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Comparative performance of *Amaranthus* (*Amaranthus* spp.) genotypes in different growing media under shade net condition

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Abstract
The current investigation entitled effect of organic manures under shade net condition in raised bed system on growth attributes of *Amaranthus* (*Amaranthus* spp.), was conducted at Dr. B. S. K. K. V., Dapoli during the *kharif* season in the year 2024. In the experiment, there were twelve treatments and three replications in Factorial Randomized Block Design (FRBD), comprising factor A: *Amaranthus* genotypes (3) and factor B: Growing media (4). The experimental results depicted that the treatment combination T_7 [Nigdi grown in with Soil + Vermicompost (10 t ha^{-1})] revealed significant superiority over other treatments in respect to the growth parameters and yield attributes *viz.*, days required for germination, plant height, number of leaves, leaf length, yield per meter square, yield per hectare. However, the treatment combination of T_5 [Nigdi local grown in soil + FYM 10 t ha^{-1})] noted significantly at par results, in *kharif* seasons. Vermicompost improved soil conditions through better nutrient availability, drainage, temperature and aeration, accelerating growth and advancing harvests in *Amaranthus*. However, final performance was chiefly governed by the inherent genetic traits of each genotype.

Keywords: Farm yard manure, vermicompost, *Amaranthus*, raised bed system, shade net

Introduction
Amaranthus (*Amaranthus* spp.), a member of the Amaranthaceae family (Chr. No. = 34), is one of the most widely consumed leafy vegetables, valued both as a food and an ornamental crop. The family comprises about 65 genera and 850 species, distributed across tropical, sub-tropical and temperate regions, with 50–60 species recognized as edible and cultivated for leafy and grain purposes, while a few exist as wild species. The genus name *Amaranthus* originates from the Greek word *"Amarantos"*, meaning "immortal" or "everlasting" (Rezwana *et al.*, 2017) [8].

Amaranthus is an annual herbaceous plant with a monoecious inflorescence, a soft woody upright to spreading habit, a deeply branched taproot and variable morphological traits including plant height (30–90 cm), leaf size, and flower color. Major cultivated species include *A. tricolor, A. dubius, A. caudatus, A. cruentus,* and *A. hypochondriacus*, grown for edible foliage, seeds, and ornamental purposes**.** Leafy *Amaranthus* (*A. tricolor, A. dubius,* etc.) is considered indigenous to South and Southeast Asia, particularly India (Shanmugavelu, 1989) [10]. Globally, it is known by diverse names such as African spinach, pig weed and tampala in China (Cole, 1989), while in India it holds regional names like Rajgira, Cheera, Chinese spinach, Chaulai (Hindi) and Math (Marathi), reflecting its wide cultural and dietary significance.

The demand for organic food is steadily increasing both in developed and developing countries. There is scope for increasing the export of organically produced leafy vegetables (*Amaranthus*, spinach, etc) fetching higher price in the market. *Amaranthus* is highly responsive to organic manures and have fewer pest and disease problems as compared to other vegetables if cultivated in protected structures (Preetha *et al.*, 2005) [6] *Amaranthus* production which largely affects the soil fertility and also have enormous impacts on human health. Over the past decades there is wide focus on the scope of research and development on organic farming of leafy vegetables (Xu *et al.*, 2003) [13].

Manoeuvre of chemical fertilizer along with growth enhancing organic manures promotes the crop productivity and thereby enhances the soil fertility.

Given its economic value, improving the yield potential of *Amaranthus* has become increasingly important. Although its agronomic practices are well standardized, there remains a need to boost its growth and productivity. Hence, this study investigates the possibility of enhancing *Amaranthus* growth parameters using different organic inputs.

Material and Methods

The experiment was carried out in the Konkan region of Maharashtra under agroclimatic conditions. It was conducted at the Department of Vegetable Science, College of Horticulture, Dapoli, during the Kharif seasons of 2024. On the global map, the geological position is located at 17º46'0" north latitude and 73º11'0" east longitude. The experimental plot was laid out in Factorial Randomized Block Design (FRBD), comprises factor A: *Amaranthus* genotypes (1. Konkan Durangi, 2. Nigdi local and 3. KPS 182 AMAR) and factor B: Growing media 1. Soil + FYM (20 t ha-1), 2. Soil + FYM (10 t ha-1), 3. Soil + Vermicompost (10 t ha-1) and 4. [Soil + Vermicompost (5 t ha-1)]. With three replications and twelve treatments *viz*., T_1 [Konkan Durangi in Soil + FYM (20 t ha-1)], T_2 [Konkan Durangi in Soil + FYM (10 t ha-1)], T_3 [Konkan Durangi in Soil + Vermicompost (10 t ha-1)], T_4 [Konkan Durangi in Soil + Vermicompost (5 t ha-1)], T_5 [Nigdi Local in Soil + FYM (20 t ha-1)], T_6 [Nigdi Local in Soil + FYM (10 t ha-1)], T_7 [Nigdi Local in Soil + Vermicompost (10 t ha-1)], T8 [Nigdi Local in Soil + Vermicompost (5 t ha-1)], T_9 [KPS 182 AMAR in Soil + FYM (20 t ha-1)], T_{10} [KPS 182 AMAR in Soil + FYM (10 t ha-1)], T_{11} [KPS 182 AMAR in Soil + Vermicompost (10 t ha-1)], T_{12} [KPS 182 AMAR in Soil + Vermicompost (5 t ha-1)]. The observations were recorded in every cycle in both kharif.

Results and Discussion

Germination

Germination (days required for germination) plays a very crucial role in determining the further plant growth, days required for harvest and form of the plant. The effect between *Amaranthus* genotype and growing media on the number of days required for germination in *Amaranthus* during each cycle. The minimum days required for germination were recorded in treatment T7 (3.2, 3.1, 2.9, 2.8 and 3.1 days). While the maximum days were observed in the treatment T_{10} (4.0, 3.9, 3.7, 3.5 and 3.9 days) during June, July, August, September- and October, respectively in kharif seasons. Germination in *Amaranthus* genotypes is primarily governed by their genetic makeup, though soil media enriched with vermicompost improve conditions like aeration, water retention, and nutrient availability that favour healthy sprouting. Ultimately, the inherent genetic traits largely determine the final germination percentage. Similar results were also seen by Modupeola *et al.* (2018) in Logos spinach and Saleh *et al.* (2022) in *Amaranthus* [5, 9].

Plant height (cm)

The plant height of *Amaranthus* as influenced by the interaction effect between *Amaranthus* genotypes and growing media at harvest was found to be significant. The maximum plant height was recorded in treatment T7 (19.4, 21.5, 19.1, 22.4, and 20.5cm), while the minimum was observed in treatment T_{10} (12.9, 14.3, 14.4, 14.8 and 13.6 cm) during June, July, August, September and October, respectively of kharif season. Plant height in *Amaranthus* genotypes is largely governed by genetic variation, though vermicompost-based growing media improve soil conditions (warmth, tilth, aeration, and nutrient availability), which support shoot growth and deeper rooting, results in higher growth and yield. Ultimately, the final plant height remains primarily determined by the inherent genetic traits of genotypes. Similar results were also reported by Modupeola *et al.* (2018) in Logos spinach; Saleh *et al.* (2022) in *Amaranthus* [5, 9].

Number of leaves

Treatment T_7 recorded the maximum number of leaves (6.5, 6.9, 7.3, 7.5 and 7.2), while the treatment T_{10} resulted in the minimum (4.5, 4.8, 5.1, 5.2 and 5.0) leaves per plant at harvest during June, July, August, September and October respectively in kharif season. Number of leaves in *Amaranthus* genotypes is mainly influenced by genetic variation, though media enriched with vermicompost, improves nutrient availability, soil warmth, and aeration, can enhance leaf development; however, the final leaf count remains largely governed by the genotype's inherent traits. Similar results were by Saleh *et al.* (2022) in *Amaranthus*; Raksun *et al.* (2022), Yadav *et al.* (2022) and Indurthi *et al.* (2024) in *Amaranthus* [4, 8, 9, 14].

Leaf length (cm)

The maximum leaf length was found in the treatment T_7 (7.3, 8.1, 8.2, 8.4 and 7.7 cm), while the combination of T_{10} resulted in the minimum leaf length (5.8, 6.5, 6.6, 6.7 and 6.2 cm) at harvest during June, July, August, September and October, respectively. Leaf length in *Amaranthus* genotypes was largely influenced by genetic variation, while vermicompost-enriched soil improved nutrient availability, warmth and aeration that supported leaf development. Nevertheless, the ultimate leaf length was primarily determined by the genotype's inherent traits. The similar results were seen by Anjali *et al.* (2022) and Raksun *et al.* (2022) in *Amaranthus* [1, 8]

Leaf breadth (cm)

The leaf breadth was seen maximum in the treatment T_{11} (5.0, 5.3, 5.5, 5.8 and 5.6 cm), while the treatment T_6 resulted in the minimum leaf breadth (2.4, 2.5, 2.6, 2.8 and 2.7 cm) during June, July, August, September and October, respectively. Leaf breadth in *Amaranthus* genotypes was strongly influenced by genetic variation, though vermicompost-amended soil improved structure, drainage, aeration, and nutrient supply that supported leaf development. However, the final leaf breadth was mainly determined by the inherent genetic traits of each genotype. The similar results were seen by Raksun *et al.* (2022) in *Amaranthus* [8].

Stem diameter

The effect between different genotypes of *Amaranthus* and growing media on stem diameter. Treatment T_{11} recorded the maximum stem diameter (1.92, 2.13, 2.15, 2.22 and 1.96 mm), while the treatment T_2 had the minimum diameter (1.50, 1.66, 1.68, 1.73 and 1.58 mm) during June, July, August, September and October, respectively. Stem diameter in *Amaranthus* genotypes was strongly influenced

by genetic variation, while vermicompost amended soil improved structure, drainage, aeration, and nutrient supply that supported stem development. Nevertheless, the final stem diameter was primarily governed by the inherent genetic traits of each variety. Similar result was found by Indurthi *et al.* (2024) in *Amaranthus* tristis L [4].

Number of cycles

During kharif season, the shortest period required for harvest was observed in the T_7 (23.6, 22.9, 22.0, 30.3 and 22.9 days), while the longest number of days required for harvest was recorded in T_{10} (25.4, 24.7, 23.5, 22.5 and 23.9 days) during June, July, August, September and October, respectively. Vermicompost in soil generally improved growing conditions by enhanced nutrient availability, drainage, soil temperature and aeration, which accelerated growth and enabled earlier harvests. However, the extent of this effect was largely influenced by the genetic makeup of each *Amaranthus* genotype. Similar result also reported by Chaudhary *et al.* (2018) in (*Amaranthus* Spp.) Cv. Arka Suguna and Indurthi *et al.* (2024) in *Amaranthus* tristis [2, 4].

Yield kg m-2

The interaction between *Amaranthus* genotypes and growing media had a significant effect on the yield per square meter (kg m-2) of *Amaranthus*. The highest yields were observed in treatment T_7 recorded 1.43 kg in June, 1.51 kg in July, 1.59 kg in August, 1.65 kg in September and 1.61 kg in October. In contrast, the lowest yields were noted in treatment T_{10}, showing 0.98 kg in June, 1.03 Kg in July, 1.08 kg in August, 1.13 kg in September and 1.10 kg in October. Similar result also reported by Vasava *et al.* (2016); Solangi *et al.* (2017) in spinach, Anjali *et al.* (2022) and Saleh *et al.* (2022) in *Amaranthus* [1, 9, 11, 12].

Table 1: Effect of *Amaranthus* genotypes and growing media on days required for germination, plant height, number of cycles and yield of *Amaranthus* in kharif

Treatments	Days required for germination					Plant height (cm)					Number of cycles	Yield t ha^{-1}				
	June	July	Aug	Sept	Oct	June	July	Aug	Sept	Oct	*Kharif*	June	July	Aug	Sept	Oct
T_1	3.6	3.5	3.3	3.1	3.5	18.3	20.3	20.5	21.1	19.3	5.07	12.0	12.6	13.3	13.8	13.4
T_2	4.2	4.0	3.8	3.6	4.0	14.3	15.8	15.9	16.4	15.0	5.00	10.5	11.0	11.6	12.1	11.3
T_3	3.8	3.7	3.5	3.3	3.7	18.2	20.6	20.4	20.9	19.2	5.18	13.7	14.5	15.2	15.8	15.4
T_4	3.9	3.7	3.6	3.4	3.8	16.0	17.7	17.9	18.4	16.9	5.11	11.7	12.3	12.9	13.4	13.6
T_5	3.6	3.5	3.3	3.1	3.5	19.0	21.1	21.3	21.9	20.1	5.30	14.2	15.0	15.7	16.3	15.8
T_6	3.7	3.6	3.4	3.2	3.6	15.9	17.6	17.8	18.3	16.8	5.28	10.0	10.5	11.0	11.5	11.1
T_7	3.2	3.1	2.9	2.8	3.1	19.4	21.5	21.8	22.4	20.5	5.38	14.3	15.1	15.9	16.5	16.1
T_8	3.4	3.3	3.1	2.9	3.3	17.1	18.9	19.1	19.7	17.9	5.36	12.0	12.7	13.3	13.8	13.7
T_9	3.9	3.8	3.6	3.5	3.9	15.3	16.9	17.1	17.6	16.1	5.00	11.8	12.5	13.1	13.6	13.2
T_{10}	4.2	4.0	3.8	3.6	4.0	12.9	14.3	14.4	14.8	13.6	5.11	9.8	10.3	10.8	11.3	11.0
T_{11}	3.7	3.6	3.4	3.2	3.6	16.9	18.8	19.0	19.6	17.9	5.24	13.0	13.7	14.4	15.0	14.7
T_{12}	3.9	3.7	3.6	3.4	3.8	14.9	16.5	16.7	17.2	15.7	5.16	10.0	10.6	11.1	11.6	11.3
S.E m ±	0,04	0.08	0.07	0.07	0.08	0.29	0.33	0.29	0.34	0.31	0.09	0.20	0.20	0.20	0.20	0.30
CD at 5%	0.12	0.23	0.22	0.21	0.23	0.86	0.96	0.86	0.99	0.91	0.18	0.60	0.65	0.68	0.80	0.70

Yield t ha-1

The highest yield (t ha-1) of *Amaranthus* after interaction between *Amaranthus* genotype and growing media during the kharif season were achieved by treatment T_7 producing 14.3 t in June, 15.1 t in July, 15.9 t in August, 16.5 t in September and 16.1 t in October. In contrast, the lowest yields were observed in treatment T_{10} which yielded 9.8 t in June, 10.3 t in July, 10.8 t in August, 11.3 t in September and 11.0 t in October. Extreme weather in open fields limits vegetable yield and quality. Under such circumstances, protected cultivation is the best option (Cheema, 2010). Higher plant height and number of leaves results in higher yield similar result also reported by Vasava *et al.* (2016); Anjali *et al.* (2022) and Saleh *et al.* (2022) [1, 3, 9, 12].

Conclusion

Based on the results recorded from the present investigation, it was concluded that the presence of nutrients in organic growing media *viz*., FYM and Vermicompost may synergize with *Amaranthus* genotypes to enhance germination and shoot elongation results in higher yield in respective treatments. On the other hand, different *Amaranthus* genotypes have their own genetic traits to show their growth characters in combination with growing media. Treatment combination T_7 [Nigdi Local in Soil + Vermicompost (10 t ha-1)] was found to be significantly superior with respect to growth and yield attributing characters (days required for germination, plant height, number of leaves, leaf length and number of cycles, yield kg m-2, t ha-1), treatment T_{11} in terms of leaf breadth and stem diameter in comparison with the other treatment combinations. Vermicompost in soil generally improved growing conditions by enhanced nutrient availability, drainage, soil temperature and aeration, which accelerated growth and earlier and high harvest of *Amaranthus*. However, the final performance was mainly determined by the inherent genetic traits of each genotype.

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