNT	0.47		0.36		0.58		1.28		1.98	
Total leaf area (cm2)	Red ruby	326.45	a	252.47	a	320.94	a	448.35	a	927.71	a
	Yellow canary	292.27	a	269.18	a	260.34	a	327.52	a	638.52	b
	Pink passion	273.32	a	284.03	a	273.50	a	382.52	a	813.74	a
	BNT	137.78		107.39		115.40		153.90		217.63	
Leaf fresh weight (g)	Red ruby	13.28	a	9.74	a	13.21	a	18.61	a	38.41	a
	Yellow canary	12.19	a	9.39	a	9.56	a	11.20	b	23.56	b
	Pink passion	11.30	a	10.12	a	9.98	a	13.43	b	30.48	ab
	BNT	6.23		4.01		5.28		5.03		12.96	
Leaf dry weight (g)	Red ruby	0.96	a	1.07	a	1.05	a	1.44	a	3.22	a
	Yellow canary	0.83	a	0.89	a	0.80	a	1.05	a	2.01	a
	Pink passion	0.81	a	0.99	a	0.88	a	1.31	a	2.75	a
	BNT	0.43		0.44		0.51		0.71		1.37	
Petiole fresh weight (g)	Red ruby	6.31	a	7.04	a	10.23	a	10.41	a	23.52	a
	Yellow canary	6.81	a	7.13	a	7.37	a	8.71	a	16.37	a
	Pink passion	6.18	a	7.41	a	8.10	a	9.15	a	20.40	a
	BNT	3.24		2.95		3.67		4.07		8.44	
Petiole dry weight (g)	Red ruby	0.39	a	0.50	a	0.92	a	0.77	a	1.74	a
	Yellow canary	0.44	a	0.43	a	0.66	a	0.51	a	1.11	a
	Pink passion	0.33	a	0.96	a	0.71	a	0.68	a	1.70	a
	BNT	0.17		0.85		0.39		0.43		0.64	
Leaf water content (%)	Red ruby	92.24	a	88.76	b	91.69	a	91.91	a	91.61	b
	Yellow canary	93.26	a	90.13	a	91.51	a	92.74	a	93.55	a
	Pink passion	93.20	a	90.65	a	91.42	a	91.34	a	91.85	b
	BNT	1.19		1.24		1.68		1.47		1.25	
Petiole water content (%)	Red ruby	93.69	a	93.16	a	91.44	a	92.44	b	93.61	a
	Yellow canary	92.88	a	94.25	a	91.80	a	94.83	a	94.37	a
	Pink passion	94.24	a	88.41	a	90.61	a	93.39	ab	93.37	a
	BNT	2.38		4.89		1.86		2.18		1.00	

Mean followed by the same letters within each column were significantly different based on LSD at $P \leq 0.05$ for each treatment and week of data measurement; WAT – week after transplanting

Tabel 4. Effect of shading on each population on leaf thickness and SPAD value

Shading inensity	Population					
	3 plants/pot		2 plants/pot		1 plant/pot	
			Leaf width (mm)			
0%	0.39	a	0.34	a	0.28	a
45%	0.26	b	0.28	ab	0.25	a
55%	0.23	b	0.26	ab	0.27	a
80%	0.16	c	0.19	b	0.15	b
BNT	0.04		0.09		0.07	
			SPAD			
0%	33.04	a	34.27	a	33.62	a
45%	26.15	b	26.94	b	28.37	ab
55%	23.58	b	22.79	b	26.11	bc
80%	21.49	c	21.33	c	20.72	c
BNT	3.58		3.67		5.40	

Mean followed by the same letters within each column were significantly different based on LSD at $P \leq 0.05$ for each treatment and week of data measurement; WAT – week after transplanting

4. Conclusion

Reducing the intensity of sunlight in an extreme way (80%) actually inhibits the growth of Swiss chard plants. Swiss chard lives at low temperature but sill need full sunlight to fulfill metabolic processes. Prefeably, Swiss chard is planted with no shading (0%). Population 1plant/pot gives the best growth and yield of Swiss chard per plant, 3 plants/pot increased total fresh weight per cultivation area, thereby maximize the use of limited urban land.

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