

Original Research Article
**PERFORMANCE OF VARIETIES
AND STANDARDIZATION OF SPACINGS ON
GROWTH PARAMETERS IN PALAK (*Beta
vulgaris* var. *bengalensis* Roxb.) UNDER
SUMMER CONDITIONS IN THE CENTRAL
TELANGANA ZONE**

ABSTRACT

A study entitled performance of varieties and standardization of spacings on growth parameters in palak. It was Factorial Randomized Block Design, with two factors (three varieties, four spacings) and three replications, conducted at Post Graduate Institute for Horticultural Sciences, Sri Konda Laxman Telangana Horticultural University, Mulugu from March to June 2024. The results revealed that Arka Anupama recorded maximum number of leaves per plant (10.51, 13.76, 12.36 and 11.35), length of leaves (13.88 cm, 14.64 cm, 12.85 cm and 12.53 cm), width of leaves (9.00 cm, 9.28 cm, 7.87 cm and 7.15 cm) at 1st, 2nd, 3rd and 4th cuttings, leaf area (100.00 cm²) and leaf area index (1.51). The maximum plant height (23.35 cm, 26.99 cm, 25.59 cm and 20.46 cm) and length of leaf petiole (8.99 cm, 10.50 cm, 9.88 cm and 7.90 cm) was recorded in All Green tall cuttings. A 30 cm × 15 cm spacing recorded maximum plant height (23.53 cm, 27.11 cm, 25.46 cm and 20.36 cm), number of leaves per plant (10.13, 13.55, 12.13 and 11.11), length of leaf petiole (9.38 cm, 10.97 cm, 10.31 cm and 8.24 cm), length of leaves (15.20 cm, 15.89 cm, 13.92 cm and 13.57 cm), width of leaves (9.89 cm, 10.20 cm, 8.64 cm and 7.85 cm) at all cuttings and leaf area (109.96 cm²). Highest leaf area index (1.11) was recorded in 30 cm × 10 cm spacing. The V₁S₄ (Arka Anupama, 30 cm × 15 cm) exhibited maximum number of leaves, length of leaves, width of leaves and leaf area, while plant height and length of leaf petiole were highest in V₂S₄ (All Green, 30 cm × 15 cm). V₁S₁ (Arka Anupama, 25 cm × 10 cm) recorded highest leaf area index on par with V₁S₃ (Arka Anupama, 30 cm × 10 cm).

Keywords: Palak, varieties, spacings, growth

1. INTRODUCTION

Palak (*Beta vulgaris* var. *bengalensis* Roxb.) is a major leafy vegetable crop [4], belongs to the family Chenopodiaceae [5] and is closely related to beetroot and chard, with a diploid chromosome number of $2n=18$. Palak originated in the Indo-Chinese region. Other names for palak include spinach beet, desi palak and beet leaf.

The edible parts of palak are the tender, succulent leaves and petioles [4]. Palak leaves are a rich source of vitamin A (9770 IU), vitamin C (70 mg), calcium (380 mg), phosphorus (30 mg) and iron (16.2 mg). Palak also contains considerable amounts of protein (3.4 g), minerals (2.2 g), carbohydrates (6.5 g), fat (0.8 g), fiber (0.7 g), nicotinic acid (3.3 mg), thiamine (0.26 mg), riboflavin (0.56 mg) and moisture (86.4 %) [5].

Varietal assessment among different varieties is necessary to compare varieties with local cultivars [2]. Among various agronomic techniques, optimizing plant density was

Comment [A1]: Where are the varieties and the spacings.

Comment [A2]: Many numbers for the results in the abstract, it should be only for the important results.

fundamental for increasing yield and the benefit-cost ratio per unit area. Higher plant density could maximize competition between plants for essential growth resources, which led to decreased yield. Conversely, lower plant density could diminish the effectiveness of inputs. Therefore, achieving the ideal plant density was crucial for allowing crops to reach their genetic potential through the effective use of growth resources [8].

Considering the above factors, the present study titled "Performance of varieties and standardization of spacings on growth parameters in palak (*Beta vulgaris* var. *bengalensis*Roxb.) under Summer conditions in the Central Telangana Zone" was initiated.

2. MATERIAL AND METHODS

The experiment was conducted at the university farm of the Post Graduate Institute for Horticultural Sciences, Mulugu, Siddipet, Sri Konda Laxman Telangana Horticultural University, from March 2024 to June 2024. The experimental site was located at a latitude of 17°43'02" N and a longitude of 78°37'48"E. The experiment design was a Factorial Randomized Block Design with two factors (varieties, spacing) and three replications. There were three levels of varieties and four levels of spacing.

2.1 Treatment details

Factor 1: Varieties

V₁: Arka Anupama
V₂: All Green
V₃: Mulayam

Factor 2: Spacings

S₁: 25 cm × 10 cm
S₂: 25 cm × 15 cm
S₃: 30 cm × 10 cm
S₄: 30 cm × 15 cm

2.2 Treatment combinations

V₁S₁: Arka Anupama + 25 cm × 10 cm
V₁S₂: Arka Anupama + 25 cm × 15 cm
V₁S₃: Arka Anupama + 30 cm × 10 cm
V₁S₄: Arka Anupama + 30 cm × 15 cm
V₂S₁: All Green + 25 cm × 10 cm
V₂S₂: All Green + 25 cm × 15 cm
V₂S₃: All Green + 30 cm × 10 cm
V₂S₄: All Green + 30 cm × 15 cm
V₃S₁: Mulayam + 25 cm × 10 cm
V₃S₂: Mulayam + 25 cm × 15 cm
V₃S₃: Mulayam + 30 cm × 10 cm
V₃S₄: Mulayam + 30 cm × 15 cm

The experimental field was thoroughly tilled, divided into 36 beds, each measuring 1 m × 3 m with a height of 0.15 m. At the time of the last ploughing, FYM (20 t/ha) was applied. The seeds were sown by opening the small furrows, 3 cm deep, with the help of a sickle. The seeds were dibbled into the soil and then covered with fine soil. Immediate irrigation after sowing and regular irrigation was provided. Regular weeding was done at 15-20 days intervals. Thinning and gap filling were performed 15 days after sowing. Four

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Comment [A4]: For leafy crops it is Preferably to use plant density than plant spacings.

cuttings were performed at 35, 55, 75 and 95 days after sowing by cutting the green leaves with the petiole from 5 cm above ground level.

Observations on growth parameters were taken one day before harvesting (cutting) from ten tagged plants in each treatment. Data on plant height (cm), length of leaf petiole (cm), length of leaves (cm), width of leaves (cm) were measured using a meter scale and number of leaves per were counted. Leaf area was recorded using a Leaf area meter. Leaf area index was calculated by the leaf area per plant (cm^2) to the land area occupied by each plant (cm^2) [9]. The data were analyzed statistically using the analysis of variance procedure for a factorial randomized block design [6].

3. RESULTS AND DISCUSSION

3.1 Plant height (cm)

The data presented in Table 1 showed that there was significant variation among varieties and spacings with respect to the plant height (cm).

Among the varieties, highest plant height (23.35 cm, 26.99 cm, 25.59 cm and 20.46 cm) was recorded for V_2 (All Green) and lowest plant height (18.93 cm, 22.53 cm, 21.04 cm and 16.83 cm) was observed for V_3 (Mulayam) at the initial, second, third and fourth cutting phases. Height of the plant (23.53 cm, 27.11 cm, 25.46 cm and 20.36 cm) was recorded highest in S_4 (30 cm \times 15 cm), while the lowest plant height (18.90 cm, 22.57 cm, 21.24 cm and 16.99 cm) was recorded in S_1 (25 cm \times 10 cm) at the initial, second, third and fourth cutting phases.

The interaction between varieties and spacing significantly affected plant height at 3rd and 4th cuttings. The maximum height of the plant (27.11 cm and 21.68 cm) was observed in V_2S_4 (All Green, 30 cm \times 15 cm) and least height of the plant (18.87 cm and 15.09 cm) was recorded in V_3S_1 (Mulayam, 25 cm \times 10 cm) at the 3rd and 4th cuttings.

Greater airspace for vegetative growth, reduced competition between plants and improved access to derive soil nutrients contributed to the increased plant height observed with wider spacing. This investigation provided results similar to those of Mahindrakar and Kulkarni [3] in palak and Shah[7] in palak.

3.2 Number of leaves per plant

The data presented in Table 1 showed that there was significant variation among varieties and spacings with respect to the number of leaves per plant.

A greater leaf number per individual plant (10.51, 13.76, 12.36 and 11.35) was noted in V_1 (Arka Anupama), while the least number of leaves per plant (6.92, 10.23, 8.52 and 7.51) was obtained in V_2 (All Green) at the initial, second, third and fourth cutting phases. Maximum leaf number per individual plant (10.13, 13.55, 12.13 and 11.11) was recorded in S_4 (30 cm \times 15 cm), while the least number of leaves per plant (7.18, 10.44, 8.89 and 7.90) was recorded in S_1 (25 cm \times 10 cm) at the initial, second, third and fourth cutting phases.

The interaction between varieties and spacing significantly impacted the leaf number per individual plant at 1st and 2nd cuttings. The maximum leaf number per individual plant (12.17 and 15.50) was obtained in V_1S_4 (Arka Anupama, 30 cm \times 15 cm), while the least leaf number per individual plant (5.61 and 8.89) was noted in V_2S_1 (All Green, 25 cm \times 10 cm) at the 1st and 2nd cuttings.

Due to competition between plants for growth resources caused by increased plant population with narrower spacing showed fewer leaves. On the other hand, plants that

Comment [A5]: The competition between plant at the small spacing 25X 10 cm should increase plant height, due to competition for sun light.

V ₁	21.16	24.80	23.34	18.67	10.51	13.76	12.36	11.35
V ₂	23.35	26.99	25.59	20.46	6.92	10.23	8.52	7.51
V ₃	18.93	22.53	21.04	16.83	8.64	11.93	10.60	9.59
S.E.m±	0.11	0.14	0.12	0.10	0.04	0.06	0.06	0.05
CD (5 %)	0.31	0.40	0.36	0.29	0.11	0.17	0.16	0.15
Spacings								
S ₁	18.90	22.57	21.24	16.99	7.18	10.44	8.89	7.90
S ₂	21.76	25.31	23.99	19.19	9.24	12.57	11.09	10.09
S ₃	20.40	24.09	22.59	18.07	8.21	11.34	9.86	8.84
S ₄	23.53	27.11	25.46	20.36	10.13	13.55	12.13	11.11
S.E.m±	0.13	0.16	0.14	0.12	0.04	0.07	0.06	0.06
CD (5 %)	0.36	0.46	0.41	0.33	0.13	0.20	0.18	0.17
Interaction								
V ₁ S ₁	19.00	22.56	21.05	16.83	8.90	12.21	10.72	9.70
V ₁ S ₂	21.61	25.26	24.25	19.39	11.06	14.39	12.89	11.91
V ₁ S ₃	20.38	24.08	22.28	17.82	9.92	12.94	11.77	10.75
V ₁ S ₄	23.65	27.30	25.80	20.63	12.17	15.50	14.07	13.05
V ₂ S ₁	20.99	24.78	23.80	19.04	5.61	8.89	7.09	6.11
V ₂ S ₂	24.14	27.56	26.15	20.91	7.29	10.58	9.14	8.12
V ₂ S ₃	22.74	26.50	25.29	20.22	6.52	9.83	7.77	6.76
V ₂ S ₄	25.55	29.12	27.11	21.68	8.26	11.62	10.07	9.05
V ₃ S ₁	16.72	20.38	18.87	15.09	7.02	10.22	8.88	7.90
V ₃ S ₂	19.52	23.10	21.59	17.27	9.38	12.75	11.25	10.23
V ₃ S ₃	18.10	21.71	20.22	16.17	8.20	11.24	10.03	9.01
V ₃ S ₄	21.40	24.92	23.48	18.78	9.97	13.52	12.24	11.22
S.E.m±	0.22	0.28	0.25	0.20	0.08	0.12	0.11	0.10
CD (5 %)	NS	NS	0.71	0.58	0.22	0.35	NS	NS

Factor 1: V₁: Arka Anupama, V₂: All Green, V₃: Mulayam

Factor 2: S₁: 25 cm × 10 cm, S₂: 25 cm × 15 cm, S₃: 30 cm × 10 cm, S₄: 30 cm × 15 cm

3.5 Width of leaves (cm)

The data presented in Table 3 showed that there was significant variation among varieties and spacings with respect to the width of leaves.

The highest leaf width (9.00 cm, 9.28 cm, 7.87 cm and 7.15 cm) was noted in V₁ (Arka Anupama), while the lowest leaf width (6.85 cm, 7.06 cm, 5.98 cm and 5.43 cm) was obtained in V₂ (All Green) at the 1st, 2nd, 3rd and 4th cuttings. The highest leaf width (9.89 cm, 10.20 cm, 8.64 cm and 7.85 cm) was noted in S₄ (30 cm × 15 cm) and lowest leaf width (5.94 cm, 6.12 cm, 5.19 cm and 4.71 cm) was noted in S₁ (25 cm × 10 cm) at the initial, second, third and fourth cutting phases.

Highest leaf width (11.28 cm, 11.63 cm, 9.86 cm and 8.96 cm) was obtained in V₁S₄ (Arka Anupama, 30 cm × 15 cm) and lowest leaf width (5.01 cm, 5.17 cm, 4.38 cm and 3.98 cm) was recorded in V₂S₁ (All Green, 25 cm × 10 cm) at the initial, second, third and fourth cutting phases.

Table.2 Effect of varieties and spacings on length of leaf petiole (cm) and length of leaves (cm) in palak

Treatments	Length of leaf petiole (cm)	Length of leaves (cm)
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	1 st cut	2 nd cut	3 rd cut	4 th cut	1 st cut	2 nd cut	3 rd cut	4 th cut
Varieties								
V ₁	7.87	9.20	8.65	6.91	13.88	14.64	12.85	12.53
V ₂	8.99	10.50	9.88	7.90	11.91	12.78	11.25	10.98
V ₃	7.19	8.41	7.90	6.32	10.67	11.61	10.25	10.01
S.E.m±	0.04	0.05	0.05	0.04	0.06	0.07	0.05	0.06
CD (5 %)	0.12	0.13	0.13	0.10	0.18	0.19	0.16	0.18
Spacings								
S ₁	6.67	7.78	7.33	5.86	9.32	10.34	9.16	8.95
S ₂	8.40	9.82	9.23	7.38	12.95	13.77	12.10	11.81
S ₃	7.62	8.91	8.37	6.69	11.13	12.05	10.62	10.37
S ₄	9.38	10.97	10.31	8.24	15.20	15.89	13.92	13.57
S.E.m±	0.05	0.05	0.05	0.04	0.07	0.08	0.06	0.07
CD (5 %)	0.13	0.15	0.15	0.12	0.21	0.22	0.18	0.20
Interaction								
V ₁ S ₁	6.64	7.76	7.29	5.83	10.92	11.85	10.45	10.20
V ₁ S ₂	8.24	9.64	9.06	7.24	14.78	15.49	13.58	13.24
V ₁ S ₃	7.52	8.80	8.26	6.60	12.55	13.39	11.77	11.49
V ₁ S ₄	9.08	10.62	9.98	7.98	17.26	17.84	15.60	15.20
V ₂ S ₁	7.57	8.78	8.32	6.65	9.11	10.13	8.98	8.78
V ₂ S ₂	9.33	10.91	10.25	8.19	12.65	13.48	11.86	11.57
V ₂ S ₃	8.54	9.99	9.39	7.50	11.00	11.92	10.51	10.27
V ₂ S ₄	10.53	12.32	11.58	9.25	14.88	15.59	13.66	13.32
V ₃ S ₁	5.82	6.80	6.39	5.11	7.95	9.04	8.04	7.86
V ₃ S ₂	7.64	8.93	8.39	6.71	11.43	12.33	10.87	10.61
V ₃ S ₃	6.80	7.95	7.47	5.97	9.85	10.84	9.59	9.36
V ₃ S ₄	8.53	9.97	9.37	7.49	13.45	14.24	12.50	12.19
S.E.m±	0.08	0.09	0.09	0.07	0.13	0.13	0.11	0.12
CD (5 %)	NS	0.25	NS	NS	0.36	0.38	0.33	0.35

Factor 1: V₁: Arka Anupama, V₂: All Green, V₃: Mulayam

Factor 2: S₁: 25 cm × 10 cm, S₂: 25 cm × 15 cm, S₃: 30 cm × 10 cm, S₄: 30 cm × 15 cm

This was probably due to the greater spacing between plants, which resulted in more nutrient absorption, sunlight exposure and soil moisture reaching the growing regions of the plant, thereby leading to a greater leaf width. The results were consistent with findings by Addula[1] in beetroot.

3.6 Leaf area (cm²)

The data presented in Table 3 showed that there was significant variation among varieties and spacings with respect to the leaf area (cm²).

V₁ (Arka Anupama) exhibited the maximum leaf area (100.00 cm²), and the lowest leaf area (75.79 cm²) was recorded in V₂ (All Green). S₄ (30 cm × 15 cm) exhibited the maximum leaf area (109.96 cm²), while the minimum leaf area (65.63 cm²) was noted in S₁ (25 cm × 10 cm).

The maximum leaf area (125.57 cm²) was obtained in V₁S₄ (Arka Anupama, 30 cm × 15 cm), followed by V₃S₄ (Mulayam, 30 cm × 15 cm) with 107.56 cm². The lowest leaf area (55.22 cm²) was recorded in V₂S₁ (All Green, 25 cm × 10 cm).

Plants under wider spacing created a more beneficial environment for water, solar energy exposure and nutrient absorption, which may have resulted in the largest leaf area. This investigation was comparable to those of Shah[7] in palak and Sruthy [8] in palak.

3.7 Leaf area index (LAI)

The data presented in Table 3 showed that there was significant variation among varieties and spacings with respect to the Leaf area index (LAI).

The maximum leaf area index (1.51) was obtained in V_1 (Arka Anupama), while least leaf area index (0.63) was noted in V_2 (All Green). The greatest leaf area index (1.11) was obtained in S_3 (30 cm × 10 cm). The smallest leaf area index (1.03) was recorded in S_4 (30 cm × 15 cm). The varieties and spacing recorded a positive impact on leaf area index.

Maximum leaf area index (1.57) was obtained in V_1S_1 (Arka Anupama, 25 cm × 10 cm) on par with V_1S_3 (Arka Anupama, 30 cm × 10 cm) with a leaf area index of 1.56, while the smallest leaf area index (0.60) was recorded in V_2S_1 (All Green, 25 cm × 10 cm).

Larger plant-to-plant spacing resulted in a lower calculated LAI, despite the increase in leaf area with spacing. Since the leaf area index considers spacing, widely separated plants had a lower LAI even if their leaf area was larger. Similar findings were reported by Sruthy [8] in palak.

Table.3 Effect of varieties and spacings on width of leaves (cm), leaf area (cm^2) and leaf area index in palak

Treatments	Width of leaves (cm)				Leaf area (cm^2)	Leaf area index
	1 st cut	2 nd cut	3 rd cut	4 th cut		
Varieties						
V_1	9.00	9.28	7.87	7.15	100.00	1.51
V_2	6.85	7.06	5.98	5.43	75.79	0.63
V_3	7.68	7.91	6.71	6.09	85.13	1.05
S.E.m \pm	0.04	0.04	0.04	0.03	0.41	0.01
CD (5 %)	0.12	0.13	0.12	0.09	1.55	0.02
Spacings						
S_1	5.94	6.12	5.19	4.71	65.63	1.06
S_2	8.38	8.64	7.32	6.65	93.03	1.06
S_3	7.16	7.38	6.25	5.68	79.28	1.11
S_4	9.89	10.20	8.64	7.85	109.96	1.03
S.E.m \pm	0.04	0.05	0.05	0.03	0.46	0.01
CD (5 %)	0.13	0.15	0.14	0.10	1.33	0.02
Interaction						
V_1S_1	7.01	7.23	6.13	5.57	77.68	1.57
V_1S_2	9.61	9.90	8.40	7.63	106.78	1.48
V_1S_3	8.11	8.36	7.09	6.44	89.97	1.56
V_1S_4	11.28	11.63	9.86	8.96	125.57	1.44
V_2S_1	5.01	5.17	4.38	3.98	55.22	0.60
V_2S_2	7.36	7.59	6.43	5.84	81.57	0.64

V ₂ S ₃	6.30	6.49	5.50	5.00	69.63	0.63
V ₂ S ₄	8.71	8.98	7.61	6.92	96.75	0.66
V ₃ S ₁	5.79	5.97	5.06	4.60	63.98	1.02
V ₃ S ₂	8.18	8.43	7.14	6.49	90.75	1.05
V ₃ S ₃	7.06	7.28	6.17	5.61	78.25	1.15
V ₃ S ₄	9.68	9.98	8.45	7.68	107.56	0.99
S.E.m±	0.08	0.09	0.08	0.06	0.81	0.01
CD (5 %)	0.23	0.26	0.24	0.18	2.31	0.03

Factor 1: V₁: Arka Anupama, V₂: All Green, V₃: Mulayam

Factor 2: S₁: 25 cm x 10 cm, S₂: 25 cm x 15 cm, S₃: 30 cm x 10 cm, S₄: 30 cm x 15 cm

4. CONCLUSION

Based on the results from this experiment, it was concluded that the variety Arka Anupama with spacing of 30 cm x 15 cm exhibited maximum number of leaves, length of leaves, width of leaves and leaf area, while plant height and length of leaf petiole were highest in variety All Green with spacing of 30 cm x 15 cm. Variety Arka Anupama with spacing of 25 cm x 10 cm recorded maximum leaf area index on par with Arka Anupama with spacing of 30 cm x 10 cm.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The author(s) therefore declare that NO generative AI tools, such as text-to-image generators and large language models (ChatGPT, COPILOT, etc.), have been employed during editing of manuscripts.

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