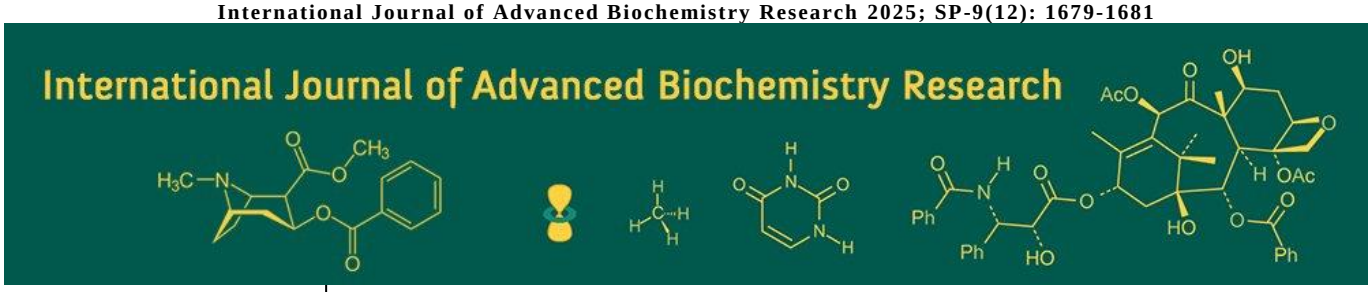

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; SP-9(12): 1679-1681
www.biochemjournal.com
Received: 09-10-2025
Accepted: 11-11-2025

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Studies on effect of Azotobacter and GA_3 on yield of flower as loose flower of Marigold (*Tagetes* spp.)

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DOI: https://www.doi.org/10.33545/26174693.2025.v9.i12St.6789

Abstract
Marigold (*Tagetes erecta* L.) is a traditional loose flower crop that is commercially farmed in a number of countries. is a member of the Asteraceae family (Compositae). It is majorly used as loose flower, garlands, and trap crop for nematodes. The chemicals used in the cultivation not only increase the cost of production but also deteriorate the soil fertility. The study was performed at Main Experimental Station Department of Floriculture and Landscape, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya 224229 (U.P.), India during the year 2019-20 and 2020-21on African marigold cv. Pusa Narangi Gainda in which combinations were used with Azotobacter and Gibberellic Acid. The results indicates that the highest flower yield per plant was recorded with the application of azotobacter by soil treatment @ 4 l/ha + 200ppm GA 3 at 30 DAT, whereas minimum flower yield per plant was noted in control also the highest flower yield per hectare was recorded with the application of azotobacter by soil treatment @ 4 l/ha + 200ppm GA 3 at 30 DAT, whereas minimum flower yield per hectare was noted in control.

Keywords: Marigold, yield, gibberellic acid, azotobacter

Introduction
African marigold (*Tagetes erecta* L., 2n =24) and French marigold (*Tagetes patula* L., 2n = 48) are the two most commonly grown kinds in India. It is also known as friendship flower in United States and student lumen (student's flower) in Germany. It was originated in central and South America. In the particularly Mexico. During the early 16th century, it expanded from Mexico to various regions of the world. (Bailey, 1963) [2]. The principal African marigold-growing states in India include Karnataka, Tamil Nadu, Andhra Pradesh, West Bengal, and Maharashtra (Kameswari *et al*., 2011) [4]. Floriculture production in India spanned 305 thousand hectares, producing 2301 thousand MT loose flowers and 762 thousand MT cut flowers annually. With a total area of 56.94 thousand hectares and a yield of 608.96 metric tonnes, marigolds are one of the most productive crops in the world (NHB 2019-2020). Marigold is regarded as a poor man crop because of its value. It can be grown in all seasons, including rainy, winter, and summer, with rainy and winter crops being the most common in eastern Uttar Pradesh. The availability of different nutrients influences marigold growth and flowering. Chemical fertilisers are commonly used to achieve a fast outcome. Excessive and indiscriminate application of chemical fertilisers, pesticides, and fungicides is currently causing soil health to deteriorate, ultimately threatening our green world. Small and marginal farmers make up the majority of India farmers. As a result, buying chemical fertilisers in big amounts, especially at a high price, is extremely difficult for them. Biofertilizers, which are microorganisms capable of mobilising nutritive nutrients from non-usable to usable forms via biological processes, show great potential under these circumstances. Biofertilizers are low-cost, environmentally friendly, and nutritionally rich for example Azotobacter, is a biofertilizer that can help to improve soil fertility significantly. Azotobacter fixes atmospheric nitrogen. Azotobacter is a nitrogen-fixing bacteria that fixes 25 to 30 kg nitrogen per acre in a free-living environment. Biofertilizers for horticultural crops include nitrogen-fixing bacteria and phosphate solubilizers. They also boost crop development and product quality by creating phytohormones, which improve plant nutrient uptake by plant roots and hence aid in long-term crop output by preserving soil productivity.

Methods and Materials

To conduct the study, IARI New Delhi provided experimental material of African marigold cv. Pusa Narangi Gainda. For African marigold, the study was set up as a Randomized Block Design (Factorial) with twelve treatment combinations and three replications. Three replications and twelve treatment combinations were used, as shown below.

Factor 1- Bio-inoculant (Azotobacter)

A 1 - Control
A 2 - Azotobacter by Root Treatment @ 0.25%
A 3 - Azotobacter by Soil Treatment @ 4 l/ha

Factor 2- Gibberellic Acid

G 1 - Control
G 2 - GA 3 100 ppm at 30 DAT
G 3 - GA 3 150 ppm at 30 DAT
G 4 - GA 3 200 ppm at 30 DAT

Treatment Combinations

Treatment Combination Explanation

T_1 A 1 G 1 (Control)
T_2 A 1 G 2 GA 3 100 ppm at 30 DAT
T_3 A 1 G 3 GA 3 150 ppm at 30 DAT
T_4 A 1 G 4 GA 3 200 ppm at 30 DAT
T_5 A 2 G 1 Azotobacter by Root Treatment @ 0.25%
T_6 A 2 G 2 Azotobacter by Root Treatment @ 0.25% + 100ppm GA 3 at 30 DAT
T_7 A 2 G 3 Azotobacter by Root Treatment @ 0.25% + 150ppm GA 3 at 30 DAT
T_8 A 2 G 4 Azotobacter by Root Treatment @ 0.25% + 200ppm GA 3 at 30 DAT
T_9 A 3 G 1 Azotobacter by Soil Treatment @ 4l/ha
T_{10} A 3 G 2 Azotobacter by Soil Treatment @ 4 l/ha+ 100ppm GA 3at 30 DAT
T_{11} A 3 G 3 Azotobacter by Soil Treatment @ 4 l/ha+ 150ppm GA 3 at 30 DAT
T_{12} A 3 G 4 Azotobacter by Soil Treatment @ 4 l/ha + 200ppm GA 3 at 30 DAT

Application of treatments

Application of NPK and organic fertilizers

According to the treatment combinations, the entire dose of phosphorus via single super phosphate, potash via Murate of potash, Vermicompost, Poultry dung, and Farmyard manure were applied at the time of field preparation. The nitrogen was applied in two split doses. the first ½ dose of total nitrogen through urea was applied at the time of seedling transplanting, and the remaining dose of nitrogen through urea was applied as a top dressing 30 days later.

Application of Bio-fertilizers

Four-week-old seedlings were removed from the nursery bed and given 30 minutes of treatment with bio-fertilizers (Azotobacter).

Procedure of treatment

The azotobacter solution was dipped into the roots of the seedlings prior to transplanting. Diluting @ 5.0 grams azotobacter culture in ten litres of water obtained the solution. The seedling was transplanted the same day after receiving root therapy. In the soil treatment, Azotobacter was combined with 4.2 grams of bio-culture in 20 kg of well-rotten cow dung in the shade and disseminated around the experimental area after 1-2 days. GA 3 was applied in the field via foliar treatment 30 days after marigold transplanting in formulations of 100 ppm, 150 ppm, and 200 ppm.

Transplanting of seedlings

After 30 days of seed sowing, marigold seedlings were transplanted. For transplantation, a group of seedlings with continuous growth and 3-5 leaves were chosen. The seedlings were transplanted in the experimental field on October 28, 2019- 20, then on October 24, 2020-2021 for the second year. Light irrigation was provided immediately after transplantation. To avoid better establishment in cool hours, transplanting was done in the evening. Seedlings were transplanted at a distance of 40 cm between row to row and plant to plant.

Results and Discussion

The maximum yield of flowers per plant (433.59 and 459.78 g during years 2019- 20 and 2020-21) was recorded with the treatment A 3 (Azotobacter by Soil Treatment 4 l/ha) followed by A 2 (Azotobacter by Root Treatment 0.25 percent), whereas the minimum yield per plant (253.9 and 265.33g in the year 2019-20 and 2020-21 respectively) with A 1 (Control). Similarly, the maximum yield of flower (443.81 and 459.26g in the years 2019-20 and 2020-21 respectively) was recorded with Treatment G4 (GA 3 200 ppm at 30 DAT) followed by treatment G 3 (GA 3 150 ppm at 30 DAT), and minimum flower yield per plant (215.43 and 229.04 g in 2019-20 and 2020-21 respectively) with treatment G1 (control). The interaction of azotobacter and gibberellic acid was found significant during both the years of investigation (2019-20 and 2020-21). The maximum flower yield per plant (601.69 and 638.21 g in the years 2019-20 and 2020-21 respectively) with the treatment A 3 G 4 (Azotobacter by Soil Treatment 4 l/ha + 200ppm GA 3 at 30 DAT) followed by A 3 G 3 (Azotobacter by Soil Treatment 4 l/ha+ 150ppm GA 3 at 30 DAT) whereas the minimum flower yield per plant (170.89 and 182.00 g in the years 2019-20 and 2020-21 respectively) with the treatment A 1 G 1 (Control).

Yield of flower per hectare

The treatment A 3 (Azotobacter by Soil Treatment 4 l/ha) produced the highest flower yield per hectare (190.68, 197.79 q in 2019-20 and 2020-21, respectively), followed by A 2 (Azotobacter by Root Treatment 0.25 percent), and the treatment A 1 (Control) produced the lowest flower yield per hectare (139.51, 143.35 q in 2019-20 and 2020-21 respectively). Similarly, Treatment G 4 (GA 3 200 ppm at 30 DAT) produced the highest flower yield per hectare (193.82, 201.25 q/ha in 2019-20 and 2020-21, respectively), followed by Treatment G 3 (GA 3 150 ppm at 30 DAT) and Treatment G 1 (Control) produced the lowest flower yield per hectare (119.52,124.12 q/ha in 2019-20 and 2020-21 respectively). During both years of research (2019-20 and 2020-21), the interaction between azotobacter and gibberellic acid was found to be significant. The treatment A 3 G 4 (Azotobacter by Soil Treatment 4 l/ha + 200ppm GA3 at 30 DAT) produced the highest flower yield per hectare (338.48 and 358.79 q in 2019-20 and 2020-21, respectively), followed by A 3 G 3 (Azotobacter by Soil Treatment 4 l/ha+ 150ppm GA3 at 30 DAT), and the treatment A 1 G 1 (Control) produced the lowest flower yield per hectare

(96.18 and 102.41 q during 2019-20 and 2020-21 respectively). The increase in yield and yield variables with GA 3 spray might be associated with enhanced crop growth, more flowers per plant, and maximum fresh weight of individual flowers, both of which would lead to an increased floral yield per plant. It may also be attributed to increased metabolite translocation from source to sink. Similar results were also reported by Khudus *et al*. (2017) [5], Sathappan (2018) [6], Arha *et al*. (2019) [1] in African marigold, Sweety *et al*. (2019) [7] in gladiolus cv. Oscar, and Kadam *et al*. (2020) [3] in gaillardia.

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