

Performance of consecutive sowing of *Amaranthus* (*Amaranthus* spp.) types in different planting systems under shade net condition

Abstract

The present investigation was carried out at [the](#) College of Horticulture, Dapoli (~~M.S~~), Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth Dapoli, ~~Dist.~~Ratnagiri, [Maharashtra](#) during *rabi* season in year 2023-2024. The experiment was laid out in [a](#) Factorial Randomized Block Design consisting of eight treatments with four replications. In the experiment Factor: A composed of four amaranthus types V₁: Konkan Durangi, V₂: DPL-AS-6, V₃: DPL-AS-4, V₄: Nigadi Local and Factor: B is planting systems B₁: Flat bed, B₂: Raised bed. During [the](#) investigation, the analysis of variance revealed that all the characters viz. growth parameters and yield attributing characters varied significantly. In amaranthus types Konkan Durangi (V₁), recorded minimum days required for germination (2.95), highest plant height (27.20 cm), stem diameter (5.10 mm), number of leaves per plant (9.17), minimum days to first harvest (23.95), maximum number of harvests (3.38), highest mean yield per square meter (1.56 kg) and yield (15.59 t ha⁻¹). In the planting systems raised bed (B₂), had the minimum days required for germination (3.32), highest plant heights (26.35 cm), number of leaves per plant (8.62), longest leaf length (7.11 cm) and widest leaf breadth (4.05 cm), largest stem diameter (4.26 mm), minimum days to first harvest (24.75), [the](#) maximum number of harvests (3.08), mean yield per square meter (1.44 kg) and yield (14.42 t ha⁻¹).

Keywords: Amaranthus types, planting systems, shade net

Introduction: Amaranthus is one of the oldest food crops in the world, with evidence of its use dating back to around 6700 BC. The genus ~~amaranthus~~ [Amaranthus](#) includes over 60 species, including leafy vegetables, grain vegetables, ornamental plants, and weeds. The word amaranth is derived from the Greek word *amarantos*, which means *unwithering* and the people who used it symbolize immortality. Amaranth belongs to the genus *Amaranthus* within the family *Amaranthaceae*, which includes around 65 genera and 850 species. The genus *Amaranthus* itself comprises 50-60 species, many of which have edible leaves. Amaranthus is one of the tropical leafy vegetable crops, acquiring increasing importance as a potential subsidiary food crop for its excellent quality of protein and micronutrients (Devdas and Saroja, 2001). The leaves of Amaranthus are good sources of essential nutrients such as proteins (66.26 g/kg-11.38 g/kg), dietary fibers (91.94 µg/g-59.96 µg/g), fat (4.35 g/kg-1.42 g/kg), carbohydrates (98.54 g/kg-15.48 g/kg), minerals such as iron (1089.19 µg/g), calcium (10.13 mg/g), magnesium (30.01 mg/g), potassium (24.96 mg/g), and zinc (986.61 µg/g). Other nutrients like vitamins C (955.19 µg/g) and beta carotene (1043.18 µg/g) (Sarker and Oba, 2019). It has [a](#) high amount of essential amino acids as whole egg protein (Drzewiecki *et al.*, 2003). Many compounds and extracts from amaranth possessed antidiabetic, antioxidant and antimicrobial activity (Anon., 2010). The leaf of Amaranthus has also been used as [a](#) tea for relieving pulmonary conditions (Anon., 1992). Amaranth is highly nutritious, being rich in calcium and beta-carotene, which help strengthen bones and reduce the risk of osteoporosis. However, the absorption of these nutrients, including beta-carotene, calcium, and iron, by the human body is relatively low. This absorption largely depends on the quality

of the fresh produce, the method of preparation, and the individual physical conditions of the consumers. Calcium in amaranth aids in muscle regeneration and helps stabilize blood pressure. Consuming 50-100 grams of amaranth leaves daily can significantly reduce the incidence of blindness in malnourished children, highlighting its potential in combating undernutrition and malnutrition. In the hills of Tamil Nadu, tribals use the juice from the leaves and stems of *Amaranthus spinosus* to treat kidney stones. Studying amaranth cultivation under shade netting in the Konkan region during the Rabi season is crucial for maximizing production on limited land, mitigating the effects of fluctuating weather conditions, and enhancing the crop's growth, yield, and nutritional composition. Shade nets create a controlled environment that protects the plants from cold spells, unseasonal rains, and pests, leading to healthier growth and potentially higher yields. Additionally, this approach promotes sustainable farming by reducing the need for chemical inputs and contributes to food security by ensuring a consistent supply of nutrient-rich amaranth throughout the season.

Materials and Methods

The experiment trial was laid out at [the College of Horticulture, Dapoli, Dist. Ratnagiri, Maharashtra \(M.S.\)](#) during *rabi* season [of year](#) 2023-24 under shade net conditions. The experiment was carried out in a factorial randomized block design with two factors, eight treatments and four replications. Factor A: [is](#) composed of four Amaranthus types V₁: Konkan durangi, V₂: DPL-AS-6, V₃: DPL-AS-4, V₄: Nigadi Local and Factor: B [is](#) composed of two planting systems B₁: Flat-bed, B₂: Raised bed. Data was recorded for different growth parameters like days required for germination, plant height (cm), number of leaves per plant, leaf length (cm), leaf breadth (cm), stem diameter (mm), days required for [the](#) first harvest, number of harvestings, mean yield per square meter (kg) and mean yield (t/ha). To record the periodical observations at every harvest, ten plants were randomly selected and tagged in each treatment of all four replications.

Result and Discussion

Days required for germination

The data presented in (Table 1) revealed that in amaranthus types minimum days required for germination were recorded in V₁ (2.95) while, maximum days to germination were recorded in V₃ (4.69). In [the](#) case of planting systems, the minimum days to germination were recorded in system B₂, with an average of (3.32) days, while the maximum days were recorded in system B₁ (3.74). While in interaction, the minimum days to germination were recorded in interaction V₁B₂ (2.75), while the maximum days were observed in the V₃B₁ (5.18). Germination times in Amaranthus vary significantly due to genetic differences in the seeds. Raised beds can markedly accelerate germination by rapidly warming up, maintaining consistent temperatures, and enhancing drainage and aeration. These results are [comparatively compared](#) with the Dabhi *et al.* (2015) in spinach beet, Pawar (2019) Vasava *et al.* (2016) in Amaranthus.

Plant height (cm)

The data from (Table 1) observed that, in Amaranthus types, variety V₁ achieved the highest average plant height (27.20 cm), whereas V₃ had the shortest (24.59 cm). In [the](#) case of planting systems, B₂ showed the greatest average plant height (26.35 cm), whereas B₁ had the

shortest average height (24.90 cm). ~~while~~ While in interaction the highest average plant height was noted in the V_1B_2 interaction (28.28 cm), whereas the lowest was recorded in V_3B_1 (23.88 cm). Genetic diversity plays a crucial role in determining plant height in Amaranthus, even when different planting methods are used. Raised beds can improve growth conditions by enhancing soil warmth, drainage, and aeration, which may encourage taller plants. However, the ultimate height is predominantly influenced by the plant's genetic makeup. The results coincide with those of, Solangi *et al.* (2017) in spinach Deogirikar and Patil (2005), Jandge *et al.* (2018), Pawar (2019) and Dabholkar (2022) in amaranthus.

Number of leaves per plant

The data in (Table 2) indicates that in Amaranthus types, V_1 exhibited the highest leaf count with an average of 9.17, while V_3 showed the lowest leaf count (8.01). while in planting systems the B_2 planting system yielded the highest number of leaves, averaging (8.62), compared to the B_1 system, which produced fewer leaves (8.41). In interaction at harvest, the average number of leaves was highest in the V_1B_2 (9.39), whereas the lowest average was found in the V_3B_1 (7.95) leaves per plant. The number of leaves in Amaranthus is largely determined by genetic factors, even across various planting systems. While raised beds can enhance soil warmth, drainage, and aeration, potentially boosting leaf development, the final leaf count is primarily governed by the plant's genetic traits. ~~The s~~ Similar outcomes were given by Pawar (2019), Dabholkar (2022) in Amaranthus, ~~and~~ Modupeola *et al.* (2018) in spinach.

Leaf length (cm)

The data presented in (Table 2) showed that V_4 had the longest leaf length with an average of 7.72 cm, while V_2 had the shortest (6.02 cm). While in planting systems B_2 observed ~~the~~ longest leaf length (7.11 cm), while B_1 had the shortest (6.74 cm). Whereas in interaction, V_4B_2 had the longest average leaf length of 7.91 cm, while the V_2B_1 had the shortest (5.76 cm). The results are similar ~~with to~~ those of Pharle (2016), Pawar (2019), Dabholkar (2022) in Amaranthus, ~~and~~ Solangi *et al.* (2017) in spinach.

Leaf breadth (cm)

Table 3 indicates that the type of Amaranthus, V_4 exhibited the largest leaf breadth, averaging 4.71 cm, whereas V_2 had the smallest breadth (3.18 cm). In ~~the~~ case of planting systems, the B_2 planting system achieved ~~the~~ widest leaves with an average breadth of 4.05 cm, while B_1 had the smallest (3.71 cm). ~~while~~ While interaction, V_4B_2 showed the greatest average leaf breadth ~~of~~ 5.00 cm, while ~~the~~ V_2B_1 had the smallest (3.09 cm). The outcomes were similarly comparable to those ~~of~~ Pharle (2016), Jandge *et al.* (2018), Pawar (2019), and Dabholkar (2022) in Amaranthus, Chauhan (2016) in spinach.

Stem diameter (cm)

Table 3 shows that ~~in~~ Amaranthus types, V_1 recorded maximum stem diameter, averaging 5.10 mm, whereas V_2 had the minimum average (3.54 mm). On ~~the~~ other hand in ~~the~~ planting system, B_2 showed the largest average stem diameter (4.26 mm), whereas B_1 had the smallest (4.01 mm) stem diameter. While interaction, the V_1B_2 achieved the highest average stem diameter ~~of~~ 5.30 mm, whereas the V_2B_1 recorded the smallest average diameter of 3.50 mm.

Stem diameter in Amaranthus varieties is predominantly influenced by genetic factors, even when grown in different planting systems. Raised beds can enhance growing conditions by improving soil warmth, drainage, and aeration, which may support better stem development. Outcomes were similar ~~with to~~ those of Mandal *et al.* (2012), Pharle (2016), Pawar (2019), and Dabholkar (2022) in ~~amaranth~~**Amaranth**, Modupeola *et al.* (2018) in spinach.

Days to first harvest

The data presented in (Table 4) on days to first harvest in ~~the~~ case of Amaranthus types, the average number of days to first harvest ~~were was~~ minimum for V₁ (23.95), which was at par ~~to with~~ V₂ (24.12). ~~while~~ **While** V₃ took the maximum average time (26.25) to first harvest. While in planting, the minimum average days to harvest were recorded for B₂ (24.75), while B₁ had the maximum (25.06) to first harvest. Whereas in interaction, V₁B₂ had the minimum days (23.83) and V₂B₁ had the maximum days (26.42) for the first harvest. The number of days to harvest Amaranthus can be affected by the interaction between plant types and raised beds. Raised beds enhance conditions such as drainage, warmth, and aeration, potentially accelerating growth. However, the impact on harvest time also depends on the genetic characteristics of each Amaranthus variety. Similar results were reported by Pharle (2016), Vasava *et al.* (2016), Dabholkar (2022) in amaranthus, ~~and~~ Solangi *et al.* (2017) in spinach.

Number of harvestings

Table 4 shows that Amaranthus types V₁ recorded the maximum number of harvests with an average of 3.38, while V₃ had the lowest average (2.53). In ~~the~~ case of planting systems, B₂ had the highest average number of harvestings (3.08), while B₁ had the lowest (2.88). While in interaction, V₁B₂ had the maximum average number of harvestings at (3.53), whereas V₂B₁ had the minimum, averaging (2.51). The interaction between Amaranthus types and raised beds can influence the number of harvests. Raised beds improve factors such as drainage, soil temperature, and aeration, which can lead to more vigorous growth and potentially increase harvest frequency. However, the genetic traits of each Amaranthus type also play a crucial role in determining the total number of harvests. These findings are consistent with those of Pharle (2016), ~~and~~ Dabholkar (2022) in amaranth.

Mean yield per square meter (kg)

The data from (Table 5) observed that, in Amaranthus types, the V₁ variety achieved the highest mean yield of (1.56 kg) per square meter, demonstrating superior productivity. Conversely, the V₃ variety yielded the least, with a mean of 1.20 kg per square meter. While in planting systems, the highest mean yield was observed in planting system B₂, which produced (1.44 kg) per square meter. Conversely, planting system B₁ yielded the least, with a mean of 1.28 kg per square meter. In ~~the~~ case of interaction the highest average yield was observed with the V₁B₂, producing (1.72 kg ~~kg~~) per square meter, in contrast, the V₃B₁ recorded the lowest average yield at (1.13 kg) per square meter. Extreme weather conditions in open fields can severely restrict vegetable yield and quality. In these situations, protected cultivation, such as using raised beds, is ideal as it improves drainage, warms the soil, and enhances aeration, which can promote stronger plant growth and potentially increase yields. The outcomes were similarly comparable to those ~~of~~ Pharle (2016), Vasava *et al.* (2016), Pawar (2019), Dabholkar (2022) in amaranth, Solangi *et al.* (2017) in spinach, Modupeola *et al.* (2018) in Lagos spinach.

Mean yield (t ha⁻¹)

The data presented in (Table 5) revealed that Amaranthus types, the V₁ variety achieved the highest mean yield of 15.59 t/ha, demonstrating superior productivity. Conversely, the V₃ variety yielded the least, with a mean of 11.96 t/ha. While in planting systems, B₂ recorded the highest mean yield (14.42 t/ha), while B₁ produced a lower mean yield of 12.81 t/ha. On the other hand, interaction showed, the V₁B₂ achieved the highest mean yield of 17.18 t/ha, while V₃B₁ recorded the minimum mean yield of 11.31 t/ha. The interaction between Amaranthus types and raised beds can impact yields measured in tons per hectare. Raised beds generally improve conditions by enhancing drainage, increasing soil temperature, and boosting aeration, which can result in higher plant growth and potentially greater yields. The similar outcomes were given by Kotadia *et al.* (2012), Pharle (2016), Vasava *et al.* (2016), Mahajan *et al.* (2017), Pawar (2019), Dabholkar (2022) in Amaranthus, Solangi *et al.* (2017) in spinach, Modupeola *et al.* (2018) in Lagos spinach.

Table 1. Response of different Amaranthus types and planting systems on days required for germination and plant height under shade net conditions during *rabi* season.

Title ??	Days required for germination					Plant height (cm)				
	V ₁	V ₂	V ₃	V ₄	MEAN	V ₁	V ₂	V ₃	V ₄	MEAN
B ₁	3.15	3.18	5.18	3.45	3.74	26.11	25.05	23.88	25.70	24.90
B ₂	2.75	3.00	4.20	3.25	3.32	28.28	25.34	25.30	26.47	26.35
MEAN	2.95	3.09	4.69	3.35	3.52	27.20	25.20	24.59	26.08	25.62
	F-test	S. Em (±)		CD @ 5%		F-test	S. Em (±)		CD @ 5%	
V	SIG	0.03		0.09		SIG	0.15		0.45	
B	SIG	0.02		0.06		SIG	0.11		0.33	
V X B	SIG	0.04		0.12		SIG	0.21		0.64	

Note: B1???, B2?? V?? B?? SIG???

Table 2. Response of different Amaranthus types and planting systems on the number of leaves per plant and leaf length under shade net conditions during *rabi* season.

	Number of leaves per plant					Leaf length (cm)				
	V ₁	V ₂	V ₃	V ₄	MEAN	V ₁	V ₂	V ₃	V ₄	MEAN
B ₁	8.96	8.30	7.95	8.45	8.41	7.35	5.76	6.33	7.54	6.74
B ₂	9.39	8.28	8.08	8.74	8.62	7.46	6.29	6.78	7.91	7.11
MEAN	9.17	8.29	8.01	8.60	8.52	7.41	6.02	6.55	7.72	6.93
	F-test	S. Em (±)		CD @ 5%		F-test	S. Em (±)		CD @ 5%	
V	SIG	0.05		0.15		SIG	0.07		0.21	
B	SIG	0.04		0.12		SIG	0.05		0.15	
V X B	SIG	0.07		0.21		NS	0.10		-	

Table 3. Response of different Amaranthus types and planting systems on leaf breadth and stem diameter under shade net conditions during *rabi* season.

	Leaf breadth (cm)					Stem diameter (mm)				
	V ₁	V ₂	V ₃	V ₄	MEAN	V ₁	V ₂	V ₃	V ₄	MEAN
B₁	4.07	3.09	3.29	4.41	3.71	4.90	3.50	3.57	4.09	4.01
B₂	4.34	3.28	3.60	5.00	4.05	5.30	3.59	3.91	4.26	4.26
MEAN	4.20	3.18	3.45	4.71	3.88	5.10	3.54	3.74	4.17	4.14
	F-test	S. Em (±)		CD @ 5%		F-test	S. Em (±)		CD @ 5%	
V	SIG	0.06		0.18		SIG	0.04		0.12	
B	SIG	0.04		0.12		SIG	0.03		0.09	
V X B	NS	0.08		-		SIG	0.05		0.16	

Table 4. Response of different Amaranthus types and planting systems on days to first harvest and number of harvestings under shade net conditions during rabi season.

	Days to first harvest					Number of harvestings				
	V ₁	V ₂	V ₃	V ₄	MEAN	V ₁	V ₂	V ₃	V ₄	MEAN
B₁	24.08	24.25	26.42	25.51	25.06	3.23	2.68	2.51	3.13	2.88
B₂	23.83	24.00	26.08	25.08	24.75	3.53	2.95	2.55	3.28	3.08
MEAN	23.95	24.12	26.25	25.30	24.91	3.38	2.81	2.53	3.20	2.98
	F-test	S. Em (±)		CD @ 5%		F-test	S. Em (±)		CD @ 5%	
V	SIG	0.07		0.22		SIG	0.03		0.07	
B	SIG	0.05		0.16		SIG	0.02		0.05	
V X B	SIG	0.11		0.33		SIG	0.03		0.12	

Table 5. Response of different Amaranthus types and planting systems on mean yield per square meter and mean Yield (ha⁻¹) under shade net condition during rabi season.

	Mean yield per square meter (kg)					Mean Yield (t ha ⁻¹)				
	V ₁	V ₂	V ₃	V ₄	MEAN	V ₁	V ₂	V ₃	V ₄	MEAN
B₁	1.40	1.23	1.13	1.36	1.28	14.00	12.34	11.31	13.61	12.81
B₂	1.72	1.34	1.26	1.44	1.44	17.18	13.44	12.61	14.45	14.42
MEAN	1.56	1.29	1.20	1.40	1.36	15.59	12.89	11.96	14.03	13.61
	F-test	S. Em (±)		CD @ 5%		F-test	S. Em (±)		CD @ 5%	
V	SIG	0.03		0.09		SIG	0.13		0.39	
B	SIG	0.02		0.06		SIG	0.09		0.27	
V X B	SIG	0.04		0.012		SIG	0.19		0.57	

Table 6 Treatment details:

Factor A: Amaranthus types	Factor B: Planting systems
V ₁ : Konkan Durangi V ₂ : DPL-AS-6 V ₃ : DPL-AS-4 V ₄ : Nigadi Local	B ₁ : Flat-bed B ₂ : Raised bed

Conclusion

Among the different varieties of Amaranthus, Konkan Durangi (V₁) grown under shade net conditions exhibited the shortest germination period, the greatest plant height, the highest number of leaves per plant, thicker stems, superior yield, and enhanced ascorbic acid and anthocyanin content compared to other Amaranthus varieties.

Among the various types of planting systems, raised beds demonstrated superior performance across all parameters (growth, yield, and quality) during the *rabi* season.

Planting Konkan Durangi on raised beds (V₁B₂) under shade net conditions resulted in the shortest time to germination and minimum days to first harvest, along with the tallest plants, highest leaf count per plant, thickest stems, most harvests, and the highest yield per square meter and per hectare. It also showed superior ascorbic acid and anthocyanin content.

6. References

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