

Comparison of the Combined Effect of Intra Row Spacing and Harvesting Interval on Yield and Yield Components of Swiss Chard (Beta vulgaris L.)

Zenebe Woldu* Kemal Negawo Tringo Melak Yared Gebeyaw
Wolkite University, P.O.Box 07, www.wku.edu.et, Wolkite, Ethiopia

Abstract
The study was carried out to evaluate the combined effect of intra-row spacing and harvesting interval (frequency) on yield and yield components of Swiss chard (*Beta vulgaris* L.), variety Ford Hook Giant. The experiment was laid out in a Randomized Complete Block Design (RCBD) with a 3*3 factorial arrangement in three replications. The factor levels were: 25cm, 30cm and 35 cm for intra-row spacing and 6, 12 and 18 days for harvesting interval. Statistically significant differences were observed among the treatment combinations on their effects on all parameters evaluated (yield, leaf length, leaf number and plant height) except leaf width. The highest yield (42.51 t/ha) and yield components (32.0cm average leaf length, 8.17 average leaf number/plant, 17.67cm average leaf width and 43.33cm average plant height) were obtained from the combined effects of 35cm intra-row spacing and 18 days harvesting interval. Conversely, the lowest measurements of the same parameters were recorded from the combined effects of 25cm intra-row spacing and 6 days harvesting interval. Growers under Wolkite conditions are therefore recommended to grow Swiss chard in a similar way.
Keywords: Swiss chard, intra-row spacing, harvesting interval, yield and yield components.
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1. Introduction

Swiss chard (*Beta vulgaris* L.), which is also sometimes known as spinach beet, sliver beet, seakale beet, chard leaf beet and spinach in various parts of the world, belongs to the family *Chenopodaceae* (Swiader *et al*., 1992 and Smith *et al.,* 2001). It is a highly nutritious leafy biennial vegetable crop frequently grown as fore-crop or after-crop in crop rotation system. It is widely known for its year round availability, low cost and wide utilization in many dishes (Gao *et al*., 2009). Nutritionally, it is important to alleviate widespread nutritional deficiencies since it contains high levels of vitamins (A, B1, B2, B3, B6 and C), minerals (Ca, P, Fe, Mg, Cu, Zn, Mn and K), dietary fiber, protein, chlorine, pantothenic acid as well as carbohydrates yielding about 20 kcal per 100g (Pyo *et al*., 2004; van Wyk, 2005; Faber *et al*., 2007 and George, 2015). Medicinally, it is known to have anti-oxidant values as well as a great role in cardiac health, brain function, cancer fighting, bone health, digestion and eye protection (Smith *et al.,* 2001).

Plant spacing (population density) plays an important role in optimizing the yield of leafy vegetables including Swiss chard. Too high or low plant population density may result in lower yields and quality while improper spacing can cause pest and disease incidence, which again leads to the same problem (Seid *et al.,* 2013, and Lopez *et al.,* 2005). Jenet *et al.* (2008) also reported that Swiss-chard yield and quality was influenced by different combinations of harvesting intervals and spacing.

Harvesting in Swiss-chard production technology is accomplished by removing the outer matured leaves at specified time intervals over its growing period. As reported by Amango *et al.* (2006), leaf yield was drastically reduced with continuous harvesting. Aliyu *et al*. (2002) on the other hand stated that, harvest maturity was one of the major factors that determined the composition and quality of Swiss-chard. The right time of harvesting maturity also resulted in enough amounts of physicochemical composition and antioxidant levels (Kolato *et al*., 2010).

However, due to limited technical information about its culture, different combination of the two factor levels have been used worldwide depending on the soil and climatic conditions (Grubben and Denton, 2004). Similarly, in Ethiopia, the actual spacing, harvest maturity and harvesting interval or frequency of Swiss-chard is not yet known as there is no any substantial location specific research result. This experiment was therefore initiated to study and determine the optimum combined effects of intra-row spacing and harvesting interval of Swiss chard under Wolkite conditions.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted at Wolkite University, Ethiopia, within the field trial site of the Department of Horticulture. Wolkite University is located about 158 km southwest of Addis Ababa at 7.8-8.5ºN latitude and 37.5-38.7ºE longitude with an altitude range of 1300-1400 m. The mean annual temperature ranges from 14ºC to

24°C with an average of 20.5°C. The average annual rainfall is 1294 mm and the soil type is by and large heavy vertisol.

2.2. Experimental Design and Procedure

The experiment was laid out in a Randomized Complete Block Design (RCBD) with a 3*3 factorial arrangement in three replications. The two factors and their respective levels were:

(1) Factor 1: Intra- row spacing with three levels (i.e. 25cm, 30cm and 35cm)
(2) Factor 2: Harvesting interval with three levels (6,12 and 18 days)

There were a total of nine treatment combinations and 27 experimental units. The plot size was 2.25m2. The spacing between plots and blocks were 0.5m and 1 m respectively. Seeds of the variety Ford Hook Giant were used, which were first raised under nursery condition and subsequently transplanted after 30 days of seeding. The inter-row spacing of the plants was maintained at the most commonly employed practice of 30cm.

2.3. Data collected

Data was collected periodically for the basic yield and yield components, i.e. yield (t/ha), average number of leaves/plant, average leaf width (cm), average leaf length (cm) and average plant height (cm).

2.4. Data Analysis

The experimental data were analyzed through the Analysis of Variance (ANOVA) by using GLM procedure of SAS software version 9.2. The Least Significant Differences (LSD %) test was used to determine the level of significance at 5% ($P < 0.05$).

3. Results and Discussion

3.1. Effect on Yield (t/ha)

As stated under Table 1 below, statistically significant difference ($p \leq 0.05$) was observed among the treatment combinations on their effect on the yield of Swiss chard. The highest yield (42.51 t/ha) was obtained from the treatment combination of 30cm intra-row spacing and 18 days harvesting interval. Conversely, the lowest yield (23.23 t/ha) was harvested from the lowest intra-row spacing of 25cm when combined with the lowest harvesting interval of six days.

This result of the experiment also concurs with previous findings of other researchers (Lopez *et al.* 2005, Delong *et al.,* 2011, Amaglao *et al., 2006*, Aliyu *et al.,* 2002 and Kolato *et al.,* 2010) that excessive increase in the number of plant population of Swiss chard per unit area, as a result of the narrow spacing, reduced the production of leaf weight per plant, which subsequently decreased the yield. Concurrently, they also stated that leaf yield was reduced drastically with continuous harvesting or shorter harvesting interval. Besides, the right time of maturity for harvesting of the leaves was one of the major factors that determined the physicochemical compositional quality and antioxidant levels of Swiss-chard.

Table 1. Combined effect of intra-row spacing and harvesting interval on yield (t/ha) of Swiss chard

No.	Treatment	Av. yield (t/ha)
1	25cm x 6 days	23.23^{bc}
2	25cm x 12 days	31.12^{abc}
3	25 cm x 18 days	39.84^{ab}
4	30cm x 6 days	25.61^{bc}
5	30cm x 12 days	38.32^{ab}
6	30 cm x 18 days	37.13^{abc}
7	35 cm x 6 days	37.72^{abc}
8	35 cm x 12 days	36.95^{abc}
9	35 cm x 18 days	42.51^{a}
	LSD (0.05)	8.214
	CV (%)	12.5

Means indicated by the same letter are not significantly different at 5% level of significance ($P \leq 0.05$), using Fishers' protected t-test.

3.2. Effect on Leaf Number

As depicted under Table 2 below, most of the treatment combinations showed statistically significant difference on their effect on leaf number of Swiss chard. While the highest average leaf number (8.17) was recorded from the treatment combinations of 35cm x 12 days and 25cm x 18 days, the lowest (5.75) was recorded from the narrowest intra-row spacing of 25cm and the shortest harvesting interval of 6 days. This result also agrees with the previous findings of Yemane *et al.* (2013) that the highest intra-row spacing of 10cm was superior in its effect on plant height and leaf number per plant of onion. Similarly, Melak Agajie (2018) reported that the number of primary branches of chickpea was increased as the intra-row spacing increased and there was a progressive increase of the number of pods per plant as both the inter and intra-row spacing increased. He further stated that for all the inter-row spacing variables tested, the harvest index of chickpea was increased as the intra-row spacing increased.

Table 2. Combined effect of intra-row spacing and harvesting interval on leaf number of Swiss-Chard

No.	Treatment	Av. leaf number/plant
1	25cm x 6 days	5.75^{b}
2	25cm x 12 days	6.92^{ab}
3	25 cm x 18 days	7.17^{ab}
4	30cm x 6 days	7.22^{ab}
5	30cm x 12 days	7.22^{ab}
6	30 cm x 18 days	7.11^{ab}
7	35 cm x 6 days	7.00^{ab}
8	35 cm x 12 days	8.17^{a}
9	35 cm x 18 days	8.17^{a}
	LSD (0.05)	1.602
	CV (%)	12.9

Means indicated by the same letter are not significantly different at 5% level of significance (P ≤ 0.05), using Fishers' protected t-test.

3.3. Effect on Plant Height (cm)

As shown under Table 3 below, most of the treatment combinations, except 25cm x 6 days and 35cm x 18 days, showed statistically none significant difference on their effect on plant height of Swiss chard. Similarly, while the highest average plant height (43.33cm) was recorded from the largest treatment combination of 35cm x 18 days, the lowest (31.33cm) was recorded from 25cm x 6 days. This result also agrees with previous findings of Yemane *et al*. (2013) that the highest intra-row spacing of 10cm was superior in its effect on plant height and leaf number per plant of onion.

Table 3. Combined effect of intra-row spacing and harvesting interval on plant height (cm) of Swiss-Chard

No.	Treatment	Av. plant height (cm)
1	25cm x 6 days	31.33^{c}
2	25cm x 12 days	35.58^{abc}
3	25 cm x 18 days	41.25^{ab}
4	30cm x 6 days	33.33^{bc}
5	30cm x 12 days	39.00^{abc}
6	30 cm x 18 days	38.00^{abc}
7	35 cm x 6 days	38.50^{abc}
8	35 cm x 12 days	36.67^{abc}
9	35 cm x 18 days	43.33^{a}
	LSD (0.05)	8.394
	CV (%)	13.0

Means indicated by the same letter are not significantly different at 5% level of significance (P ≤ 0.05), using Fishers' protected t-test.

3.4. Effect on Leaf Length (cm)

Table 4 below shows that all the treatment combinations, other than 25 cm x 6 days and 35 cm x 18 days, showed statistically none significant difference on their effect on leaf length of Swiss chard. While the highest leaf length (32cm) was obtained from the treatment combination of 35cm x 18 days, the lowest (24cm) was recorded from treatment combination 25cm x 6 days.

Table 4. Combined effect of intra-row spacing and harvesting interval on leaf length (cm) of Swiss chard

No.	Treatment	Av. leaf length/plant (cm)
1	25cmx 6 days	24.00[b]
2	25cmx 12 days	25.42[ab]
3	25 cm x 18 days	29.92[ab]
4	30cm x 6 days	26.33[ab]
5	30cm x 12 days	27.33[ab]
6	30 cm x 18 days	29.33[ab]
7	35 cm x 6 days	29.17[ab]
8	35 cm x 12 days	29.00[ab]
9	35 cm x 18 days	32.00[a]
	LSD (0.05)	7.556
	CV (%)	15.6

Means indicated by the same letter are not significantly different at 5% level of significance ($P \leq 0.05$), using Fishers' protected t-test.

3.5. Effect on Leaf Width (cm)

Unlike in the other parameters evaluated, all the treatment combinations showed statistically none significant difference on their effect on leaf width of Swiss chard (Table 5). However, the highest leaf width (17.67cm) was again obtained from the combined effect of 35cm intra-row spacing and 18 days harvesting interval while the least (14.08cm) was recorded from the lowest treatment combination of 25cm x 6 days.

Table 5. Combined effect of intra-row spacing and harvesting interval on leaf width (cm) of Swiss-Chard

No.	Treatment	Av. leaf width/plant (cm)
1	25cm x 6 days	14.08[a]
2	25cm x 12 days	14.75[a]
3	25 cm x 18 days	16.33[a]
4	30cm x 6 days	15.44[a]
5	30cm x 12 days	15.78[a]
6	30 cm x 18 days	15.89[a]
7	35 cm x 6 days	14.67[a]
8	35 cm x 12 days	16.00a
9	35 cm x 18 days	17.67[a]
	LSD (0.05)	4.465
	CV (%)	16.5

Means indicated by the same letter are not significantly different at 5% level of significance ($P \leq 0.05$), using Fishers' protected t-test.

4. Concluding Remarks

All the treatment combinations, other than 25cm x 6 days and 35cm x 18 days, showed statistically none significant difference on their effect on leaf length of Swiss chard.

While the highest average leaf number (8.17) was obtained from the treatment combinations of 35cm x 12 days and 25cm x 18 days, the lowest (5.75) was recorded from 25cm x 6 days.

All the treatment combinations showed statistically none significant difference on their effect on leaf width of Swiss chard. However, the highest average leaf width (17.67cm) was recorded from the combined effect of 35 cm intra-row spacing and 12 days harvest interval.

While the highest average plant height (43.33cm) was obtained from the treatment combination of 35cm x 18 days, the lowest (31.33 cm) was recorded from 25cm x 6 days.

Therefore, since the highest yield (42.51 t/ha) and yield components (32.0cm average leaf length, 8.17 average leaf number, 17.67cm average leaf width and 43.33cm average plant height) were obtained from the combined effect of 35 cm intra-row spacing and 18 days harvesting interval, Swiss chard growers under conditions similar to Wolkite are recommended to use the same treatment combination.

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