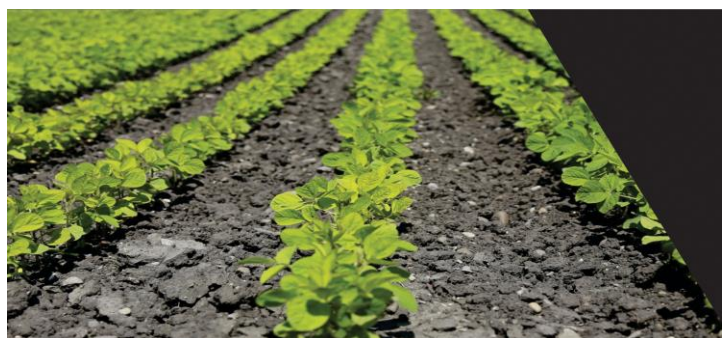




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Evaluation of polybag size and potting media on seedling height and tiller formation in *Bambusa tulda* (Roxb.)

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Abstract

Bamboo plays a significant role in ecological sustainability, rural livelihoods and industrial applications. Among the various species, *Bambusa tulda* is widely valued for its fast growth, high biomass production and multiple economic uses. Successful establishment of bamboo plantations largely depends on the production of healthy and vigorous seedlings in nurseries. Therefore, the present study was conducted to evaluate the effect of different polybag sizes and potting media on seedling height and tiller formation in *Bambusa tulda*. The experiment was carried out under nursery conditions using three polybag sizes (8 × 12 inches, 6 × 9 inches and 5 × 8 inches) and eight potting media combinations consisting of soil, sand, farmyard manure (FYM), vermicompost, ash and sawdust in different proportions. Growth parameters such as plant height and number of tillers were recorded at monthly intervals for a period of six months after planting. The results revealed that both polybag size and potting media significantly influenced seedling growth. Among the potting mixtures, the treatment consisting of soil + sand + FYM + vermicompost (2:1:0.5:0.5) produced the highest plant height and maximum tiller number throughout the observation period. Similarly, the largest polybag size (8 × 12 inches) recorded superior growth performance compared to the smaller polybags, indicating that greater rooting space and improved moisture and nutrient availability promoted better seedling development. The interaction between nutrient-enriched potting media and larger polybags further enhanced seedling vigour. The study concludes that the use of vermicompost-based potting media in larger polybags is an effective nursery practice for producing robust *Bambusa tulda* seedlings for plantation and bamboo resource development.

Keywords: *Bambusa tulda*, polybag size, potting media, seedling growth, tiller production

1. Introduction

Bamboo is an ecologically and economically important resource that provides a wide range of benefits to human society. It serves as a vital raw material for housing, tools, basketry and handicrafts, while also contributing to environmental functions such as water regulation, soil stabilization and ecosystem protection. In many Asian cultures, bamboo holds significant social and cultural value. It is popularly known as “the poor man’s timber” in India, “the friend of the people” in China and “the brother” in Vietnam, reflecting its deep connection with rural livelihoods and traditional practices (Banik, 2016) ^[2].

Historically, bamboo has played an important role in supporting rural economies by providing materials for construction, household implements and even food. In recent decades, bamboo has gained prominence as a renewable industrial raw material with diverse applications in paper production, textiles, construction and various eco-friendly products. Its rapid growth rate and strong regenerative capacity make bamboo a sustainable alternative to conventional materials such as timber, steel and plastics (Maviton and Shankar, 2022) ^[8]. Botanically, bamboo belongs to the grass family (Poaceae) and is classified as a woody grass that can attain heights of up to 40 m. Globally, more than 1,700 species of bamboo have been reported (Nayak and Mishra, 2016) ^[10]. Major centres of bamboo diversity include India, China and Brazil, with India’s northeastern region and moist deciduous forests supporting a significant proportion of the country’s bamboo resources (Sawarkar *et al.*, 2021) ^[13].

At the global level, bamboo supports the livelihoods of nearly 2.5 billion people, and more than one billion people depend on bamboo for housing and related needs. In India, bamboo-bearing areas cover approximately 154,670 km², with the largest share found in Madhya Pradesh (FSI, 2023) ^[1]. However, the Forest Survey of India (2021) reported a decline of about 1.06 million hectares of bamboo resources, primarily due to deforestation, overexploitation and habitat degradation. In response to this decline, the Government of India initiated the National Bamboo Mission with a budget allocation of ₹12.90 billion to promote bamboo cultivation on both forest and non-forest lands. The mission aims to enhance bamboo productivity, strengthen rural livelihoods and ensure a stable supply of raw materials for bamboo-based industries (Kaushal *et al.*, 2021) ^[5].

Bambusa tulda is one of the most important tropical bamboo species widely distributed in South and Southeast Asia. It belongs to the family Poaceae and is commonly found in countries such as India, Bangladesh, Myanmar and Thailand. In India, *Bambusa tulda* occurs predominantly in the northeastern states and other moist tropical regions where it grows well under warm and humid climatic conditions. The species is valued for its fast growth, high biomass production and adaptability to different environmental conditions. It is a medium to large-sized clumping bamboo that can attain heights of 15 to 25 m with straight and strong culms. Due to its superior culm quality, it is widely used for construction, scaffolding, furniture making, handicrafts and paper pulp production. In addition to its economic importance, the species also contributes to ecological functions such as soil conservation, carbon sequestration and restoration of degraded lands.

This study is important to identify the suitable nursery practices for producing healthy and vigorous *Bambusa tulda* seedlings. Polybag size and potting media significantly influence root development, nutrient availability and overall seedling growth. Optimizing these factors can improve seedling height and tiller formation, leading to better establishment and survival in field plantations. The findings will help nursery managers and bamboo growers to adopt efficient propagation techniques for large-scale bamboo cultivation and restoration programs.

2. Material and methods

The present study "Evaluation of polybag size and potting media on seedling height and tiller formation in *Bambusa tulda*" was conducted during 2024-25 at the nursery of the College of Forestry, Sirsi, Uttara Kannada district, Karnataka, located at 14°36' N latitude, 75°53' E longitude and 619 m MSL, under the hilly zone (Zone-9). The area receives an average annual rainfall of 1924.6 mm, with temperatures ranging between 14.9 °C and 35 °C. Six-month-old seedlings procured from the Forest Department nursery were used as experimental material. The study was laid out in a two-factorial Completely Randomized Design (CRD) with three replications. Factor I consisted of three polybag sizes: P1 (8" × 12"), P2 (6" × 9") and P3 (5" × 8"). Factor II included eight potting mixtures: T₁ (Soil + Sand + FYM, 2:1:1), T₂ (Soil + Sand + FYM, 1:1:1), T₃ (Soil + Sand + FYM, 2.5:0.5:1), T₄ (Soil + Sand + FYM + Vermicompost, 2:1:0.5:0.5), T₅ (Soil + Sand + Vermicompost, 2:1:1), T₆ (Soil + Sand + FYM + Ash, 2:1:0.5:0.5), T₇ (Soil + Sand + Ash, 2:1:1) and T₈ (Soil + Sand + FYM + Sawdust, 2:1:0.5:0.5). Regular watering and periodic weeding were carried out to ensure proper maintenance and healthy growth of the seedlings. Growth parameters, like plant height and number of tillers, were recorded at monthly intervals for a period of six months after planting. The collected data were subjected to statistical analysis to assess the effects of different treatments.

3. Results and discussion

3.1 Plant Height

From Table 1 it is evident that polybag size had a significant effect on plant height of *Bambusa tulda* seedlings. The largest polybag (P1: 8 × 12 inches) produced the tallest plants, reaching 75.77 cm at 180 days after planting, followed by P2 (6 × 9 inches) with 47.71 cm, while the smallest polybag (P3: 5 × 8 inches) recorded the lowest height (34.97 cm). The better performance in larger polybags may be due to greater soil volume, which supports improved root growth, moisture retention and nutrient uptake. Potting mixtures also significantly influenced plant height. Among the treatments, T₄ (soil + sand + FYM + vermicompost) produced the tallest seedlings (73.91 cm), followed by T₆ (soil + sand + FYM + ash) and T₈ (soil + sand + FYM + sawdust). The lowest height was recorded in T₇ (soil + sand + ash). This indicates that nutrient-enriched mixtures, particularly those containing vermicompost, enhanced vegetative growth. The interaction effect of polybag size and potting mixture was also significant. The maximum plant height was recorded in T₄P1 (soil + sand + FYM + vermicompost in 8 × 12 inch polybags) with 107.13 cm, whereas the minimum height was observed in T₇P3 (soil + sand + ash in 5 × 8 inch polybags) with 23.67 cm. Overall, larger polybags combined with nutrient-rich potting mixtures resulted in better seedling growth.

Plant height is an important indicator of early seedling vigour, reflecting the combined effects of photosynthetic activity and root development. As presented in Table 1 and Fig. 1, plant height of *Bambusa tulda* seedlings was significantly influenced by potting mixtures, polybag size and their interaction over the six-month period. Among the potting mixtures, T₄ (Soil + Sand + FYM + Vermicompost, 2:1:0.5:0.5) recorded the highest plant height (73.91 cm), likely due to improved nutrient availability, microbial activity and moisture retention provided by vermicompost and FYM. Similar findings were reported by Dwivedi *et al.* (2012) ^[4] in *Dendrocalamus strictus*. Treatments T₆ (Soil + Sand + FYM + Ash) and T₈ (Soil + Sand + FYM + Sawdust) also showed good growth, whereas T₇ (Soil + Sand + Ash) produced the lowest height (32.36 cm), indicating that nutrient-rich organic media are essential for better seedling growth (Rawat *et al.*, 2015) ^[12]. Polybag size also significantly affected plant height, with the largest polybag P1 (8 × 12 inches) producing the tallest seedlings (75.77 cm), followed by P2 and P3. Larger containers likely support better root growth and nutrient uptake, resulting in improved shoot development, as reported by Kumar *et al.* (2014) ^[6] in *Bambusa balcooa*. The interaction between potting mixture and polybag size was also significant, with T₄P1 producing the maximum plant height, confirming that nutrient-enriched media combined with larger containers promote superior seedling growth (Dwivedi *et al.*, 2012) ^[4].

3.2 Number of tillers

From Table 2 it is seen that, polybag size significantly influenced tiller production in *Bambusa tulda* seedlings (Table 8). The largest polybag size, P1 (8 × 12 inches), produced the highest number of tillers (5.58) at six months after planting, followed by P2 (6 × 9 inches) with 3.98 tillers, while the smallest polybag P3 (5 × 8 inches) recorded the lowest tiller number (3.28). The improved tiller formation in larger polybags may be due to greater rooting space, better moisture retention and enhanced nutrient availability. Potting mixtures also showed a significant effect on tiller production. Among the treatments, T₄ (soil + sand + FYM + vermicompost) recorded the highest number of tillers (5.40), followed by T₆ (soil + sand + FYM + ash), whereas T₇ (soil + sand + ash) produced the lowest tiller count (2.89). This indicates that

nutrient-rich and well-structured potting media, particularly those containing vermicompost, support better tiller development. The interaction between polybag size and potting mixture was also significant. The maximum tiller number was observed in T₄P₁ (soil + sand + FYM + vermicompost in 8 × 12 inch polybags) with 7.80 tillers, followed by T₆P₁ and T₈P₁. In contrast, the lowest tiller production was recorded in T₇P₃ (soil + sand + ash in 5 × 8 inch polybags). Overall, larger polybags combined with nutrient-enriched potting media promoted better tiller formation in *Bambusa tulda* seedlings.

The results presented in Table 2 and Fig. 2, indicate that both potting mixture and polybag size significantly influenced tiller production in *Bambusa tulda*. Among the treatments, T₄ (Soil + Sand + FYM + Vermicompost, 2:1:0.5:0.5) recorded the highest number of tillers (5.40), which may be attributed to improved nutrient availability, soil structure and microbial activity provided by FYM and vermicompost. Similar results were reported by Prabhat and Singh (2012) [11] in *Dendrocalamus strictus* and Lal

et al. (2016) [7] in *Bambusa balcooa*, where organic media enhanced shoot and tiller development. Treatment T₆ (Soil + Sand + FYM + Ash) also showed good performance (4.98 tillers), possibly due to the role of ash in improving soil pH and supplying essential nutrients such as potassium and silica, as reported by Chaitanya *et al.* (2017) [3]. Polybag size also had a significant effect, with the largest size P₁ (8 × 12 inches) producing the highest number of tillers (5.58), likely due to greater root space and better moisture retention, similar to the findings of Mohammed *et al.* (2014) [9]. The interaction between potting mixture and polybag size was also significant, with T₄P₁ producing the maximum number of tillers (7.80), followed by T₆P₁ and T₈P₁. Similar interaction effects of container size and potting media on seedling growth were reported by Sharma *et al.* (2019) [14] in *Dendrocalamus strictus*. Overall, the combination of FYM and vermicompost in larger polybags is recommended for improving tiller production and nursery performance of *Bambusa tulda*.

Table 1: Plant height (cm) of *Bambusa tulda* influenced by polybags and potting mixture

Polybag sizes (P)	Plant height (cm)						% Increase
	30DAP	60DAP	90DAP	120DAP	150DAP	180DAP	
P ₁ - 8 x 12 inches	32.95	41.48	49.73	64.85	72.98	75.77	43.49
P ₂ - 6 x 9 inches	24.24	28.70	35.70	43.21	45.63	47.71	50.81
P ₃ - 5 x 8 inches	18.18	20.48	25.78	28.59	32.25	34.97	51.99
SEm ±	0.12	0.18	0.21	0.28	0.25	0.31	--
C.D. @ 5%	0.33	0.50	0.61	0.79	0.71	0.89	--
Treatments (T)							
T ₁ - Soil + Sand + FYM (2:1:1)	19.73	22.20	29.04	31.33	33.73	36.56	53.97
T ₂ - Soil + Sand + FYM (1:1:1)	23.98	28.58	33.31	42.51	46.38	48.64	49.30
T ₃ - Soil + Sand + FYM (2.5:0.5:1)	24.80	29.89	37.22	46.36	48.62	50.98	48.65
T ₄ - Soil + Sand + FYM+ Vermicompost (2:1:0.5:0.5)	31.71	39.53	46.47	60.62	70.98	73.91	42.90
T ₅ - Soil + Sand + Vermicompost (2:1:1)	27.04	31.36	40.89	49.69	53.18	55.53	48.69
T ₆ - Soil + Sand + FYM + Ash (2:1:0.5:0.5)	28.98	36.62	42.98	53.87	61.51	64.07	45.23
T ₇ - Soil + Sand + Ash (2:1:1)	17.11	20.18	24.20	28.76	29.56	32.36	52.87
T ₈ - Soil + Sand + FYM + Sawdust (2:1:0.5:0.5)	27.62	33.40	42.44	51.27	58.31	60.47	45.68
SEm ±	0.19	0.29	0.35	0.45	0.41	0.51	--
C.D. @ 5%	0.54	0.82	1.00	1.28	1.15	1.45	--
Interactions (T × P)							
P ₁ :T ₁	24.13	29.27	38.93	44.67	44.80	48.53	49.72
P ₂ :T ₁	18.20	19.60	28.93	29.53	29.80	32.87	55.37
P ₃ :T ₁	16.87	17.73	19.27	19.80	26.60	28.27	59.67
P ₁ : T ₂	32.07	40.47	45.07	60.53	69.67	71.73	44.71
P ₂ : T ₂	22.00	25.80	34.07	42.60	42.73	45.73	48.11
P ₃ : T ₂	17.87	19.47	20.80	24.40	26.73	28.47	62.77
P ₁ : T ₃	32.53	44.07	51.07	67.60	73.07	76.53	42.51
P ₂ : T ₃	23.73	26.07	36.13	43.93	44.20	47.07	50.41
P ₃ : T ₃	18.13	19.53	24.47	27.53	28.60	29.33	61.81
P ₁ : T ₄	43.73	52.87	61.93	84.33	104.00	107.13	40.82
P ₂ : T ₄	29.60	40.20	43.93	55.40	66.47	69.47	42.61
P ₃ : T ₄	21.80	25.53	33.53	42.13	42.47	45.13	48.30
P ₁ : T ₅	34.53	44.13	52.67	72.27	77.27	79.40	43.49
P ₂ : T ₅	27.53	30.20	39.73	45.73	47.47	49.80	55.28
P ₃ : T ₅	19.07	19.73	30.27	31.07	34.80	37.40	50.99
P ₁ : T ₆	37.60	48.73	56.33	72.47	87.60	90.60	41.50
P ₂ : T ₆	28.47	36.80	42.20	54.60	55.53	57.60	49.43
P ₃ : T ₆	20.87	24.33	30.40	34.53	41.40	44.00	47.43
P ₁ : T ₇	24.07	27.87	36.33	44.53	44.67	47.20	51.00
P ₂ : T ₇	16.60	18.73	19.13	24.33	26.20	26.20	63.36
P ₃ : T ₇	10.67	13.93	17.13	17.40	17.80	23.67	45.08
P ₁ : T ₈	34.93	44.47	55.53	72.40	82.73	85.00	41.09
P ₂ : T ₈	27.80	32.20	41.47	49.53	52.60	52.93	52.52
P ₃ : T ₈	20.13	23.53	30.33	31.87	39.60	43.47	46.31
SEm ±	0.33	0.50	0.61	0.78	0.70	0.88	--
C.D. @ 5%	0.93	1.43	1.73	2.22	2.00	2.50	--

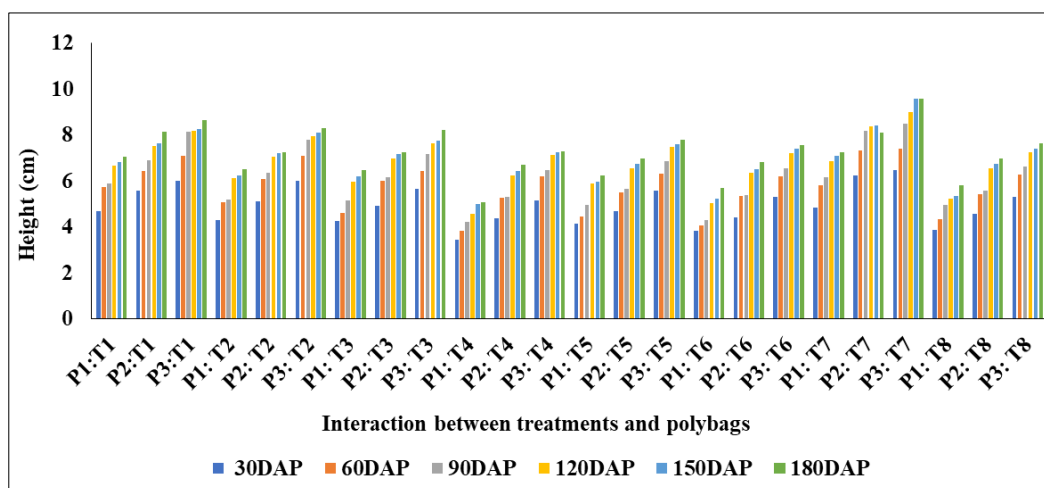


Fig 1: Interaction between different treatments and polybags on height of *Bambusa tulda* seedlings

Where, P1- 8 x 12 inches, P2- 6 x 9 inches P3- 5 x 8 inches; T₁ - Soil + Sand + FYM (2:1:1), T₂- Soil + Sand + FYM (1:1:1), T₃- Soil + Sand + FYM (2.5:0.5:1), T₄ - Soil + Sand + FYM+ Vermicompost (2:1:0.5:0.5), T₅- Soil + Sand + Vermicompost

(2:1:1), T₆-Soil + Sand + FYM + Ash (2:1:0.5:0.5), T₇- Soil + Sand + Ash (2:1:1), T₈-Soil + Sand + FYM + Sawdust (2:1:0.5:0.5)

Table 2: Number of tillers in *Bambusa tulda* influenced by polybags and potting mixture

Polybag sizes (P)	No. of tillers						% Increase
	30DAP	60DAP	90DAP	120DAP	150DAP	180DAP	
P1 - 8 x 12 inches	2.53	3.00	3.71	3.97	4.53	5.58	45.34
P2 - 6 x 9 inches	1.89	2.28	2.71	2.93	3.07	3.98	47.49
P3 - 5 x 8 inches	1.58	1.82	2.04	2.19	2.55	3.28	48.17
SEm ±	0.01	0.01	0.01	0.02	0.02	0.03	--
C.D. @ 5%	0.03	0.03	0.04	0.05	0.04	0.08	--
Treatments (T)							
T ₁ - Soil + Sand + FYM (2:1:1)	1.69	1.98	2.29	2.49	2.73	3.56	47.47
T ₂ - Soil + Sand + FYM (1:1:1)	1.89	2.36	2.71	2.89	3.18	4.04	46.78
T ₃ - Soil + Sand + FYM (2.5:0.5:1)	1.93	2.38	2.76	2.96	3.27	4.18	46.17
T ₄ - Soil + Sand + FYM+ Vermicompost (2:1:0.5:0.5)	2.36	2.76	3.44	3.67	4.33	5.40	43.70
T ₅ - Soil + Sand + Vermicompost (2:1:1)	2.09	2.53	2.91	3.24	3.60	4.47	46.76
T ₆ - Soil + Sand + FYM + Ash (2:1:0.5:0.5)	2.29	2.64	3.36	3.56	3.98	4.98	45.98
T ₇ - Soil + Sand + Ash (2:1:1)	1.53	1.69	2.02	2.09	2.20	2.89	52.94
T ₈ - Soil + Sand + FYM + Sawdust (2:1:0.5:0.5)	2.22	2.60	3.07	3.33	3.76	4.73	46.93
SEm ±	0.02	0.02	0.02	0.03	0.02	0.05	--
C.D. @ 5%	0.05	0.06	0.06	0.09	0.07	0.13	--
Interactions (T × P)							
P1:T ₁	2.00	2.47	2.87	3.20	3.20	4.20	47.62
P2:T ₁	1.67	1.87	2.07	2.33	2.67	3.60	46.39
P3:T ₁	1.40	1.60	1.93	1.93	2.33	2.87	48.78
P1:T ₂	2.40	3.07	3.60	3.67	4.00	5.00	48.00
P2:T ₂	1.80	2.13	2.53	2.67	2.93	3.80	47.37
P3:T ₂	1.47	1.87	2.00	2.33	2.60	3.33	44.14
P1:T ₃	2.53	3.13	3.60	3.80	4.20	5.07	49.90
P2:T ₃	1.80	2.13	2.60	2.73	3.00	4.00	45.00
P3:T ₃	1.47	1.87	2.07	2.33	2.60	3.47	42.36
P1:T ₄	3.00	3.33	4.67	5.00	6.40	7.80	38.46
P2:T ₄	2.27	2.87	3.33	3.53	3.67	4.60	49.35
P3:T ₄	1.80	2.07	2.33	2.47	2.93	3.80	47.37
P1:T ₅	2.53	3.13	3.67	4.13	4.73	5.47	46.25
P2:T ₅	2.00	2.53	3.00	3.27	3.27	4.33	46.19
P3:T ₅	1.73	1.93	2.07	2.33	2.80	3.60	48.06
P1:T ₆	2.93	3.27	4.60	4.67	5.53	6.73	43.54
P2:T ₆	2.20	2.73	3.13	3.53	3.53	4.53	48.57
P3:T ₆	1.73	1.93	2.33	2.47	2.87	3.67	47.14
P1:T ₇	2.00	2.40	2.73	3.13	3.13	4.13	48.43
P2:T ₇	1.33	1.33	1.87	1.87	2.07	2.67	49.81
P3:T ₇	1.27	1.33	1.47	1.27	1.40	1.87	67.91
P1:T ₈	2.87	3.20	3.93	4.13	5.00	6.20	46.29
P2:T ₈	2.07	2.67	3.13	3.47	3.40	4.33	47.81
P3:T ₈	1.73	1.93	2.13	2.40	2.87	3.67	47.14
SEm ±	0.03	0.03	0.04	0.05	0.04	0.08	--
C.D. @ 5%	0.09	0.10	0.10	0.15	0.12	0.22	--

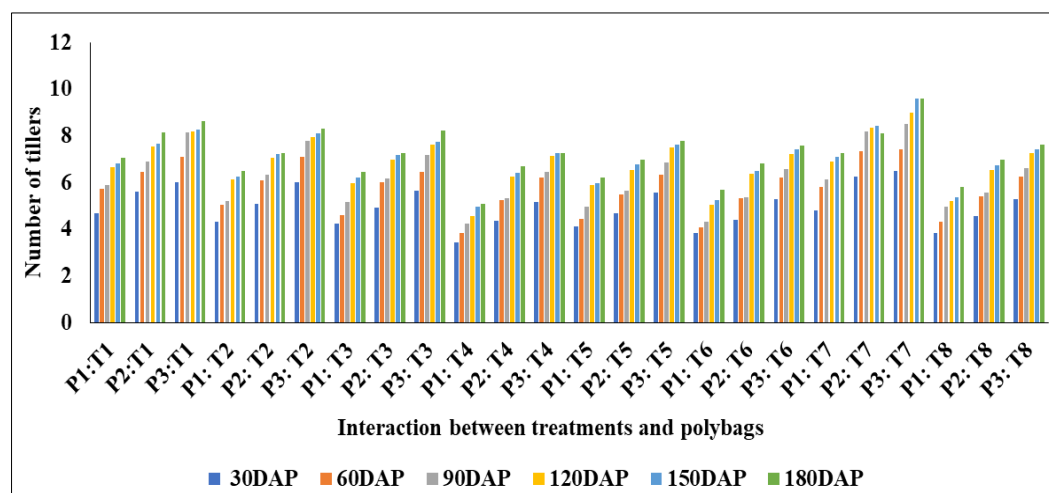


Fig 2: Interaction between different treatments and polybags on number of tillers in *Bambusa tulda* seedlings

Where, P1- 8 x 12 inches, P2- 6 x 9 inches P3- 5 x 8 inches; T₁ - Soil + Sand + FYM (2:1:1), T₂ - Soil + Sand + FYM (1:1:1), T₃ - Soil + Sand + FYM (2.5:0.5:1), T₄ - Soil + Sand + FYM + Vermicompost (2:1:0.5:0.5), T₅ - Soil + Sand + Vermicompost (2:1:1), T₆ - Soil + Sand + FYM + Ash (2:1:0.5:0.5), T₇ - Soil + Sand + Ash (2:1:1), T₈ - Soil + Sand + FYM + Sawdust (2:1:0.5:0.5)

4. Conclusion

The present study demonstrated that both polybag size and potting media significantly influenced the growth performance of *Bambusa tulda* seedlings under nursery conditions. Among the treatments, the potting mixture consisting of soil + sand + FYM + vermicompost (2:1:0.5:0.5) showed superior results in terms of plant height and tiller production. Similarly, the larger polybag size (8 x 12 inches) provided better root space, moisture retention and nutrient availability, resulting in improved seedling growth compared to smaller polybags. The interaction between nutrient-rich potting media and larger polybags further enhanced seedling vigour and development. Therefore, the combination of soil + sand + FYM + vermicompost in 8 x 12 inch polybags can be recommended as an effective nursery practice for producing healthy and vigorous *Bambusa tulda* seedlings for plantation and bamboo-based resource development.

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