# 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 College of Horticulture, Dapoli (M.S), Dr.Balasaheb Sawant Konkan Krishi Vidyapeeth Dapoli, Dist. Ratnagiri during *rabi* season in year 2023-2024. The experiment was laid out in Factorial Randomized Block Design consist of eight treatments with four replications. In the experiment Factor: A composed four amaranthus types $V_1$: Konkan Durangi, $V_2$: DPL-AS-6, $V_3$: DPL-AS-4, $V_4$: Nigadi Local and Factor: B is planting systems $B_1$: Flat bed, $B_2$: Raised bed. During investigation, the analysis of variance revealed that all the characters viz. growth parameters and yield attributing characters varied significantly.In amaranthus types Konkan Durangi ($V_1$), 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 ($B_2$), 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), 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 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 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 tea for relieving pulmonary condition (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 College of Horticulture, Dapoli, Dist. Ratnagiri (M.S.) during *rabi* season 2023-24 under shade net condition. The experiment was carried out in a factorial randomized block design with two factors, eight treatments and four replications. Factor A: composed of four Amaranthus types $V_1$: Konkan durangi, $V_2$: DPL-AS-6, $V_3$: DPL-AS-4, $V_4$: Nigadi Local and Factor: B composed of two planting systems $B_1$: Flat bed, $B_2$: 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 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 $V_1$ (2.95) while, maximum days to germination were recorded in $V_3$ (4.69). In case of planting systems, the minimum days to germination were recorded in system $B_2$, with an average of (3.32) days, while the maximum days were recorded in system $B_1$ (3.74). While in interaction, the minimum days to germination were recorded in interaction $V_1B_2$ (2.75), while the maximum days were observed in the $V_3B_1$ (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 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 $V_1$ achieved the highest average plant height (27.20 cm), whereas $V_3$ had the shortest (24.59 cm). In case of planting systems, $B_2$ showed the greatest average plant height (26.35 cm), whereas $B_1$ had the shortest average height (24.90 cm). 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 V3B1 (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 similar outcomes were given by Pawar (2019), Dabholkar (2022) in Amaranthus, 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 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 those of Pharle (2016), Pawar (2019), Dabholkar (2022) in Amaranthus, 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 case of planting systems, the $B_2$ planting system achieved widest leaves with an average breadth of 4.05 cm, while $B_1$ had the smallest (3.71 cm). while interaction, $V_4B_2$ showed the greatest average leaf breadth 5.00 cm, while the $V_2B_1$ had the smallest (3.09 cm). The outcomes were similarly comparable to those Pharle (2016), Jandge*et al.* (2018), Pawar (2019), and Dabholkar (2022) in Amaranthus, Chauhan (2016) in spinach.

**Stem diameter (cm)**

Table 3 shows that Amaranthus types, $V_1$ recorded maximum stem diameter, averaging 5.10 mm, whereas $V_2$ had the minimum average (3.54 mm). On other hand in 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 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 those of Mandal e*t al*. (2012),Pharle (2016), Pawar (2019), and Dabholkar (2022) in amaranth,Modupeola*et al.* (2018) in spinach.

**Days to first harvest**

The data presented in (Table 4) on days to first harvestin case of Amaranthus types, the average number of days to first harvest were minimum for $V_1$ (23.95), which was at par to $V_2$ (24.12). while $V_3$ took the maximum average time (26.25) to first harvest. While in planting, the minimum average days to harvest were recorded for $B_2$ (24.75), while $B_1$ had the maximum (25.06) to first harvest. Whereas in interaction, $V_1B_2$ had the minimum days (23.83) and $V_2B_1$ 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, Solangi*et al.* (2017) in spinach.

**Number of harvestings**

Table 4 shows that Amaranthus types $V_1$ recorded the maximum number of harvests with an average of 3.38, while $V_3$ had the lowest average (2.53). In case of planting systems, $B_2$ had the highest average number of harvestings (3.08), while $B_1$ had the lowest (2.88). While in interaction, $V_1B_2$ had the maximum average number of harvestings at (3.53), whereas $V_2B_1$ 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), Dabholkar (2022) in amaranth.

**Mean yield per square meter**(kg)

The data from (Table 5) observed that, in Amaranthus types, the $V_1$ variety achieved the highest mean yield of (1.56 kg) per square meter, demonstrating superior productivity. Conversely, the $V_3$ 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 $B_2$, which produced (1.44 kg) per square meter. Conversely, planting system $B_1$ yielded the least, with a mean of 1.28 kg per square meter. In case of interaction the highest average yield was observed with the $V_1B_2$, producing (1.72 kg kg) per square meter, in contrast, the $V_3B_1$ 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 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 $V_1$ variety achieved the highest mean yield of 15.59 t/ha, demonstrating superior productivity. Conversely, the $V_3$ variety yielded the least, with a mean of 11.96 t/ha. While in planting systems, $B_2$ recorded the highest mean yield (14.42 t/ha), while $B_1$ produced a lower mean yield of 12.81 t/ha. On other hand interaction showed, the $V_1B_2$ achieved the highest mean yield of 17.18 t/ha, while $V_3B_1$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 condition during *rabi* season.**

| | **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 | |

**Table 2.Response of different Amaranthus types and planting systems on number of leaves per plant and leaf lengthunder shade net condition 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 condition 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** |
| **$B_1$** | 4.07 | 3.09 | 3.29 | 4.41 | 3.71 | 4.90 | 3.50 | 3.57 | 4.09 | 4.01 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **$B_2$** | 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 condition 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** |
| **$B_1$** | 24.08 | 24.25 | 26.42 | 25.51 | 25.06 | 3.23 | 2.68 | 2.51 | 3.13 | 2.88 |
| **$B_2$** | 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** |
| **$B_1$** | 1.40 | 1.23 | 1.13 | 1.36 | 1.28 | 14.00 | 12.34 | 11.31 | 13.61 | 12.81 |
| **$B_2$** | 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<br>**$V_2$**: DPL-AS-6<br>**$V_3$**: DPL-AS-4<br>**$V_4$**: Nigadi Local | **$B_1$**: Flat bed<br>**$B_2$**: Raised bed |

## Conclusion

Among the different varieties of Amaranthus, Konkan Durangi ($V_1$) 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 ($V_1B_2$) 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.



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