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Evaluation of sowing time and spacing on growth of Winged bean (*Psophocarpus tetragonolobus* L.) in Konkan region

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Abstract
The research was conducted at the Vegetable Research Field, Department of Vegetable Science, College of Horticulture, Dapoli, under the auspices of Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist.-Ratnagiri, Maharashtra. The aim of the research was to determine the sowing time and the optimal plant spacing of winged bean. The experiment was laid out in Factorial Randomized Block Design with nine treatment combinations and three replications. The treatments were three levels of sowing time (2nd fortnight of September, 2nd fortnight of October and 2nd fortnight of November) and three levels of spacing (50 x 50 cm, 50 x 75 cm and 50 x 100 cm). The results of the analysis of variance show that growth parameters [germination percentage (100.00%), days to 1st flowering (52.67), days to 50% flowering (72.17), number of inflorescences per vine (50.00), number of pods per vine (80.87) and vine length at final harvest (799.33 cm)] were recorded from sowing in 2nd fortnight of September with plant spacing of 50 x 50 cm. According to our analysis, the 2nd fortnight of September seems to be the best time for sowing and winged beans can be grown with a spacing of 50 × 50 cm.

Keywords: Winged bean, sowing time, spacing, Konkan

Introduction
The winged bean (*Psophocarpus tetragonolobus* L.), a dicotyledonous climbing vegetable, is a multipurpose legume also known as the Goa bean, Four-angled bean, or "soybean of the tropics". It belongs to the family Leguminosae, subfamily Papilionoidea and has a diploid chromosome number of 2n=2x=18 (Saran *et al.*, 2024) [11]. It's renowned as a "one species supermarket" because all parts of the plant are edible and highly nutritious. The leaves are used like spinach, flowers are eaten as a salad, tubers are consumed raw or processed and the seeds are used in various processed foods. Primarily grown as a backyard crop by tribal communities in eight Indian states including Manipur, Mizoram, Assam and Tamil Nadu. It has recently gained popularity due to its high protein content (Singh *et al.*, 2022) [15].
Proper sowing time and plant spacing are crucial for the growth and yield of winged beans. Sowing time determines the crop's exposure to critical factors like rainfall and temperature at different growth stages (Zeleke *et al.*, 2019) [16]. An appropriate sowing date, combined with suitable cultural practices, is vital for improving crop quality. Plant spacing is equally important, as it regulates interplant competition for essential resources such as solar radiation, water, and nutrients (Singh *et al.*, 2006) [6]. An optimal plant population enhances the canopy's ability to capture these resources efficiently. Conversely, high plant density can increase competition, leading to the depletion of limiting resources and potentially hindering growth (Jiang *et al.*, 2013) [5].
In high rainfall areas like Konkan, it is necessary to know the suitable sowing time and spacing for winged bean production. Hence with a view to stimulate the production of winged bean present investigation entitled, "Evaluation of sowing time and spacing on growth of Winged bean (*Psophocarpus tetragonlobus* L.) in Konkan region"

Materials and Methods

The current study was conducted during the *Kharif* and *Rabi* seasons of 2024-25 at the Vegetable Research Field, Department of Vegetable Science, College of Horticulture Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, India. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three replications. Two factors were studied during the research *viz.*, 1) Sowing time (S): S_1- 2nd fortnight of September, S_2- 2nd fortnight of October and S_3- 2nd fortnight of November; 2) Plant spacing (D): D_1- 50 x 50 cm, D_2- 20 x 75 cm and D_3- 50 x 100 cm. The total area of the experimental field was 27 x 32 m and the plot size was 8 x 1 m. A single seed was planted on the flatbed at the location where fertilizer was applied, following the three different spacings and at a depth of 2-3 cm with three different sowing times. The crop was fertilized with vermicompost (5 t ha^{-1}), nitrogen (50 kg ha^{-1}), phosphorous (80 kg ha^{-1}) and potassium (50 kg ha^{-1}). The total amount of vermicompost and phosphorous were applied during final land preparation. Nitrogen and the rest of the potassium was applied one month after sowing. They were applied using urea, single super phosphate and muriate of potash, respectively. Irrigation, along with other intercultural operations was taken as and when necessary. The collected data were analysed using the standard analysis of variance method as outlined by Panse and Sukhatme (1995) [10].

Results and Discussion

Effect of sowing time

Significant variations were recorded for each of the parameters under investigation across the various sowing times. The highest germination percentage (95.93%) was recorded in S_1 (2nd fortnight of September) and the lowest germination percentage (62.52%) was observed in S_3 (2nd fortnight of December).

The September sowing took the minimum number of days to first flowering (53.07 days) and 50% flowering (73.14 days) compared with the maximum number of days to first flowering (61.07 days) and 50% flowering (75.12 days) in the December sowing. The plant's early growth phase was characterized by early 1st flowering and 50% flowering because of a longer growing season and favourable temperatures, as well as late flowering because of lower temperatures. Similar results were reported by Choudhary *et al.* (2020) [2] in pea and Sermenali *et al.* (2011) [12] in broccoli.

The highest number of inflorescences per vine was recorded in S_1 (48.69), while the lowest was observed in S_3 (39.07) and the maximum number of pods per vine (75.64) was recorded in S_1 (2nd fortnight of September). Whereas, S_3 (66.07) was observed in the minimum number of pods per vine. Similar results were recorded in Palsaniya *et al.* (2016) [9] in mung bean, Haque *et al.* (2020) [3] in dwarf hyacinth bean and Ahmed *et al.* (2023) [1] in green gram.

The highest (750.16 cm) vine length at final harvest was recorded in the 2nd fortnight of September (S_1) and the lowest (688.63 cm) in the 2nd fortnight of December (S_3). Higher growing periods and favourable temperatures caused the early-planted crop's plant height to increase, while lower temperatures during the crop's early growth phase caused the late-planted crop's plant height to decrease. The results were consistent with those recorded by Shashi and Hemrajsinh (2015) [13] in lima bean, Mrinalini *et al.* (2017) [7] in cucumber and Haque *et al.* (2020) [3] in dwarf hyacinth bean.

Table 1: Effect of sowing time on growth parameter of winged bean

Sowing time	Germination percentage (%)	Days to 1st flowering	Days to 50% flowering	Number of inflorescences per vine	Number of pods per vine	Vine length at final harvest (cm)
S_1	95.93	53.07	73.14	48.69	75.64	750.16
S_2	95.54	54.24	75.12	48.64	72.80	719.62
S_3	62.52	61.07	81.50	39.07	66.07	688.63
Result	SIG	SIG	SIG	SIG	SIG	SIG
S.E. m±	1.36	0.30	0.34	0.29	0.79	5.14
CD at 5%	4.07	0.90	1.02	0.88	2.36	15.42
Sowing time- S_1-2nd fortnight of September, S_2- 2nd fortnight of October, S_3- 2nd fortnight of December						

Effect of spacing

The maximum germination percentage is (89.69%) in plant spacing D_3 (50 x 100 cm) and the minimum germination percentage is (81.95%) in D_1 (50 x 50 cm). All of the spacing treatments had the same days to the 1st flowering range (55.22 to 56.87 days) and 50% flowering ranged from (75.49 to 77.73 days). Since plants with more space and resources can grow more efficiently and transition to the reproductive stage, the increased spacing may lead to earlier flowering. On the other hand, increased competition for resources may cause closer spacing to postpone flowering, thereby prolonging the vegetative growth phase. Similar results were reported by Lee (1988), Harsha *et al.* (2017) [4] and Painginkar *et al.* (2021) [8] in yard long bean.

The effect of various spacing on the number of inflorescences per vine was found to be statistically significant. The highest number of inflorescences per vine was recorded in D_3 (45.76), which was followed by D_2 (45.31), while the lowest was observed in D_1 (44.33). The highest number of pods per vine was recorded in D_1 (73.56) which was significantly superior to D_2 (70.96) and D_3 (69.47). However, it is worth noting that the lowest number of pods was observed in D_3. Comparable findings were documented by Haque *et al.* (2020) [3] in dwarf hyacinth bean.

The maximum vine length at last harvest (749.78 cm) was recorded in wider spacing (50 x 100 cm) and the minimum vine length at last harvest (693.69 cm) was observed in closer spacing (50 x 50 cm). The increased space availability in these arrangements can be connected to the longer vine length observed with wider spacing. Similar findings in relation to vine length were also observed by Harsha *et al.* (2017) [4] in yard long bean, Painginkar *et al.* (2021) [8] in yard long bean and Shirale *et al.* (2024) in French bean.

Table 2: Effect of spacing on growth parameter of winged bean

Sowing time	Germination percentage (%)	Days to 1st flowering	Days to 50% flowering	Number of inflorescences per vine	Number of pods per vine	Vine length at final harvest (cm)
D_1	81.95	56.29	76.54	44.33	69.47	693.69
D_2	82.34	56.87	77.73	45.31	70.96	715.24
D_3	89.69	55.22	75.49	45.76	73.56	746.78
Result	SIG	SIG	SIG	SIG	SIG	SIG
S.E. m±	1.36	0.30	0.34	0.29	0.79	5.14
CD at 5%	4.07	0.90	1.02	0.88	2.36	15.42
Spacing (D)- D_1 - 50 x 50 cm, D_2 - 50 x 75 cm, D_3 -50 x 100 cm						

Interaction effect

The combination effect of sowing time and plant spacing was found to be significantly influenced in all parameters. The highest germination percentage (100.00%) was recorded in S_1D_1, which was at par with S_2D_2 (97.03%), S_1D_1 (96.88%), S_2D_3 (95.83%) and S_2D_1 (93.75%). In contrast, the lowest germination percentage (55.21%) was observed in S_3D_1.

The minimum days for the 1st flowering (52.67 days) was recorded in S_1D_3, which was followed by S_1D_2 (52.93 days) and at par with S_1D_1 (53.60 days), S_2D_3 (53.80 days) and S_2D_1 (54.00 days). The maximum days for 1st flowering (62.73 days) was observed in S_3D_3 and the earliest 50% flowering was recorded in S_1D_3 (72.17 days), which was statistically at par with S_1D_1 (73.60 days) and S_1D_2 (73.67 days). The maximum number of days for 50% flowering was observed at S_3D_2 (83.93 days).

The interaction effect between sowing time and spacing on the number of inflorescences per vine was found to be statistically significant. The maximum number of inflorescences was recorded in S_1D_3 (50.00) followed by S_2D_3 (48.73) and S_1D_2 (48.67). In contrast, the minimum was observed in S_3D_3 (38.53). Among the treatment combinations the highest number of pods per plant was recorded in S_1D_3 (80.87), while the lowest was noted in S_3D_3 (66.00).

Sowing on the 2nd fortnight of September combined with 50 x 100 cm spacing resulted in the highest vine length at last harvest (799.33 cm) and the lowest vine length at last harvest (667.69 cm) was observed in the 2nd fortnight of December combined with 50 x 50 cm.

The significant interaction between sowing time and plant spacing on the quantity of pods per plant indicates that these two elements collaborate to significantly influence the crop's productivity. Early sowing provides the plants with a favourable beginning, enabling them to develop robust stems and leaves prior to the primary reproductive phase. When this is paired with wider spacing, each plant receives ample sunlight, water, and nutrients with minimal competition, resulting in an abundance of branches and flowers and consequently, greater vegetative growth.

Table 3.: Interaction effect of sowing time and spacing on growth parameter of winged bean

Treatment combination	Germination (%)	Days to 1st flowering	Days to 50% flowering	Number of inflorescences per vine	Number of pods per vine	Vine length at final harvest (cm)
S_1D_1	96.88	53.60	73.60	47.40	72.67	717.00
S_1D_2	90.91	52.93	73.67	48.67	73.40	734.13
S_1D_3	100.00	52.67	72.17	50.00	80.87	799.33
S_2D_1	93.75	54.00	75.67	46.67	71.73	696.60
S_2D_2	97.03	54.93	75.60	47.53	72.87	713.60
S_2D_3	95.83	53.80	74.10	48.73	73.80	748.67
S_3D_1	55.21	61.27	80.37	38.93	65.47	667.47
S_3D_2	59.09	62.73	83.93	39.73	66.73	698.00
S_3D_3	73.25	59.20	80.20	38.53	66.00	701.33
Result	SIG	SIG	SIG	SIG	SIG	SIG
S.E. m±	2.35	0.52	0.59	0.51	1.37	8.91
CD at 5%	7.05	1.55	1.77	1.52	4.09	26.70
Sowing time- S_1-2nd fortnight of September, S_2- 2nd fortnight of October, S_3- 2nd fortnight of December						
Spacing (D)- D_1 - 50 x 50 cm, D_2 - 50 x 75 cm, D_3 -50 x 100 cm						

Conclusion

Based on the above result, we can conclude that the treatment combination of S_1D_1 (2nd fortnight of September, 50 x 50 cm) can be recommended for growers aiming to optimize vegetative growth and early flowering to coincide with the optimum temperature condition required for the growth of winged bean. This combination is the most suitable under Konkan conditions.

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