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Effect of Different Bio-fertilizers and Farm Yard Manure on Flowering Attributes of Dahlia (*Dahlia variabilis* L.) cv. Kenya

Kaosarul Islam [a*], Md Ramjan [b], Khan Bilal Mukhtar Ahmed [b], Anish Ahmad [b], Saifa Khatoon [b] and Samima Parvin [b]

[a] Department of Floriculture and Landscaping, Faculty of Horticulture, Bidhan Chandra Krishi Vishwavidyalaya, Nadia, W.B.-741252, India.
[b] Centre of Agricultural Education, Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh-202002 (Uttar Pradesh), India.

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 was carried out at Centre of Agricultural Education Research Farm, Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh to study the comparative effect of different bio-fertilizers and farm yard manure on the flowering attributes of Dahlia (*Dahlia variabilis* L.) cv. Kenya. The experiment was laid out in completely randomized block design (CRBD) with three replications and twelve treatments. Comparative performance was studied for eight quantitative traits viz. days taken to flower bud appearance, flower bud diameter (mm), days

**Corresponding author: E-mail: gn8327@myamu.ac.in;*

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taken to flower anthesis, average weight of fresh flower per plant (g), flower diameter (cm), number of flowers per plant, flowering duration (days), days taken to colour break. In the present investigation the influence of FYM and three biofertilizers viz. *Azotobacter chroococcum*, Potassium Mobilizing Biofertilizer (K.M.B) and Phosphate Solubilizing Biofertilizer (P.S.B) and their combination on the field of dahlia (*Dahlia variabilis* L.) cv. Kenya. Among the treatments, T_{11} (FYM @ 1.5 kg/block + *Azotobacter chroococcum* @ 2.8 mL/block + K.M.B @ 1.8 mL/block + (P.S.B) @ 3.6 mL/block) recorded a significant effect on the flowering attributes, followed by T_{12} (FYM @ 1 kg/block + *Azotobacter chroococcum* @ 2.8 mL/block + K.M.B @ 1.8 mL/block + P.S.B @ 3.6 mL/block).

Keywords: Dahlia; flowering; bio-fertilizers and farm yard manure.

1. INTRODUCTION

Dahlia (*Dahlia variabilis* L.) is a highly sought-after, tuberous-rooted perennial, celebrated for its stunning flowers. Known as "water cane," "water pipe," and "hollow stem flower" due to its hollow stems, dahlia is prized for its elegance and grandeur. It's unmatched as a bedding plant for its versatility and beauty, lasting over two weeks depending on the cultivar. With a chromosome number of 2n = 64, dahlia belongs to the Asteraceae family and originated in Mexico, where it was declared the national flower in 1963. The genus was named by Abbe Cavanilles in 1791, honouring Swedish botanist Dr. Andreas Dahl. Introduced to India in 1857 by the Agri-Horticultural Society of India, Kolkata, the country has made significant contributions to flower-pot dahlia forms and plant breeding (Raghupathi *et al.,* 2017) The name Dahlia variabilis reflects its ability to create new forms and hybridize, resulting in various types and classifications.

There are approximately 20,000 recognized dahlia varieties, as per the International Registration of Dahlias (Marina, 2015). Dahlia is undoubtedly a prized flowering plant in gardens, holding a prominent position in any garden setting. The Netherlands leads in tuberous-rooted dahlia production, followed by other major producers like Japan, France, South Africa, the UK, Italy, Germany, and the USA (De Hertogh and Le Nard, 1993). In India, commercial dahlia cultivation is prominent in the North-West and Central plains. However, the crop is also grown in the hills and plains of Eastern India, including Jammu and Kashmir, where it has commercial potential.

Dahlia also boasts medicinal and nutritional benefits. Its tubers are rich in starch-inulin, convertible to fructose, a sweetener suitable for diabetic patients (Ioana *et al*., 2017). Soil infertility is a major constraint to crop yields in developing nations, especially for resource-poor farmers. Integrated nutrient management (INM) using farmyard manure (FYM) and biofertilizers can address this issue, enhance flower quality and vase life while reducing cost (Kumar *et al*., 2006). Biofertilizers provide an eco-friendly means of reducing chemical fertilizer use by increasing nutrient availability to plants (Singhal *et al*., 2003). Beneficial bacteria like Azotobacter, a free-living nitrogen-fixing bacterium, improve plant nutrition by interacting with phosphate-solubilizing bacteria. Azotobacter can fix 15-20 kg/ha N annually and produce antifungal compounds (Kumar and Chaudhary, 2018). Using FYM and biofertilizers like Azotobacter, potassium mobilizing biofertilizer (KMB), and phosphate solubilizing biofertilizer (PSB) can increase yields and save on chemical fertilizers, with PSB potentially increasing yields by 200-500 kg/ha (Kumar and Chaudhary, 2018).

2. MATERIALS AND METHODS

This study was carried out at, Centre of Agricultural Education Research Farm, Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh, Uttar Pradesh. The experiment site was situated at 27.88° N latitude, 78.20° E longitude and above the 178-metre mean sea level. Aligarh is situated in the middle portion of Doab or the land between the Ganga and Yamuna rivers. The planting material for the experiment was procured from Rekha Nursery, Kolkata. The healthy and disease-free seedlings of uniform size were selected. FYM & bio-fertilizers used in the experiment were used from the Faculty for Agricultural Science, Aligarh Muslim University, Aligarh, Uttar Pradesh, during the year 2023-2024.

The experiment was laid out in completely randomized block design with three replications and twelve treatments. The comparative

Table 1. Details of treatment of the experiment

S. No	Treatment	Details of Treatment
1.	T_1	Control
2.	T_2	FYM @ 2.5 kg/block
3.	T_3	FYM @ 1.5 kg/block + *Azotobacter chroococcum* @ 2.8 mL/block
4.	T_4	FYM @ 1.5 kg/block + Potassium Mobilizing Biofertilizer (K.M.B) @ 1.8 mL/block
5.	T_5	FYM @ 1.5 kg/block + Phosphate Solubilizing Biofertilizer (P.S.B) @ 3.6 mL/block
6.	T_6	FYM @ 1 kg/block + *Azotobacter chroococcum* @ 2.8 mL/block
7.	T_7	FYM @ 1 kg/block + Potassium Mobilizing Biofertilizer (K.M.B) @ 1.8 mL/block
8.	T_8	FYM @ 1 kg/block + Phosphate Solubilizing Biofertilizer (P.S.B) @ 3.6 mL/block
9.	T_9	FYM @ 1.5 kg/block + *Azotobacter chroococcum* @ 2.8 mL/block + Potassium Mobilizing Biofertilizer (K.M.B) @ 1.8 mL/block
10.	T_{10}	FYM @ 1 kg/block + *Azotobacter chroococcum* @ 2.8 mL/block + Potassium Mobilizing Biofertilizer (K.M.B) @ 1.8 mL/block
11.	T_{11}	FYM @ 1.5 kg/block + *Azotobacter chroococcum* @ 2.8 mL/block + Potassium Mobilizing Biofertilizer (K.M.B) @ 1.8 mL/block + Phosphate Solubilizing Biofertilizer (P.S.B) @ 3.6 mL/block
12.	T_{12}	FYM @ 1 kg/block + *Azotobacter chroococcum* @ 2.8 mL/block + Potassium Mobilizing Biofertilizer (K.M.B) @ 1.8 mL/block + Phosphate Solubilizing Biofertilizer (P.S.B) @ 3.6 mL/block

performance was studied for eight quantitative traits viz. days taken to flower bud appearance, flower bud diameter (mm), days taken to flower anthesis, average weight of fresh flower per plant (g), flower diameter (cm), number of flowers per plant, flowering duration (days) and days taken to colour break. The detail of treatment of the experiment is given in Table 1.

2.1 Preparation of Biofertilizer and Application

Biofertilizers *Azotobacter*, Potassium Mobilizing Biofertilizer (K.M.B) & Phosphate Solubilizing Biofertilizer (P.S.B) were obtained from the department and have been used according to the combination of treatment plans quantity of each bio-fertilizer combination i.e. *Azotobacter* @ 2.8 mL/block, PSB @ 3.6 mL/block and KMB @ 1.8 mL/block was mixed with 500 mL water in glass beakers and shaken well (Chaudhary, 2021; Pandey *et al.,* 2017). Selected healthy seedlings were placed in the bio-fertilizer solution for half an hour so that the root portion of the seedlings remained completely dipped in the solution. After bio-fertilizer treatment on roots of dahlia, seedlings were taken out, shade dried and planted in the prepared field.

3. RESULTS AND DISCUSSION

Notably significant variation in flowering growth was seen in dahlia (*Dahlia variabilis* L.) cv. Kenya when multiple bio-fertilizers and farm yard manure were employed. The results demonstrated that the application of biofertilizers, FYM and its combination had a significant effect on the flowering attributes of dahlia. Among the treatments, the treatment T_{11} was recorded the minimum flower bud appearance (45.33), flower anthesis (58.78) and colour break (49.11) while maximum number of days to flower bud appearance (65.78), flower anthesis (77.67) and colour break (67.78) were observed in T_2 (Table 2 and Figs. 1, 3 and 8). Delayed bud appearance, colour break and flower anthesis may be attributed to the fact that higher doses of biofertilizers delayed the reproductive phase of the plant, particularly nitrogen which enhances plant's juvenile phase. These findings are in support with the study conducted by Sharma and Singh (2001) as well as by Kumar *et al*. (2019).

1. Days to flower bud appearance

The earliest bud initiation (45.33 days) was observed in T_{11}, followed closely by T_{12} (51.89 days). Treatments with FYM combined with a single biofertilizer (T_3–T_8) ranged between 53–55 days, showing moderate improvement over control (65.78 days). This suggests that inoculants accelerate bud initiation.

2. Flower bud diameter

Maximum bud diameter was obtained in T_{11} (20.02 mm), significantly higher than T_1 (14.17

mm). T_{12} also performed well (19.13 mm), whereas intermediate values were recorded in T_2 (18.54 mm) and T_{10} (18.18 mm). The results indicate that phosphorus and potassium mobilization in combination with nitrogen fixation strongly contribute to larger bud formation.

3. Days to Anthesis

T_{11} recorded the earliest anthesis (58.78 days), whereas control (77.67 days) was the most delayed. T_{12} (62.11 days) and T_{10} (64.89 days) also showed early anthesis, while T_3–T_8 showed values around 65–67 days. This demonstrates the role of balanced nutrient availability in accelerating floral opening.

4. Average fresh flower weight per plant

The heaviest flowers were produced under T_{11} (48.30 g), followed by T_{12} (45.54 g). Control plants (32.15 g) bore the lightest flowers. Among single biofertilizer combinations, T_2 (41.13 g) and T_8 (39.20 g) performed better than T_3, T_4, T_5, T_6, and T_7. These findings indicate that FYM in synergy with PSB and Azotobacter improves biomass allocation toward floral structures.

5. Flower diameter

T_{11} achieved the maximum flower diameter (18.88 cm), followed by T_{12} (17.38 cm). In contrast, the smallest flowers were produced in T_1 (12.81 cm). Treatments T_2 and T_{10} also showed relatively large flowers (16.81 and 16.30 cm respectively), reinforcing that integrated nutrient management supports both size and quality.

6. Number of flowers per plant

T_{11} recorded the highest flower count (20.59), with T_{12} (18.88) ranking second. The control (7.80) produced the lowest number. Intermediate results were observed in T_2 (17.00) and T_{10} (15.99). This indicates that balanced nutrition not only enhances flower size but also boosts total productivity per plant.

7. Flowering duration

Maximum flowering duration was observed in T_{11} (14.17 days) and T_{12} (13.04 days). This was almost double that of control plants (7.89 days), meaning that integrated biofertilizer use extends the ornamental value and marketability of the crop.

8. Days to colour break

The earliest colour break occurred in T_{11} (49.11 days), followed by T_{12} (52.67 days), while T_1 (67.78 days) was the most delayed. Treatments T_2, T_3, and T_4 were intermediate (53–55 days). The reduced time to colour break indicates a positive role of nutrient synergy in pigment synthesis and petal development.

Prasad *et al.* (2018) as well as by Chaudhary *et al.* (2020) observed the same trend in the flowering attributes.

Supply of nutrients in adequate quantities through biofertilizers under T_{11} improved various vegetative parameters including branch number, leaf number and leaf size, which in turn resulted in increased flower number. Increased leaf number and size resulted in better photo assimilation by plants leading to quantitative improvement in flowering parameters. Phosphorus played an important role in regulating the reproductive stage and profoundly influences the flowering of plants. The results are in close agreement with findings of Sheergojri *et al*. (2013).

Biofertilizers enhance nutrient availability, including carbon, phosphorus, nitrogen, and sulfur, by accelerating mineralization of organic residues in soil (Sharma *et al*., 2007), while preventing heavy metal uptake (Bhattacharjee and Dey, 2014). They provide nitrogen in forms like ammonium, amino acids, and nitrate without risking overdose. Applying biofertilizers stimulates Azotobacter and PSB survival, directly or indirectly promoting bacterial growth and plant metabolic activities, leading to increased root exudates and a favorable environment for microorganisms (Kumar *et al*., 2001; Choudhary *et al.,* 2018; Soni *et al*., 2022). Farmyard manure (FYM) improves soil's physio-chemical properties, such as pH, EC, organic carbon, and macro- and micro-nutrients, due to its high nutrient content (Jeyabasakaran *et al*., 2001). Potassium mobilizing biofertilizer (KMB) solubilizes inorganic potassium sources, like muriate of potash, by producing organic acids, enhancing flowering attributes (Bagyalakshami *et al*., 2012). Shubha's 2006 study found that combining Azospirillum, vermicompost, and 75% of the recommended nitrogen and phosphorus dose led to the highest plant height, leaf count, branch number, flower bud initiation, flowering duration, flower yield per plant, and xanthophyll yield, which is consistent with our experimental results.

Table 2. Effect of different treatments on different flowering attributes in dahlia (*Dahlia variabilis* L.) cv. Kenya

Treatments	Flowering Attributes							
	Days taken to flower bud appearance	Flower bud diameter (mm)	Days taken to flower anthesis	Average weight of fresh flower per plant (g)	Flower diameter (cm)	Number of flowers per plant	Flowering duration (days)	Days taken to colour break
T_1	65.78	14.17	77.67	32.15	12.81	7.80	7.89	67.78
T_2	51.22	18.54	63.45	41.13	16.81	17.00	12.11	53.22
T_3	54.11	15.89	67.55	35.44	14.33	12.65	9.83	54.56
T_4	55.34	16.66	66.56	38.93	15.11	12.22	9.65	55.22
T_5	53.89	17.09	66.11	36.89	15.42	12.56	10.29	54.89
T_6	54.33	17.46	65.67	36.78	14.89	11.92	9.69	55.33
T_7	53.44	16.80	66.34	35.49	15.22	12.88	9.94	54.78
T_8	53.11	17.67	65.00	39.20	16.00	15.11	10.88	54.11
T_9	50.56	17.39	65.89	37.44	15.60	11.77	9.78	55.22
T_{10}	52.89	18.18	64.89	40.51	16.30	15.99	11.33	53.89
T_{11}	45.33	20.02	58.78	48.30	18.88	20.59	14.17	49.11
T_{12}	51.89	19.13	62.11	45.54	17.38	18.88	13.04	52.67
Grand Mean	53.49	17.41	65.83	38.98	15.73	14.11	10.71	55.06
SE(m)±	2.79	0.74	2.88	1.87	0.73	0.73	0.57	2.42
CV%	9.04	7.35	7.58	8.32	8.08	8.99	9.29	7.61
C.D. at 5%	8.02	1.11	8.27	5.38	2.11	2.10	1.65	6.95
P value at 5%	0.0196	0.0308	0.0422	0.0141	0.0015	0.0000	0.0000	0.0144

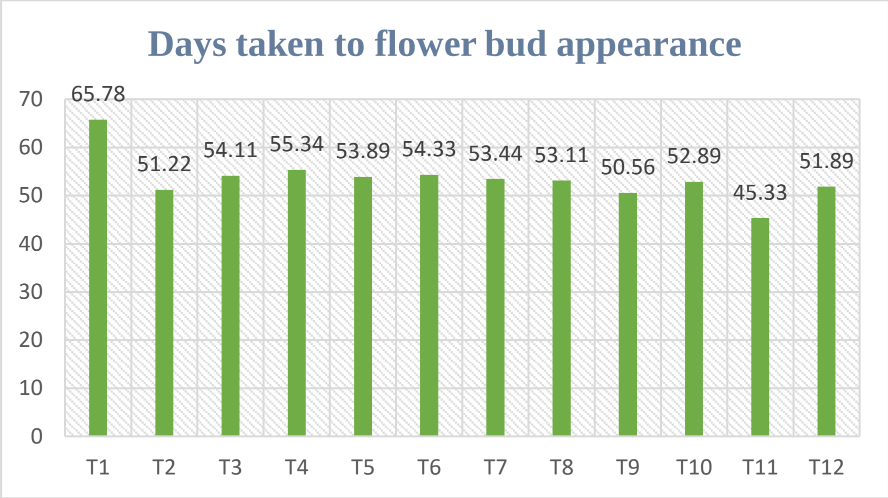

Fig. 1. Effect of FYM and biofertilizers on days taken to flower bud appearance in dahlia (*Dahlia variabilis* L.) cv. Kenya

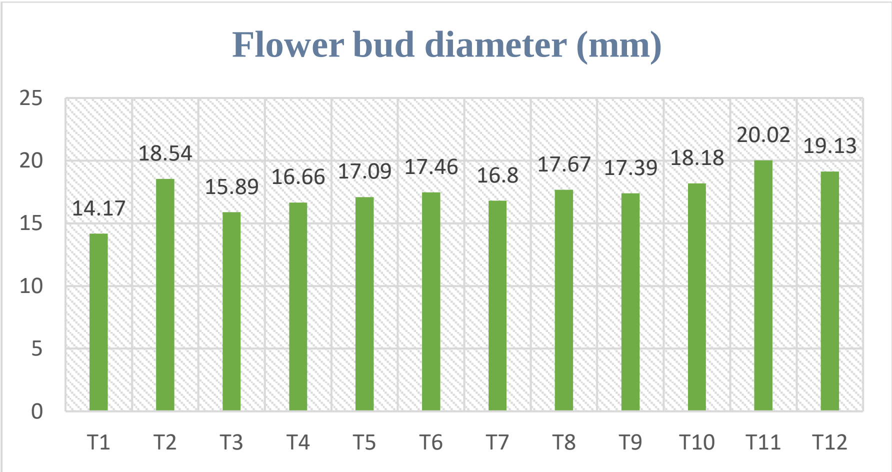

Fig. 2. Effect of FYM and biofertilizers on flower bud diameter (mm) in dahlia (*Dahlia variabilis* L.) cv. Kenya

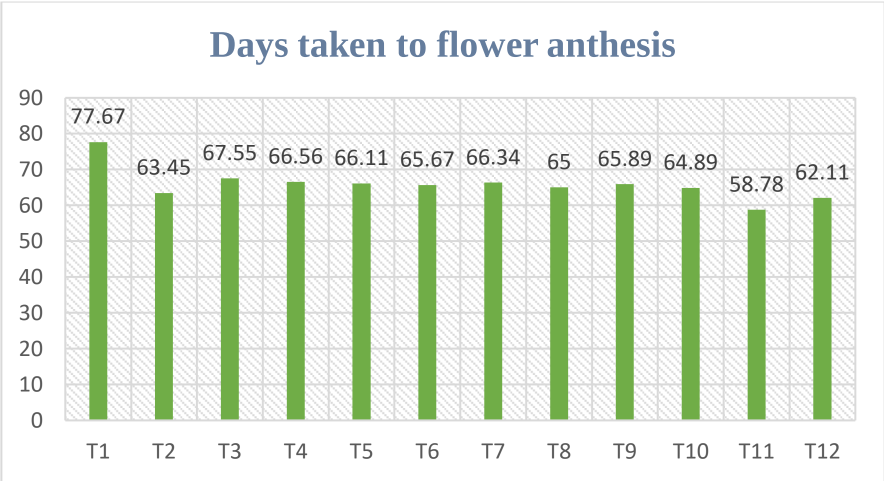

Fig. 3. Effect of FYM and biofertilizers on days taken to flower anthesis in dahlia (*Dahlia variabilis* L.) cv. Kenya

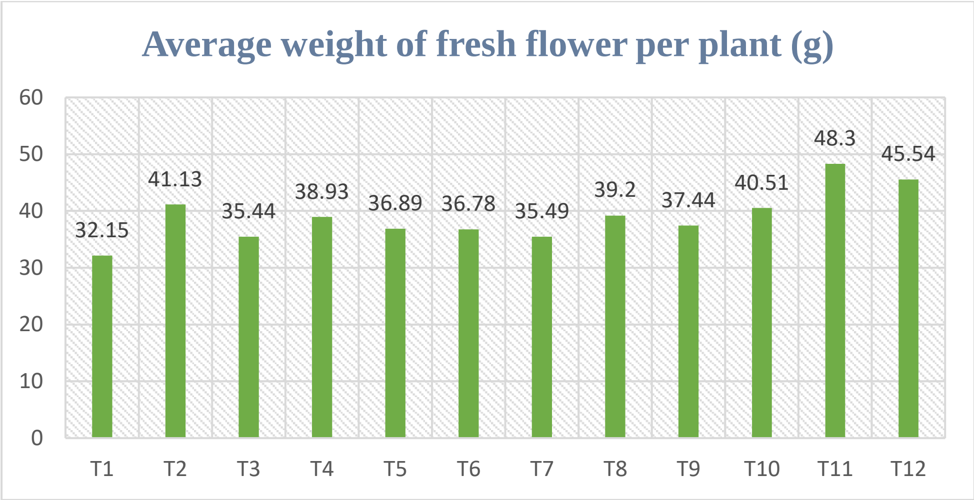

Fig. 4. Effect of FYM and biofertilizers on average weight of fresh flower per plant (g) in dahlia (*Dahlia variabilis* L.) cv. Kenya

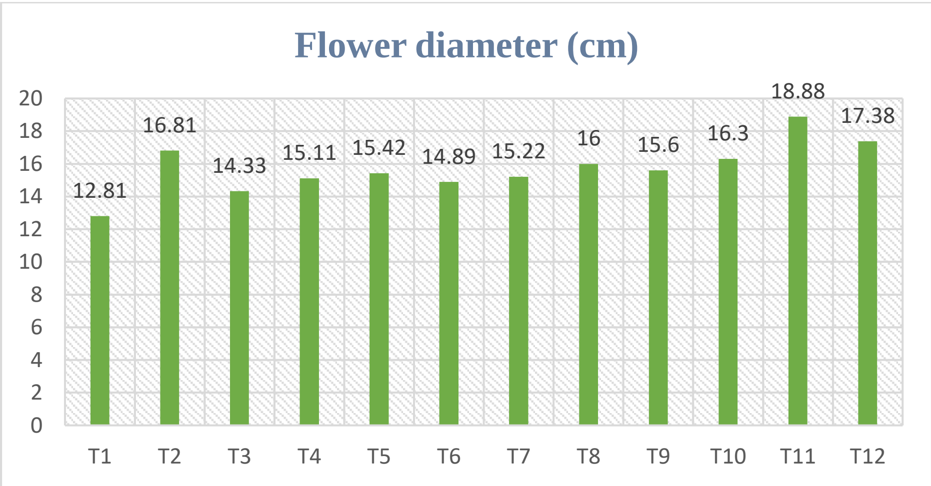

Fig. 5. Effect of FYM and biofertilizers on flower diameter (cm) in dahlia (*Dahlia variabilis* L.) cv. Kenya

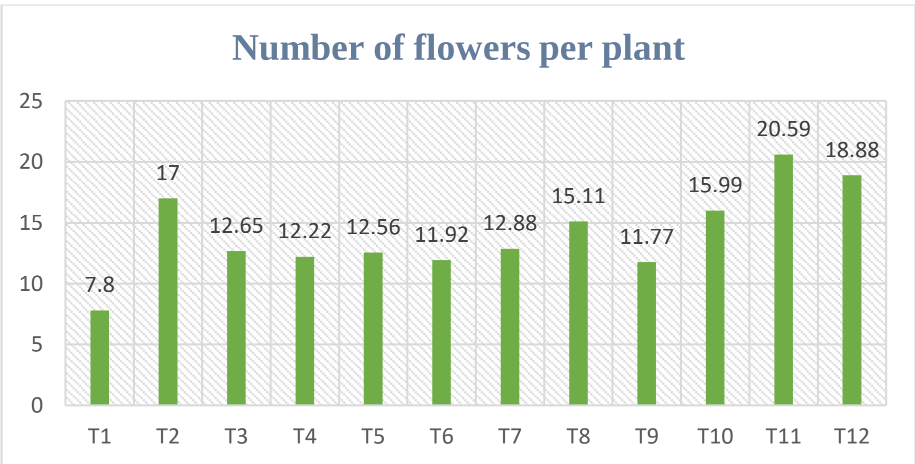

Fig. 6. Effect of FYM and biofertilizers on number of flowers per plant in dahlia (*Dahlia variabilis* L.) cv. Kenya

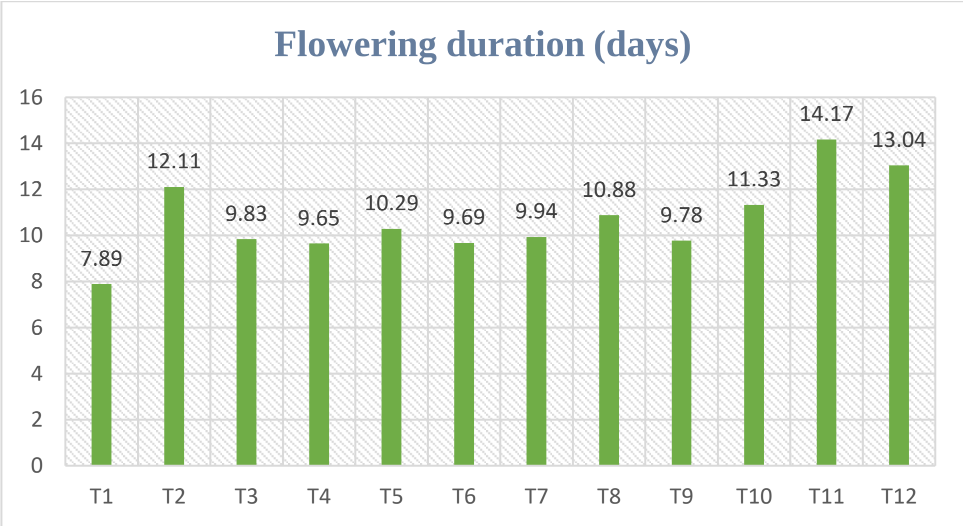

Fig. 7. Effect of FYM and biofertilizers on flowering duration (days) in dahlia (*Dahlia variabilis* L.) cv. Kenya

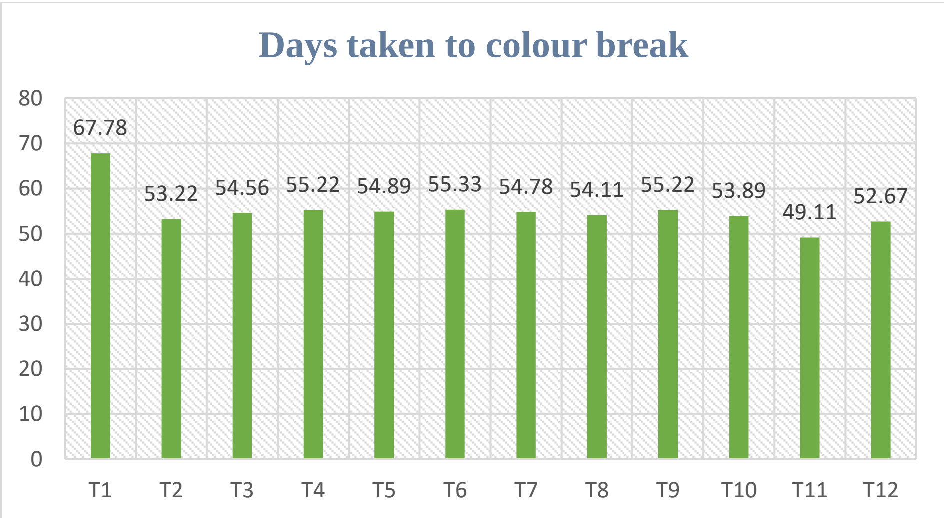

Fig. 8. Effect of FYM and biofertilizers on days taken to colour break in dahlia (*Dahlia variabilis* L.) cv. Kenya

4. CONCLUSION

Based on experimental findings, it is concluded that the treatment T_{11} (FYM @ 1.5 kg/block + *Azotobacter chroococcum* @ 2.8 mL/block + Potassium Mobilizing Biofertilizer (K.M.B) @ 1.8 mL/block + Phosphate Solubilizing Biofertilizer (P.S.B) @ 3.6 mL/block) was found superior in increasing the quality of all the flowering attributes.

Based on the findings of this study, it is recommended that farmers and horticulturists consider using bio-fertilizersin combination with farm yard manure to improve the flowering attributes of Dahlia. This approach can contribute to sustainable and environmentally friendly of Dahlia production, while also improving crop yields and quality.

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 writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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