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Influence of different varieties and planting density on quality, biochemical and sensory attributes of Swiss chard (*Beta vulgaris* L. var. *cicla*)

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Abstract
A field experiment was conducted during the winter season of 2025–26 at the Instructional-cum-Research Farm, Rajarshee Chhatrapati Shahu Maharaj Government College of Agriculture, Kolhapur, Maharashtra, to evaluate the influence of five Swiss chard varieties and three planting densities on quality, biochemical and sensory attributes. The experiment was laid out in a Factorial Randomized Block Design with three replications. Quality parameters included leaf colour and petiole colour, biochemical parameters included moisture content, and chlorophyll content, and sensory evaluation of crispness and texture using a nine-point Hedonic scale. Significant varietal differences were observed for moisture and chlorophyll content. Barese White recorded the highest moisture content (96.37%), while Swiss chard Green recorded the maximum chlorophyll content (1.60 mg g^{-1}). Sensory evaluation showed that Barese White received the highest overall acceptability rating (7.13), followed by Swiss chard Green (6.80) and Yellow Dorat (6.73). Planting density had no significant effect on biochemical or sensory quality attributes, although the closer spacing of 30 × 20 cm recorded slightly higher sensory scores. The study indicates that quality characteristics of Swiss chard are primarily governed by varietal differences rather than planting density. Barese White was found superior for moisture content and consumer acceptability, whereas Swiss chard Green was superior for chlorophyll content. For fresh market production under Kolhapur conditions, cultivation of Barese White at 30 × 20 cm spacing is recommended.

Keywords: Swiss chard, varieties, planting density, quality, sensory evaluation, chlorophyll, moisture content, consumer acceptability

1. Introduction

Leafy vegetables are important components of a balanced diet as they provide essential vitamins, minerals, dietary fibre, and bioactive compounds that contribute to human health and nutritional security (Kumar *et al*., 2024; Srivastava *et al*., 2024) [6, 15]. Among them, Swiss chard (*Beta vulgaris* L. var. *cicla*), a member of the family Chenopodiaceae, has gained increasing attention due to its high nutritional value, adaptability, and year-round production potential (Boswell *et al*., 2021) [2].

Swiss chard is an excellent source of vitamins A, C, and K, along with important minerals such as calcium, magnesium, potassium, and iron (Gamba *et al*., 2021; Ivanović *et al*., 2019) [4]. In addition, its leaves contain abundant phenolic compounds and flavonoids, including syringic acid, kaempferol, and vitexin derivatives, which possess strong antioxidant activity and help reduce oxidative stress and the risk of chronic diseases (Pyo *et al*., 2004; Ninfali *et al*., 2007) [9, 13]. The nutritional composition and antioxidant potential of Swiss chard are influenced by genotype and cultivation practices, making the selection of suitable varieties and planting density important for improving produce quality (Ozbek and Saral, 2023; Pokluda and Kuben, 2002) [10, 12].

Quality attributes, biochemical constituents, and sensory characteristics determine consumer acceptance and market value of leafy vegetables. Varietal differences and planting density can influence chlorophyll content, moisture content, colour, texture, crispness, and overall acceptability. However, limited information is available on the combined effect of different

varieties and planting density on these attributes under the agro-climatic conditions of western Maharashtra.
Therefore, the present investigation was undertaken to evaluate the effect of different varieties and planting density on the quality, biochemical, and sensory attributes of Swiss chard under open-field conditions.

2. Objectives
1. To study the effect of planting density on quality of different Swiss chard varieties.
2. To evaluate the effect of planting density on biochemical characters of different Swiss chard varieties.
3. To assess the sensory attributes of different Swiss chard varieties under different planting densities.

3. Materials and Methods
3.1 Experimental Site
The experiment was conducted during the winter season of 2025-26 (November 2025 to January 2026) at the Instructional-cum-Research Farm of the Horticulture Section, Rajarshee Chhatrapati Shahu Maharaj Government College of Agriculture, Kolhapur, Tal. Karveer, Dist. Kolhapur, Maharashtra.

3.2 Experimental Design and Treatments

Particulars	Description
Crop	Swiss chard (*Beta vulgaris* L. var. *cicla*)
Season	November 2025 - January 2026
Design	Factorial Randomized Block Design (FRBD)
Replications	3
Factors	2 (Varieties and Spacing)
Treatment Combinations	15
Net Plot Size	1.8 m × 1.8 m
Observational Plants	5 plants per plot
Fertilizer Dose	FYM + 80:40:40 N:P_2O_5:K_2O kg/ha

Factor A: Varieties (5)
- V_1: Barese White
- V_2: Golden Sunrise
- V_3: Red Rhubarb
- V_4: Yellow Dorat
- V_5: Swiss chard Green

Factor B: Planting Density/Spacing (3)
- S_1: 45 cm × 30 cm (24 plants/plot)
- S_2: 30 cm × 30 cm (36 plants/plot)
- S_3: 30 cm × 20 cm (54 plants/plot)

3.3 Crop Establishment and Management
Seeds were sown on 10 November 2025 in protrays, and healthy seedlings were transplanted on 11 December 2025 into the experimental field according to the respective treatment combinations. Recommended agronomic practices, including irrigation, nutrient management, intercultural operations, and plant protection measures, were followed uniformly throughout the crop growth period

3.4 Observations Recorded
3.4.1 Quality Characters
3.4.1.1 Leaf Colour
Leaf colour was recorded by visual observation at the marketable stage of the crop and expressed qualitatively.

3.4.1.2 Petiole Colour
Petiole colour was recorded by visual observation at the marketable stage and expressed qualitatively.

3.4.2 Biochemical Characters
3.4.2.1 Moisture Content (%)
Moisture content of Swiss chard leaves was determined by the oven-drying method and calculated by formula,
Moisture content = [(Initial weight- final weight)/Initial weight] × 100

3.4.2.2 Chlorophyll Content (mg/g)
Total chlorophyll content of Swiss chard leaves was estimated following the standard procedure described by Sadashivam and Manickam (1992) and was recorded at 645 and 663 nm using a spectrophotometer.

3.4.3 Sensory Evaluation
The Swiss chard samples were evaluated organoleptically for crispness and texture by a panel of five judges using a nine-point Hedonic scale as described by Amerine *et al.* (1965) [1].

3.5 Statistical Analysis
The experimental data were subjected to statistical analysis by adopting the appropriate for a Factorial Randomized Block Design (FRBD) by Panse and Sukhatme (1985) [11]. The significance of treatment differences was tested at the 5% level of significance. The standard error of mean [SE(m) ±] and critical difference (CD) were worked out wherever treatment effects were found to be significant.

4. Results and discussion
4.1 Quality Characters
4.1.1 Leaf colour
Leaf colour remained uniformly green across all Swiss chard varieties and was not affected by planting density. No noticeable variation in leaf colour intensity was observed among the treatments, indicating that leaf colour is a stable varietal characteristic under the present experimental conditions.

4.1.2 Petiole colour
Distinct variation in petiole colour was observed among the Swiss chard varieties, whereas planting density had no effect on this trait. Barese White (V_1) and Swiss Chard Green (V_5) exhibited white petioles, Golden Sunrise (V_2) and Yellow Dorat (V_4) had yellow petioles, while Red Rhubarb (V_3) produced red petioles. The stability of petiole colour across different spacing treatments indicates that this character is primarily controlled by genetic factors rather than agronomic practices. The observed varietal differences in petiole colour may enhance the visual appeal and market preference of Swiss chard. Similar findings have been reported by Pokluda and Kuben (2002), Bozokalfa *et al.* (2016), and Moratagi *et al.* (2021) [3, 7, 12]

4.2 Biochemical Characters
4.2.1 Moisture Content
Moisture content was significantly influenced by varieties, whereas the effects of planting density and the interaction between varieties and planting density were non-significant (Table 1). Among the varieties, Barese White (V_1) recorded the highest moisture content (96.37%), followed by Swiss

Chard Green (V_5) (95.81%), while Red Rhubarb (V_3) recorded the lowest moisture content (90.99%). The higher moisture content observed in Barese White may be attributed to its superior water-holding capacity and succulent leaf tissues, which contribute to improved freshness and consumer acceptability. The non-significant effect of planting density indicates that moisture content is primarily governed by genetic factors rather than spacing under the present experimental conditions. These findings are in agreement with the reports of Nath *et al.* (2020) [8] in Spinach, who also observed significant varietal differences in the quality attributes of Swiss chard.

Table 1: Moisture content (%) of Swiss chard as influenced by varieties and spacing

Treatment	S_1 (45×30 cm)	S_2 (30×30 cm)	S_3 (30×20 cm)	Variety Mean
V_1: Barese White	95.84	96.15	97.10	96.37
V_2: Golden Sunrise	95.29	94.48	94.57	94.78
V_3: Red Rhubarb	90.47	90.44	92.06	90.99
V_4: Yellow Dorat	93.84	93.05	91.98	92.96
V_5: Swiss chard Green	95.93	94.39	96.55	95.62
Spacing Mean	94.27	93.70	94.45	94.14

Source	SEm±	CD@5%	CV
Variety	0.56	1.63	1.80
Spacing	0.44	NS	
Interaction	0.98	NS	

4.2.2 Chlorophyll Content

Chlorophyll content was significantly influenced by varieties, whereas the effects of planting density and the interaction between varieties and planting density were non-significant (Table 2). Among the varieties, Swiss Chard Green (V_5) recorded the highest chlorophyll content (1.60 mg g^{-1}), followed by Red Rhubarb (V_3) and Yellow Dorat (V_4) (1.58 mg g^{-1}), while Golden Sunrise (V_2) recorded the lowest chlorophyll content (1.51 mg g^{-1}). The higher chlorophyll content observed in Swiss Chard Green may be attributed to its genetic potential for greater chlorophyll synthesis and pigment accumulation. The non-significant effect of planting density indicates that chlorophyll content remained relatively stable across the spacing levels evaluated. These findings are in agreement with those of Sahil *et al.* (2023) [14] in lettuce and Tejaswi *et al.* (2024) [16] in Palak, who also reported significant varietal variation in the biochemical quality attributes of Swiss chard

Table 2: Chlorophyll content (mg/g) of Swiss chard as influenced by varieties and spacing

Treatment	S_1 (45×30 cm)	S_2 (30×30 cm)	S_3 (30×20 cm)	Variety Mean
V_1: Barese White	1.55	1.54	1.56	1.55
V_2: Golden Sunrise	1.48	1.58	1.47	1.51
V_3: Red Rhubarb	1.60	1.53	1.61	1.58
V_4: Yellow Dorat	1.58	1.62	1.54	1.58
V_5: Swiss chard Green	1.60	1.61	1.60	1.60
Spacing Mean	1.56	1.58	1.55	1.56

Source	SEm±	CD@5%	CV
Variety	0.02	0.05	3.44
Spacing	0.01	NS	
Interaction	0.03	NS	

4.3 Sensory Evaluation

The highest variety mean rating for crispness and texture was observed in Barese White (V_1) (7.13) followed by Swiss chard Green(V_5), Yellow Dorat(V_4), Golden Sunrise (V_2) and Red Rhubarb (V_3) with rating of 6.80, 6.73, 6.67 and 6.60, respectively. The maximum spacing mean rating was 6.96 observed in 30 × 20 cm (S_3) followed by 45 × 30 cm (S_1) and 30 × 30 cm (S_2) with ration of 6.80 and 6.60, respectively.

Table 3: Sensory evaluation of Swiss chard (Hedonic scale rating)

Varieties	Spacing	character		Variety mean
		Crispness	Texture	
Barese White	45 × 30 cm (S_1)	7.2	7.2	7.13
	30 × 30 cm (S_2)	6.8	7.0	
	30 × 20 cm (S_3)	7.2	7.4	
Golden Sunrise	45 × 30 cm (S_1)	6.6	6.6	6.67
	30 × 30 cm (S_2)	6.8	6.4	
	30 × 20 cm (S_3)	7.0	6.6	
Red Rhubarb	45 × 30 cm (S_1)	6.4	6.4	6.60
	30 × 30 cm (S_2)	6.4	6.4	
	30 × 20 cm (S_3)	7.2	6.8	
Yellow Dorat	45 × 30 cm (S_1)	7.2	6.8	6.73
	30 × 30 cm (S_2)	6.4	6.4	
	30 × 20 cm (S_3)	7.0	6.6	

Swiss chard Green	45 × 30 cm (S_1)	6.4	7.2	6.80
	30 × 30 cm (S_2)	6.8	6.6	
	30 × 20 cm (S_3)	6.4	7.4	
Spacing Mean	45 × 30 cm (S_1)	30 × 30 cm (S_2)	30 × 20 cm (S_3)	
	6.80	6.60	6.96	

5. Conclusion

The present study demonstrated that quality, biochemical, and sensory attributes of Swiss chard were predominantly influenced by varietal differences, whereas planting density had no significant effect on most of these parameters. Barese White exhibited superior moisture content and sensory acceptability, while Swiss Chard Green recorded the highest chlorophyll content. Leaf and petiole colours were found to be stable varietal characteristics and remained unaffected by planting density. Although the closer spacing (30 × 20 cm) produced slightly better sensory scores, the differences among spacing treatments were not significant. Therefore, Barese White may be recommended for superior eating quality and consumer acceptability, whereas Swiss Chard Green may be preferred for enhanced chlorophyll content and nutritional quality under the agro-climatic conditions of western Maharashtra.

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