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# Growth and Yield of Amaranthus (*Amaranthus* spp.) Varieties in Different Planting Systems under Shade Nets during the *Kharif* Season

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

The present investigation carried out at College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth Dapoli, Dist. Ratnagiri during *kharif* season in year 2023-2024. The experiment was laid out in Factorial Randomized Block Design consist of eight treatments with four replications.

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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 (3.12), highest plant height (25.72 cm), stem diameter (4.98 mm), number of leaves per plant (8.72), minimum days to first harvest (24.83), maximum number of harvests (3.30), highest mean yield per square meter (1.39 kg) and yield (13.92 t $ha^{-1}$). In the planting systems raised bed ($B_2$), had the minimum days required for germination (3.41), highest plant heights (25.27 cm), number of leaves per plant (8.45), longest leaf length (7.06 cm) and widest leaf breadth (3.99 cm), largest stem diameter (4.17 mm), minimum days to first harvest (25.60), maximum number of harvests (3.01), mean yield per square meter (1.31 kg) and yield (13.06 t $ha^{-1}$).

*Keywords: Amaranthus types; planting systems; shade net; kharif season.*

## 1. INTRODUCTION

Amaranthus (*Amaranthus* spp.) is the most common leafy vegetable crop belongs to family *Amaranthaceae*, originated from India or Indo Chinese region. The family *Amaranthaceae* comprises 65 genera and 850 species widely distributed throughout world in tropical, sub-tropical and temperate regions as grain crops, pot herbs, ornamentals and dye plant of which 50-60 species are edible and it is cultivated for leafy as well as grain purpose. 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) [1]. Many compounds and extracts from amaranth possessed antidiabetic, antioxidant and antimicrobial activity [2]. The tender stem of Amaranth is used as a drumstick in making curry. Due to its medicinal and leafy qualities, it is in high demand as a commercial crop. In addition to being utilized as a vegetable, amaranth leaves have therapeutic properties that increase vegetable growers prefer this crop due to its easy of cultivation, short duration, low pest and disease incidence, positive nutrition response, higher yield and diverse genotypes suitable for specific agro-climatic conditions. It can be used in any cropping system. In Maharashtra, particularly in the Konkan region, amaranth is a popular leafy vegetable that is grown commercially in the *summer* and *rabi* seasons. Studying amaranth cultivation under shade net in the Konkan region is imperative for several reasons. Firstly, it addresses the challenge of limited land availability by maximizing production in confined spaces, thereby enhancing agricultural productivity. Secondly, it offers a solution to mitigate the adverse effects of extreme weather conditions, such as excessive rainfall or scorching heat, by providing a controlled environmental condition to plant growth. So, research on evaluation of Amaranthus varieties in diverse planting systems under shade nets during *kharif* season may create a more favorable microclimate, enhancing biomass accumulation and yield characteristics.

## 2. MATERIALS AND METHODS

The experiment trial was laid out at College of Horticulture, Dapoli, Dist. Ratnagiri (M.S.) during *Kharif* 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 $ha^{-1}$). To record the periodical observations at every harvest, ten plants were randomly selected and tagged in each treatment of all four replications.

## 3. RESULTS AND DISCUSSION

### 3.1 Days Required for Germination

The data presented in (Table 1) revealed that, among the Amaranthus types, Konkan Durangi ($V_1$) required the fewest days for germination (3.12 days) which was at par with $V_2$ (3.18) while, maximum days to germination were recorded in $V_3$ (4.74). In case of planting systems, the minimum days to germination were recorded in system $B_2$, with an average of (3.41) days, while the maximum days were recorded in system $B_1$ (3.83). While in interaction, the minimum days to germination were recorded in $V_1B_2$ (3.02), while the maximum days were observed in the $V_3B_1$ (5.25). Germination times in Amaranthus vary due to genetic differences in seed. Raised beds often speed up germination by warming quickly, maintaining consistent temperatures and improving drainage and aeration. These results are comparatively with the Mahajan et al. [3] and Gowtham and Mohanalakshmi [4] in coriander, Vasava et al. [5] in amaranthus.

### 3.2 Plant Height (cm)

The data from (Table 1) observed that, in amarathus types during, variety $V_1$ exhibited the highest plant height at (25.72 cm), while variety $V_3$ recorded the lowest (23.56 cm). In case of planting systems, the maximum average plant height was observed in $B_2$ (25.27 cm), while the minimum average height was recorded in planting system $B_1$ (23.88 cm). while in interaction, the maximum average plant height was recorded in the interaction of $V_1B_2$ (26.85cm), while the minimum was observed in $V_3B_1$ (23.12 cm). Genetic variation greatly influences plant height in Amaranthus, even across different planting systems. While raised beds improve conditions like soil warmth, drainage, and aeration, which can promote taller growth. The results coincide with those of Haldavanekar et al. (2022), Solangi et al. [6] in spinach Pharle [7], Jandge et al. [8], Pawar [9] and Dabholkar [10] in amaranthus.

### 3.3 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 8.72, while $V_3$ showed the lowest leaf count (7.92). While in planting systems, the $B_2$ planting system yielded the highest number of leaves, averaging (8.45), compared to the $B_1$ system, which produced fewer leaves (8.17). In interaction of $V_1B_2$ recorded the maximum number of leaves, averaging 9.0, while the interaction of $V_3B_1$ resulted in the minimum (7.84) leaves per plant. The number of leaves in Amaranthus is largely determined by genetic factor, even when grown in different planting systems. Although raised beds can improve soil warmth, drainage, and aeration, which may enhance leaf development, the final leaf count is predominantly governed by the plant's genetic traits. The similar outcomes were given by Haldavanekar et al. (2022), Kurrey et al. [11], Pawar [9] in amaranthus, Modupeola et al. [12] in spinach.

### 3.4 Leaf Length (cm)

The data presented in (Table 2) showed that $V_4$ had the longest leaf length with an average of 7.61 cm, while $V_2$ had the shortest (5.97 cm). While in planting systems $B_2$ continued to produce the longest leaf length (7.06 cm), while $B_1$ had the shortest (6.64 cm). Whereas in interaction $V_4B_2$ recorded the maximum average leaf length of 7.93 cm, while the $V_2B_1$ had the minimum (5.73 cm). The results are similar with those of Pharle [7], Pawar [9], Dabholkar [10] in amaranthus, Solangi et al. [6] in spinach.

### 3.5 Leaf Breadth (cm)

Table 3 indicates that the type of amaranthus, $V_4$ exhibited the greatest average leaf breadth 4.57 cm, while $V_2$ had the smallest (3.09 cm). In case of planting systems, the $B_2$ planting system achieved the highest average leaf breadth of 3.99 cm, in contrast to $B_1$, which had the lowest (3.62 cm). While interaction in the $V_4B_2$ recorded the maximum average leaf breadth of 4.89 cm, whereas the $V_2B_1$ had the minimum (2.96 cm). The outcomes were similarly comparable to those Pharle [7], Jandge et al. [8], Pawar [9], and Dabholkar [10] in Amaranthus, Chauhan [13] in spinach.

### 3.6 Stem Diameter (mm)

Table 3 shows that amaranthus types, $V_1$ exhibited the largest average stem diameter of 4.98 mm, while $V_2$ had the smallest average diameter (3.44 mm). On other hand in planting system, $B_2$ planting system resulted in the largest average stem diameter of 4.17 mm, while $B_1$ had the smallest average diameter (3.86 mm). While interaction in the $V_1B_2$ recorded the maximum average stem diameter of 5.15 mm, while the $V_2B_1$ had the minimum average diameter 3.37

mm. Stem diameter in Amaranthus types is primarily influenced by genetic factors, even with different planting systems. Raised beds enhance conditions such as soil warmth, drainage, and aeration, which can improve stem development, but the final stem diameter is mainly determined by the plant's genetic traits. Outcomes were similar with those of Mandal et al. [14], Pharle [7], Pawar [9], and Dabholkar [10] in amaranth, Modupeola et al. [12] in spinach.

### 3.7 Days to First Harvest

The data presented in (Table 4) on days to first harvest in case of amaranthus types, average number of days to first harvest were minimum for $V_1$ (24.83), which was at par to $V_2$ (25.03). In contrast, $V_3$ required the maximum average time of 27.25 days. While in planting minimum average days to harvest were recorded for $B_2$ (25.60), while $B_1$ had the maximum (26.10). Whereas in interaction shortest days to first harvest was observed in the $V_1B_2$ (24.42), while the longest was in the $V_2B_1$ (27.42 days) for the first harvest. The number of days to harvest Amaranthus can be influenced by the interaction between plant types and raised beds. While raised beds improve conditions like drainage, warmth, and aeration to speed up growth, the effect is also dependent on the genetic makeup of each Amaranthus type. Similar results were reported by Pharle [7], Vasava et al. [5], Dabholkar [10] in amaranthus, Solangi et al. [6] in spinach.

### 3.8 Number of Harvestings

Table 4 shows that amaranthus types, $V_1$ achieved the highest average number of harvests (3.30), while $V_3$ had the lowest average of 2.45. In case of planting systems, $B_2$ had the highest average number of harvestings (3.01), while $B_1$ had the lowest (2.81). While in interaction the highest average number of harvestings was in the $V_1B_2$ (3.45), while the lowest was in $V_2B_1$, averaging (2.43). The interaction between Amaranthus types and raised beds can affect the number of harvests. Raised beds improve conditions such as drainage, soil temperature, and aeration, promoting more vigorous growth and potentially more frequent harvests. However, the number of harvests is also influenced by the genetic characteristics of each Amaranthus type. These findings are consistent with those of Pharle [7], Dabholkar [10] in amaranth.

### 3.9 Mean Yield per Square Meter (kg)

The data from (Table 5) observed that, in amarathus types, the $V_1$ variety achieved the highest mean yield of (1.39 kg) per square meter, demonstrating superior productivity. Conversely, the $V_3$ variety yielded the least, with a mean of 1.05 kg per square meter. While in planting systems highest mean yield was observed in planting system $B_2$, which produced (1.31 kg) per square meter. In contrast, the lowest mean yield was recorded in planting system $B_1$, with (1.12) kg per square meter. In case of interaction highest average yield was observed with the $V_1B_2$, producing (1.55 kg) per square meter, while the lowest was with the $V_3B_1$, yielding (0.97 kg) per square meter. Extreme weather conditions in open fields are major factors limiting vegetable yield and quality. In such cases, protected cultivation is the best option. Raised beds enhance growing conditions by improving drainage, increasing soil temperature, and boosting aeration, leading to more vigorous plant growth and potentially higher yields. The outcomes were similarly comparable to those Pharle [7], Vasava et al. [5], Pawar [9], Dabholkar [10] in amaranth, Solangi et al. [6] in spinach, Modupeola et al. [12] in Lagos spinach.

### 3.10 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 13.92 t/ha, demonstrating superior productivity. Conversely, the $V_3$ variety yielded the least, with a mean of 10.51 t/ha. While in planting systems $B_2$ recorded the highest mean yield (13.06 t/ha), whereas planting system $B_1$ yielded the lowest (11.24 t/ha). On other hand interaction showed $V_1B_2$ achieved the highest mean yield of 15.46 t/ha, while the $V_3B_1$ yielded the lowest (9.74 t/ha). The interaction between Amaranthus types and raised beds can influence yields measured in tons per hectare. Raised beds typically enhance conditions by improving drainage, increasing soil temperature, and boosting aeration, which can lead to higher plant growth and potentially increased yields. However, the degree of this improvement is also affected by the genetic characteristics of each Amaranthus type. The similar outcomes were given by Kotadia et al. [15], Pharle [7], Vasava et al. [5], Mahajan et al. [3], Pawar [9], Dabholkar [10] in amaranthus, Solangi et al. [6] in spinach, Modupeola et al. [12] in Lagos spinach [16].

**Table 1. Response of different amaranthus types and planting systems on days required for germination and plant height under shade net condition during *kharif* 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 |
| $B_1$ | 3.23 | 3.30 | 5.25 | 3.53 | 3.83 | 24.59 | 23.68 | 23.12 | 24.13 | 23.88 |
| $B_2$ | 3.02 | 3.05 | 4.23 | 3.33 | 3.41 | 26.85 | 24.85 | 24.00 | 25.39 | 25.27 |
| MEAN | 3.12 | 3.18 | 4.74 | 3.43 | 3.62 | 25.72 | 24.26 | 23.56 | 24.76 | 24.58 |
| | F-test | S. Em (±) | | CD @ 5% | | F-test | S. Em (±) | | CD @ 5% | |
| V | SIG | 0.03 | | 0.09 | | SIG | 0.12 | | 0.36 | |
| B | SIG | 0.02 | | 0.06 | | SIG | 0.09 | | 0.27 | |
| V X B | SIG | 0.04 | | 0.12 | | SIG | 0.17 | | 0.51 | |

**Table 2. Response of different amaranthus types and planting systems on number of leaves per plant and leaf length under shade net condition during *kharif* 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 |
| $B_1$ | 8.43 | 8.18 | 7.84 | 8.23 | 8.17 | 7.30 | 5.73 | 6.26 | 7.29 | 6.64 |
| $B_2$ | 9.00 | 8.19 | 8.00 | 8.61 | 8.45 | 7.42 | 6.21 | 6.70 | 7.93 | 7.06 |
| MEAN | 8.72 | 8.18 | 7.92 | 8.42 | 8.31 | 7.36 | 5.97 | 6.48 | 7.61 | 6.85 |
| | F-test | S. Em (±) | | CD @ 5% | | F-test | S. Em (±) | | CD @ 5% | |
| V | SIG | 0.07 | | 0.21 | | SIG | 0.07 | | 0.21 | |
| B | SIG | 0.05 | | 0.15 | | SIG | 0.05 | | 0.15 | |
| V X B | SIG | 0.10 | | 0.30 | | NS | 0.10 | | - | |

**Table 3. Response of different amaranthus types and planting systems on leaf breadth and stem diameter under shade net condition during *kharif* 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 |
| $B_1$ | 4.12 | 2.96 | 3.17 | 4.24 | 3.62 | 4.82 | 3.37 | 3.42 | 3.85 | 3.86 |
| $B_2$ | 4.25 | 3.23 | 3.58 | 4.89 | 3.99 | 5.15 | 3.51 | 3.81 | 4.24 | 4.17 |
| MEAN | 4.18 | 3.09 | 3.37 | 4.57 | 3.80 | 4.98 | 3.44 | 3.61 | 4.05 | 4.02 |
| | F-test | S. Em (±) | | CD @ 5% | | F-test | S. Em (±) | | CD @ 5% | |
| V | SIG | 0.07 | | 0.21 | | SIG | 0.03 | | 0.10 | |
| B | SIG | 0.05 | | 0.15 | | SIG | 0.02 | | 0.07 | |
| V X B | NS | 0.10 | | - | | SIG | 0.04 | | 0.14 | |

**Table 4. Response of different amaranthus types and planting systems on days to first harvest and number of harvestings under shade net condition during *kharif* 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 |
| $B_1$ | 25.24 | 25.22 | 27.42 | 26.51 | 26.10 | 3.15 | 2.60 | 2.43 | 3.08 | 2.81 |
| $B_2$ | 24.42 | 24.83 | 27.08 | 26.08 | 25.60 | 3.45 | 2.88 | 2.48 | 3.23 | 3.01 |
| MEAN | 24.83 | 25.03 | 27.25 | 26.30 | 25.85 | 3.30 | 2.74 | 2.45 | 3.15 | 2.91 |
| | F-test | S. Em (±) | | CD @ 5% | | F-test | S. Em (±) | | CD @ 5% | |
| V | SIG | 0.07 | | 0.21 | | SIG | 0.03 | | 0.09 | |
| B | SIG | 0.05 | | 0.15 | | SIG | 0.02 | | 0.06 | |
| V X B | SIG | 0.10 | | 0.30 | | SIG | 0.04 | | 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 *kharif* 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 |
| $B_1$ | 1.24 | 1.10 | 0.97 | 1.19 | 1.12 | 12.38 | 10.96 | 9.74 | 11.87 | 11.24 |
| $B_2$ | 1.55 | 1.23 | 1.13 | 1.32 | 1.31 | 15.46 | 12.28 | 11.28 | 13.21 | 13.06 |
| MEAN | 1.39 | 1.16 | 1.05 | 1.25 | 1.22 | 13.92 | 11.62 | 10.51 | 12.54 | 12.15 |
| | F-test | S. Em (±) | | CD @ 5% | | F-test | S. Em (±) | | CD @ 5% | |
| V | SIG | 0.02 | | 0.06 | | SIG | 0.08 | | 0.24 | |
| B | SIG | 0.01 | | 0.03 | | SIG | 0.06 | | 0.18 | |
| V X B | SIG | 0.03 | | 0.07 | | SIG | 0.11 | | 0.34 | |

## 4. CONCLUSION

Among the various types of amaranthus it can be concluded that, Konkan Durangi ($V_1$) planted under shed net condition recorded minimum days required for germination with maximum plant height, number of leaves per plant, stem diameter, high yield than other amaranthus types.

Raised beds outperformed other planting systems in all measured parameters (growth, yield, and quality) during the *kharif* season.

Planting of Konkan Durangi on raised bed ($V_1B_2$) under shed net condition recorded minimum days required for germination, days required for first harvest with maximum plant height, number of leaves per plant, stem diameter, number of harvests, yield per square meter, yield t/ha.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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