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Journal homepage: <http://www.plantarchives.org>

DOI Url : <https://doi.org/10.51470/PLANTARCHIVES.2026.v26.no.2.049>

## INTEGRATED APPLICATION OF NANO-FERTILIZERS AND ORGANIC MANURES ON GROWTH PARAMETERS OF CALENDULA (*Calendula officinalis* L.) cv. BON BON APRICOT

Preeti Sahu<sup>1\*</sup>, G.P. Nag<sup>2</sup>, T.L. Sahu<sup>1</sup>, R.K. Dewangan<sup>3</sup>, Rinu<sup>1</sup> and Menka<sup>1</sup>

<sup>1</sup>Department of Floriculture and Landscaping, MGUVV, Durg - 491 111, Chhattisgarh, India.

<sup>2</sup>Department of Vegetable Science, MGUVV, Durg - 491 111, Chhattisgarh, India.

<sup>3</sup>Department of Fruit Science, MGUVV, Durg - 491 111, Chhattisgarh, India.

\*Corresponding author E-mail : [preetisahu20202939@gmail.com](mailto:preetisahu20202939@gmail.com)

(Date of Receiving-27-05-2026; Date of Revision-21-07-2026; Date of Acceptance-07-08-2026)

### ABSTRACT

The present study entitled “Integrated application of nano-fertilizers and organic manures on growth parameter of Calendula (*Calendula officinalis* L.) cv. Bon Bon Apricot” was conducted during the *Rabi* season of 2025–2026 at the Research cum Instructional Farm, Krantikari Debridhur College of Horticulture and Research Station, Jagdalpur, (C.G.) under a Randomized Block Design with 12 treatments and 3 replications. The results indicated that growth parameters were significantly influenced by the combined application of organic manures and nano-fertilizers. Treatment T<sub>12</sub> [Integrated organic mix (25% of FYM + 25% of VC) + Nano mix (Nano Urea @ 1ml/L + Nano DAP @ 1.25ml/L), recorded superior performance at later growth stages, while T<sub>7</sub> [Vermicompost (50% of 2.5t/ha) + FYM (50% of 5t/ha)], showed better results at the early stage. At 60 and 90 DAT, T<sub>12</sub> exhibited maximum plant height (22.92 and 25.77 cm), number of leaves (72.63 and 97.11) and number of branches (10.81 and 16.22), along with highest plant spread at 90 DAT. Overall, integrated nutrient management with nano-fertilizers and organic manures significantly improved vegetative growth of calendula.

**Key words :** Integrated nutrient management, Nano fertilizers, Organic manures, Growth parameters, Plant height.

### Introduction

*Calendula* (*Calendula officinalis* L.), widely known as calendula, pot marigold, Mary’s gold, or poor man’s saffron, belongs to the family Asteraceae. The name is derived from the Latin word “calends” which means the first day of each month, indicating its long flowering period. As the flowers follow the sun’s movement, the plant has traditionally been linked with the summer zodiac sign. It is an annual herbaceous plant native to the Mediterranean region, characterized by its bright yellow to orange blossoms (Gazim *et al.*, 2008).

*Calendula* is a fragrant annual herb that can reach a height of up to 80 cm, featuring a slender, lightly branched stem that may grow upright or spread slightly (Kazemi *et al.*, 2014). The inflorescences of *Calendula* are yellow

and form a compact flower head, known as a capitulum, with a diameter of approximately 4–7 cm. It is extensively cultivated for multiple uses such as cut flowers, border decoration, dried flowers, loose flowers and oil extraction (Sahu *et al.*, 2023).

Organic manures improve the chemical properties of soil and enhance crop productivity. Materials such as farmyard manure and vermicompost which are derived from natural sources including animal waste and agricultural by-products can also help reduce environmental pollution (Buriro *et al.*, 2015). Nano-fertilizers are an emerging technology in which nutrients are reduced to nanoscale particles greatly enhancing their absorption efficiency. These fertilizers are easily taken up by plants through both roots and leaves. Their slow-

release nature also contributes to more efficient nutrient utilization. Additionally, nano-complexes can function effectively across a broad range of pH conditions (Mazaherinia *et al.*, 2010).

### Materials and Methods

The present experiment on *Calendula officinalis* L.) was conducted during the *Rabi* season of 2025–2026 at the Research cum Instructional Farm, Krantikari Debridhur College of Horticulture and Research Station, Jagdalpur, under MGUVV, Chhattisgarh. The experiment was laid out in a Randomized Block Design (RBD) with twelve treatments and three replications. The treatments consisted of T<sub>1</sub>: Control, T<sub>2</sub>: Nano Urea @4ml/L, T<sub>3</sub>: Nano DAP@5ml/L, T<sub>4</sub>: Vermicompost @2.5t/ha, T<sub>5</sub>: FYM @5t/ha, T<sub>6</sub>: Nano Urea @ 2ml/L + Nano DAP@2.5ml/L, T<sub>7</sub>: Vermicompost (50% of 2.5t/ha) + FYM (50% of 5t/ha), T<sub>8</sub>: Nano Urea@2ml/L + 50% of FYM @5t/ha, T<sub>9</sub>: Nano DAP@2.5ml/L + 50% of FYM @5t/ha, T<sub>10</sub>: Nano Urea @ 2ml/L (2 sprays) + 50% of Vermicompost @ 2.5t/ha, T<sub>11</sub>: Nano DAP @ 2.5ml/L + 50% of Vermicompost @ 2.5t/ha, T<sub>12</sub>: Integrated organic mix (25% of FYM + 25% of VC) + Nano mix (Nano Urea @ 1ml/L + Nano DAP @1.25ml/L). Observation were recorded on vegetative parameters including Plant height (cm), Number of leaves plant<sup>-1</sup>, Number of branches plant<sup>-1</sup> and Plant spread (cm).

### Results and Discussion

#### Plant height (cm)

Table 1 and Fig. 1 indicated significant differences in plant height at 30, 60 and 90 DAT among treatments. At 30 DAT, the highest plant height was recorded in T<sub>7</sub> [Vermicompost (50% of 2.5t/ha) + FYM (50% of 5t/ha)] (12.93 cm), which was statistically at par with T<sub>4</sub>, while the lowest was observed in T<sub>1</sub> (8.33 cm). At 60 and 90 DAT, T<sub>12</sub> [Integrated organic mix (25% of FYM + 25% of VC) + Nano mix (Nano Urea@1ml/L + Nano DAP @1.25ml/L)] recorded the maximum plant height (22.92 cm and 25.77 cm, respectively). This was statistically at par with T<sub>10</sub> and T<sub>11</sub> at 60 DAT and 90 DAT, whereas T<sub>1</sub> showed the minimum plant height (14.77 cm and 17.78 cm, respectively). The variation in plant height is due to the combined use of organic manures and nano fertilizers, which improved nutrient availability and uptake, enhancing vegetative growth. Poor growth in the control was attributed to the absence of external nutrients. Similar findings have been reported by Vasudevan and Bahadur (2024) in calendula.

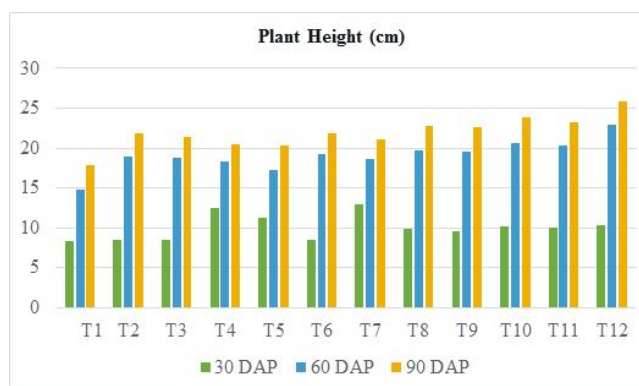


**Fig. 1 :** Effect of organic manures and nano fertilizers on plant height of Calendula.

**Table 1 :** Effect of organic manures and nano fertilizers on plant height of Calendula.

| Notation        | Treatment details                                                                                 | Plant height (cm) |        |        |
|-----------------|---------------------------------------------------------------------------------------------------|-------------------|--------|--------|
|                 |                                                                                                   | 30 DAT            | 60 DAT | 90 DAT |
| T <sub>1</sub>  | Control                                                                                           | 8.33              | 14.77  | 17.78  |
| T <sub>2</sub>  | Nano Urea @ 4ml/L                                                                                 | 8.53              | 18.93  | 21.79  |
| T <sub>3</sub>  | Nano DAP@ 5ml/L                                                                                   | 8.50              | 18.83  | 21.43  |
| T <sub>4</sub>  | Vermicompost @ 2.5t/ha                                                                            | 12.51             | 18.30  | 20.53  |
| T <sub>5</sub>  | FYM @ 5t/ha                                                                                       | 11.17             | 17.20  | 20.33  |
| T <sub>6</sub>  | Nano Urea @ 2ml/L + Nano DAP@2.5ml/L                                                              | 8.53              | 19.23  | 21.83  |
| T <sub>7</sub>  | Vermicompost (50% of 2.5t/ha) + FYM (50% of 5t/ha)                                                | 12.93             | 18.57  | 21.08  |
| T <sub>8</sub>  | Nano Urea@2ml/L + 50% of FYM @5t/ha                                                               | 9.93              | 19.72  | 22.74  |
| T <sub>9</sub>  | Nano DAP@ 2.5ml/L + 50% of FYM @5t/ha                                                             | 9.60              | 19.60  | 22.54  |
| T <sub>10</sub> | Nano Urea@2ml/L + 50% of Vermicompost @2.5t/ha                                                    | 10.23             | 20.67  | 23.77  |
| T <sub>11</sub> | Nano DAP@2.5ml/L+50% of Vermicompost@2.5t/ha                                                      | 10.07             | 20.27  | 23.27  |
| T <sub>12</sub> | Integrated organic mix (25% of FYM+25% of VC) + Nano mix (Nano Urea @1ml/L + Nano DAP @ 1.25ml/L) | 10.30             | 22.92  | 25.77  |
|                 | CD at 5%                                                                                          | 1.64              | 2.62   | 2.81   |
|                 | SE(m) ±                                                                                           | 0.56              | 0.89   | 0.95   |

#### Number of leaves plant<sup>-1</sup>

Table 2 and Fig. 2 indicated that at 30 DAT, the maximum number of leaves plant<sup>-1</sup> was recorded under treatment T<sub>7</sub> [Vermicompost (50% of 2.5t/ha) + FYM

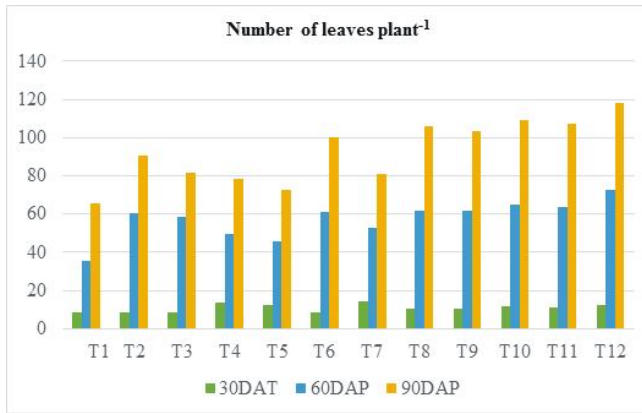


**Fig. 2 :** Effect of organic manures and nano fertilizers on number of leaves plant<sup>-1</sup> of Calendula.

**Table 2 :** Effect of organic manures and nano fertilizers on number of leaves plant<sup>-1</sup> of Calendula.

| Notation        | Treatment details                                                                                | Number of leaves plant <sup>-1</sup> |        |        |
|-----------------|--------------------------------------------------------------------------------------------------|--------------------------------------|--------|--------|
|                 |                                                                                                  | 30 DAT                               | 60 DAT | 90 DAT |
| T <sub>1</sub>  | Control                                                                                          | 8.33                                 | 35.63  | 50.78  |
| T <sub>2</sub>  | Nano Urea @4ml/L                                                                                 | 8.53                                 | 60.57  | 81.77  |
| T <sub>3</sub>  | Nano DAP@5ml/L                                                                                   | 8.40                                 | 58.23  | 78.77  |
| T <sub>4</sub>  | Vermicompost@2.5t/ha                                                                             | 13.93                                | 49.83  | 68.66  |
| T <sub>5</sub>  | FYM @5t/ha                                                                                       | 12.63                                | 45.40  | 61.20  |
| T <sub>6</sub>  | Nano Urea@2ml/L + Nano DAP@2.5ml/L                                                               | 8.57                                 | 61.27  | 85.77  |
| T <sub>7</sub>  | Vermicompost (50% of 2.5t/ha) + FYM (50% of 5t/ha)                                               | 14.43                                | 52.70  | 73.83  |
| T <sub>8</sub>  | Nano Urea@2ml/L + 50% of FYM @5t/ha                                                              | 10.50                                | 61.97  | 89.11  |
| T <sub>9</sub>  | Nano DAP@2.5ml/L + 50% of FYM @5t/ha                                                             | 10.30                                | 61.63  | 87.77  |
| T <sub>10</sub> | Nano Urea@2ml/L+50% of Vermicompost @2.5t/ha                                                     | 11.77                                | 64.67  | 93.44  |
| T <sub>11</sub> | Nano DAP@2.5ml/L+50% of Vermicompost@2.5t/ha                                                     | 11.20                                | 63.60  | 90.77  |
| T <sub>12</sub> | Integrated organic mix (25% of FYM+25% of VC) + Nano mix (Nano Urea @1ml/L + Nano DAP @1.25ml/L) | 12.23                                | 72.63  | 97.11  |
|                 | CD at 5%                                                                                         | 1.59                                 | 9.36   | 10.47  |
|                 | SE(m)±                                                                                           | 0.54                                 | 3.17   | 3.55   |

(50% of 5t/ha)] (14.43), which was statistically at par with T<sub>4</sub>, whereas the minimum number of leaves was recorded under T<sub>1</sub> (control) (8.33). The maximum number

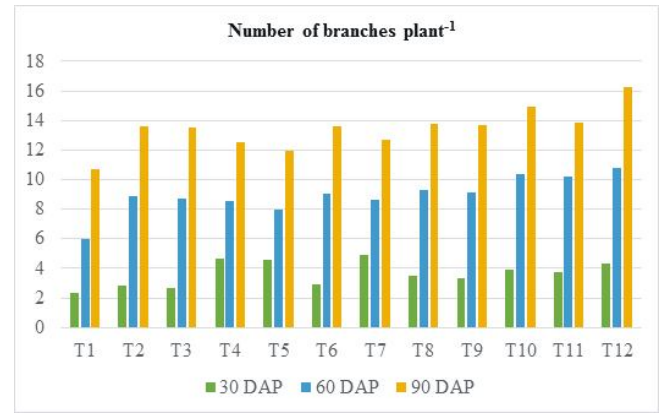


**Fig. 3 :** Effect of organic manures and nano fertilizers on number of branches plant<sup>-1</sup> of Calendula.

of leaves was recorded under T<sub>12</sub> [Integrated organic mix (25% FYM + 25% VC) + Nano mix (Nano Urea @ 1 ml/L + Nano DAP @ 1.25 ml/L)], with 72.63 leaves at 60 DAT and 97.11 leaves at 90 DAT. At 60 DAT, T<sub>12</sub> was statistically at par with T<sub>10</sub> and T<sub>11</sub>, while at 90 DAT it was at par with T<sub>10</sub>, T<sub>11</sub>, T<sub>8</sub> and T<sub>9</sub>. The minimum number of leaves was recorded under T<sub>1</sub> (control), with 35.63 and 50.78 leaves at 60 and 90 DAT, respectively. The increase in the number of leaves under integrated nutrient management may be attributed to the balanced supply of nutrients from organic manures and nano fertilizers, which enhanced cell division, chlorophyll formation, photosynthesis and vegetative growth. The lowest number of leaves in the control (T<sub>1</sub>) was due to the absence of external nutrient application, resulting in restricted vegetative growth. Similar findings have been reported by Singh *et al.* (2015) reported in calendula, Gowtham and Karuppaiah (2024) in crossandra.

#### Number of branches plant<sup>-1</sup>

Table 3 and Fig. 3 indicated that at 30 DAT, the maximum number of branches was recorded in T<sub>7</sub> [Vermicompost (50% of 2.5t/ha) + FYM (50% of 5t/ha)] (12.93 cm), which was statistically at par with T<sub>4</sub> and T<sub>5</sub>, while the minimum was observed in T<sub>1</sub> (8.33 cm). At 60 and 90 DAT, T<sub>12</sub> [Integrated organic mix (25% of FYM + 25% of VC) + Nano mix (Nano Urea@1ml/L + Nano DAP @1.25ml/L)] recorded the highest number of branches (10.81 and 16.22, respectively), which was statistically at par with T<sub>10</sub>, T<sub>11</sub> and T<sub>8</sub> at 60 DAT and T<sub>10</sub> at 90 DAT, whereas T<sub>1</sub> showed the minimum number of branches (5.94 and 10.70, respectively). The increased number of branches under integrated nutrient management may be attributed to the balanced nutrient supply from organic manures and nano fertilizers, which promoted vegetative growth, cell division and axillary bud development. The lowest number of branches was

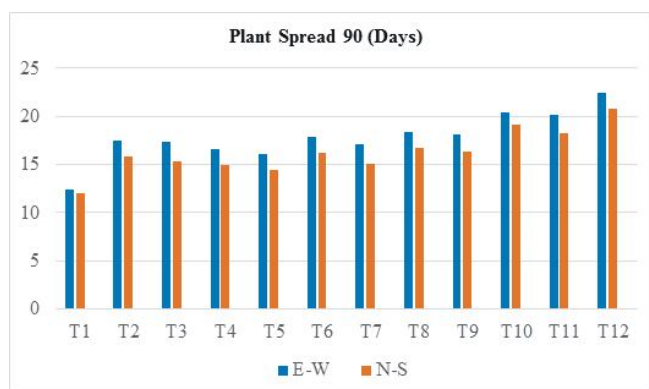


**Fig. 4 :** Effect of organic manures and nano fertilizers on plant spread (cm) of Calendula.

**Table 3 :** Effect of organic manures and nano fertilizers on number of branches plant<sup>-1</sup> of Calendula.

| Notation        | Treatment details                                                                                 | Number of branches plant <sup>-1</sup> |        |        |
|-----------------|---------------------------------------------------------------------------------------------------|----------------------------------------|--------|--------|
|                 |                                                                                                   | 30 DAT                                 | 60 DAT | 90 DAT |
| T <sub>1</sub>  | Control                                                                                           | 2.37                                   | 5.94   | 10.70  |
| T <sub>2</sub>  | Nano Urea @4ml/L                                                                                  | 2.80                                   | 8.91   | 13.60  |
| T <sub>3</sub>  | Nano DAP@5ml/L                                                                                    | 2.67                                   | 8.73   | 13.50  |
| T <sub>4</sub>  | Vermicompost@2.5t/ha                                                                              | 4.63                                   | 8.57   | 12.53  |
| T <sub>5</sub>  | FYM @5t/ha                                                                                        | 4.57                                   | 7.97   | 11.93  |
| T <sub>6</sub>  | Nano Urea@2ml/L + Nano DAP@2.5ml/L                                                                | 2.90                                   | 9.04   | 13.63  |
| T <sub>7</sub>  | Vermicompost (50% of 2.5t/ha) + FYM (50% of 5t/ha)                                                | 4.87                                   | 8.67   | 12.70  |
| T <sub>8</sub>  | Nano Urea@2ml/L + 50% of FYM @ 5t/ha                                                              | 3.53                                   | 9.27   | 13.77  |
| T <sub>9</sub>  | Nano DAP@2.5ml/L + 50% of FYM @5t/ha                                                              | 3.34                                   | 9.12   | 13.70  |
| T <sub>10</sub> | Nano Urea@2ml/L + 50% of Vermicompost @2.5t/ha                                                    | 3.87                                   | 10.37  | 14.90  |
| T <sub>11</sub> | Nano DAP@2.5ml/L+50% of Vermicompost@2.5t/ha                                                      | 3.73                                   | 10.24  | 13.88  |
| T <sub>12</sub> | Integrated organic mix (25% of FYM+25% of VC) + Nano mix (Nano Urea @1ml/L + Nano DAP @ 1.25ml/L) | 4.33                                   | 10.81  | 16.22  |
|                 | CD at 5%                                                                                          | 0.53                                   | 1.64   | 1.62   |
|                 | SE(m)±                                                                                            | 0.18                                   | 0.56   | 0.55   |

recorded in the control (T<sub>1</sub>) due to the absence of external nutrient application. Similar findings were reported by Mehdi *et al.* (2022), Vasudevan and Bahadur (2024) in

**Table 4 :** Effect of organic manures and nano fertilizers on plant spread (cm) of Calendula.

| Notation        | Treatment details                                                                                  | Plant spread (cm) |       |
|-----------------|----------------------------------------------------------------------------------------------------|-------------------|-------|
|                 |                                                                                                    | E-W               | N-S   |
| T <sub>1</sub>  | Control                                                                                            | 12.40             | 12.07 |
| T <sub>2</sub>  | Nano Urea @4ml/L                                                                                   | 17.43             | 15.77 |
| T <sub>3</sub>  | Nano DAP@5ml/L                                                                                     | 17.32             | 15.32 |
| T <sub>4</sub>  | Vermicompost@2.5t/ha                                                                               | 16.57             | 14.90 |
| T <sub>5</sub>  | FYM @5t/ha                                                                                         | 16.13             | 14.47 |
| T <sub>6</sub>  | Nano Urea@2ml/L+Nano DAP @2.5ml/L                                                                  | 17.87             | 16.20 |
| T <sub>7</sub>  | Vermicompost (50% of 2.5t/ha)+ FYM (50% of 5t/ha)                                                  | 17.08             | 15.08 |
| T <sub>8</sub>  | Nano Urea@2ml/L +50% of FYM @5t/ha                                                                 | 18.33             | 16.67 |
| T <sub>9</sub>  | Nano DAP@2.5ml/L + 50% of FYM @5t/ha                                                               | 18.07             | 16.40 |
| T <sub>10</sub> | Nano Urea@2ml/L + 50% of Vermicompost @2.5t/ha                                                     | 20.47             | 19.13 |
| T <sub>11</sub> | Nano DAP@2.5ml/L +50% of Vermicompost@2.5t/ha                                                      | 20.20             | 18.20 |
| T <sub>12</sub> | Integrated organic mix (25% of FYM + 25% of VC) + Nano mix (Nano Urea @1ml/L + Nano DAP @1.25ml/L) | 22.50             | 20.83 |
|                 | CD at 5%                                                                                           | 3.41              | 2.46  |
|                 | SE(m)±                                                                                             | 1.16              | 0.83  |

calendula and Chaudhary *et al.* (2025) in gaillardia.

#### Plant spread (cm)

Table 4 and Fig. 4 indicated that at 90 DAT, the maximum plant spread in E–W (22.50 cm) and N–S (20.83 cm) directions was recorded under T<sub>12</sub> [Integrated organic mix (25% FYM + 25% VC) + Nano mix (Nano Urea @1 ml/L + Nano DAP @1.25 ml/L)], which was statistically at par with T<sub>10</sub> and T<sub>11</sub> (E–W) and T<sub>10</sub> (N–S). The minimum spread was observed under T<sub>1</sub> (control) with 12.40 cm (E–W) and 12.07 cm (N–S). The significant variation in plant spread among treatments attributed to differences in nutrient availability and utilization. Integrated nutrient management enhanced vegetative growth and canopy expansion through a balanced nutrient supply, while the lowest plant spread was recorded in the control (T<sub>1</sub>) due to the absence of external nutrient application. Similar findings were reported by Sahith *et al.* (2023) in marigold and Vasudevan and Bahadur (2024) in calendula.

## Conclusion

The present investigation revealed among the treatment, T<sub>12</sub> [Integrated organic mix (25% FYM + 25% VC) + Nano mix (Nano Urea @ 1 ml/L + Nano DAP @ 1.25 ml/L)] was found most effective in enhancing vegetative growth parameters, including plant height, number of leaves plant<sup>-1</sup>, number of branches plant<sup>-1</sup> and plant spread. The superior performance is attributed to the balanced and sustained nutrient supply and improved nutrient use efficiency under integrated nutrient management. In research control (T<sub>1</sub>) recorded the lowest values among all treatment, highlighting the importance of external nutrient application for optimum vegetative growth of calendula.

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