**Effect of different seed priming techniques on growth, flowering and seed attributes in balsam (*Impatiensbalsamina*)**

**ABSTRACT**

The present experiment was carried out at the Horticulture Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, in balsam (*Impatiens* *balsamina*) using Factorial Randomized Block Design (RBD) comprising of 5 genotypes and 5 seed priming treatments *viz*., control, biopriming with *Trichoderma* (1mg/g of seeds)*,* thiourea (50 ppm), thiourea (50 ppm) + *Trichoderma* (1mg/g of seeds) and hydropriming with distilled water. The findings concluded that maximum plant height (82.67 cm), maximum plant spread (81.22 cm), highest number of leaves per plant (618.12), earliest flowering (48.74 days), longest flowering duration (64.12 days), flowers per plant (283.41), number of seeds per pod (11.62 seeds), number of pods per plant (302.22) and number of seeds per plant (2977.89) were recorded with the treatment including thiourea (50 ppm) + *Trichoderma* (1mg/g of seeds). Present study showed that pre-sowing treatment of balsam seeds with thiourea (50 ppm) + *Trichoderma* (1mg/g of seeds) for 24 hours significantly improved the vegetative, flowering and seed attributes.

 **Keywords:** Priming, balsam, *Trichoderma*, thiourea

**Introduction**

 Balsam (*Impatiens* *balsamina*) is generally grown as an ornamental plant and the flowers bloom in the upper axils and resemble those of roses or camellias, appearing in a range of colours such as scarlet, red, pink, white, purple and rose (Singh and Sisodia, 2017). Traditionally, most *Impatiens balsamina* species are native to tropical and subtropical areas (Grey-Wilson, 1980), although some can also be found in the temperate zones of Northern Asia, North America and Europe (Song *et al.*, 2003). It is widespread in countries such as China, India, Korea, Indonesia and other parts of Asia (Qian *et al.*, 2023). Balsam is an upright annual herb, usually cultivated as an ornamental flowering plant, native of the Himalayas, India (Yadav *et al*., 2024). It can withstand heavy rain and high humidity conditions in atmosphere (Pal *et al*., 2023). The oil of seeds can be utilized for burning lamps and also in surface coating industry (Singh *et al*., 2018). This annual plant is an excellent choice for garden beds, mixed borders and walkways, while its compact dwarf varieties are ideal for container gardening in patios, balconies and other small spaces (Pal *et al*., 2018).

Seed priming is a water-based method that regulates seed temperature and moisture to trigger early metabolic activity without initiating full germination, enhancing germination rate and seed quality (Sisodia *et al.*, 2018). Priming efficiently creates the germinating stage without causing radicle emergence, which may leads to improved germination percentage and uniformity (Sung *et al*, 2008). Seed priming promotes cross-tolerance that assists enhanced germination percentage and seedling establishment under adverse climatic conditions (Chen *et al*., 2012). Seed priming aims to synchronize emergence for uniform crop establishment, speed up germination and protect seeds from environmental stress during early seedling growth (Sisodia *et al.*, 2018).

Seed priming methods are classified based on the compounds used, including hydropriming, hormone priming, osmopriming, chemopriming, solid matrix priming, nutripriming, thermopriming and biopriming (Sher *et al*., 2019). Biopriming with *Trichoderma* boosts production of phytohormones, secondary metabolites and osmoprotectants, which help maintain cell water balance during drought stress without disrupting normal metabolism (Anjum *et al.*, 2014). Plant growth regulators like thiourea have played significant role in ornamental crops in terms of growth and breaking dormancy (Singh *et al*., 2018). Thiourea helps in breaking seed dormancy and also stimulates seed germination and early growth of seedlings (Padhi *et al*., 2018). Hydropriming treatment (distilled water) significantly improved the germination capacity of fungus-infected seeds at the first and second count and the proportion of diseased seedlings and dead seeds was seen to have decreased (Vidyashree and Patil, 2021). Priming is done in balsam to enhance seed germination, improve seedling vigor, and ensure uniform and faster emergence. It helps break seed dormancy, activates essential metabolic processes before sowing and prepares the seed to grow more efficiently once planted. Since very meager or no work has been done so far on balsam seed priming therefore, in this study effect of seed priming on growth and development of balsam has been investigated.

**Materials and Methods**

The present experiment was carried out during rainy season of July 2024-25 at the Horticulture Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. In this experiment, balsam (*Impatiens* *balsamina*) seeds were primed with different priming agents to study their impact on growth, flowering and seed attributes. Five balsam genotypes were chosen for the experiment (JB-1, JB-2, JB-3, JB-4 and JB-5), that were procured from Department of Horticulture, College of Agriculture, J.N.K.V.V., Jabalpur, Madhya Pradesh. These genotypes were treated with five levels of treatments with five replications. The treatments are T1 (Control), T2 (*Trichoderma* 1mg/g of seeds), T3 (Thiourea 50 ppm), T4 (*Trichoderma* 1mg/g of seeds+ Thiourea 50ppm) and T5 (Hydropriming). After the seeds were treated they were sown in the nursery bed with a row to row spacing of 15 cm followed by light irrigation. Seedlings were transplanted to earthen pots after 30 days of sowing. Plants were irrigated thrice in a week to keep soil moisture at the field capacity. The experiment was carried out using a Factorial Randomized Block Design (RBD), incorporating two factors: the first comprising five genotypes and the second consisting of five treatments, as previously described. Each treatment combination was replicated five times. Various parameters such as plant height, plant spread, number of leaves per plant, days to flowering, flowering duration, total flowers per plant, number of seeds per pod, number of pods per plant and number of seeds per plant were observed and analyzed statistically. All recorded observations were analyzed using the OP-STAT computer software. The Factorial Randomized Block Design analysis of variance was used to test the effect of different seed priming techniques on balsam genotypes. The mean difference was evaluated by CD at 5% level of significance.

**Results and Discussion**

Significant differences were observed in various plant growth and development parameters, aiding in the assessment of plant suitability for specific purposes. These results are consistent with previous studies on ornamental plants and highlight the diverse applications of different plant types in horticulture.

**Growth parameters**

Significant variations were observed in the plant growth parameters, including plant height, plant spread and number of leaves. Treatment T4(82.67 cm) significantly recorded the highest average plant height comparing to others. The minimum average plant height was observed under control (72.90 cm) (Table 1). Whereas, the maximum average plant spread was observed in treatment T4 (81.22 cm) which was significantly higher than other treatments (Table 1). The maximum number of leaves were observed in treatment T4 (618.12 leaves), significantly higher than other treatments (Table 2). This could be related to enhanced photosynthetic activity and nutrient uptake by thiourea and *Trichoderma* improved tolerance of the plants against the biotic and abiotic stresses. Similar findings were observed in *Eustoma grandiflorum* by Maliha *et al*. (2023), by Kaur *et al*. (2023) in *Gladiolus grandiflorus* L. and by Thakur and Garg (2024) in *Viola tricolor*.

**Flowering parameters**

Annuals and ornamental herbs enhance garden aesthetics with their vivid colors, varied forms and textures. Their versatility suits borders, beds, containers and hanging baskets. Significant differences were observed in various flowering parameters under different treatments. Treatment T4 (48.74 days) resulted in the significantly earliest flowering in comparison to T3 (48.97 days), T5 (49.86 days) and T2 (51.00 days) (Table 3). TreatmentT4 (64.12 days) showed the significantly longest flowering duration, closely followed by T3 (63.90 days) and minimum flowering duration was observed in treatment T1 (56.42 days) showing that seed priming enhances flowering duration (Fig. 1). Whereas, total flowers per plant were maximum in treatment T4 (283.41 flowers) which was significantly higher than others (Table 3). This highlights the positive influence of seed priming, particularly the combination of *Trichoderma* and Thiourea. This could be result of increased uptake of essential minerals like potassium (K⁺) and calcium (Ca²⁺) and enhanced auxins synthesis by thiourea that ultimately increase cell division. Similar findings were observed by Pawar *et al*. (2018) in *Gladiolus grandiflorus* L.

**Seed parameters**

Significant differences were observed in seed parameters under various treatments given in Table 2 and Table 4. Among the treatments, T4 significantly produced the highest number of seeds per pod (11.62 seeds) whereas T1 (8.60 seeds) and T5 (8.77 seeds) exhibited the minimum seeds per pod. Number of pods per plant was maximum in treatment T4 (302.22) and treatment T1 had minimum, 219.34 pods per plant. Treatment T4 results in the significantly highest number of seeds per plant (2,977.89 seeds/plant). In contrast, T1 (2007.31 seeds/plant) had the lowest number of seeds per plant. This might be due to thiourea priming which supported plant growth by maintaining better water balance, improving stomatal conductance and serving as a compatible osmolyte, thereby aiding in the production of quality seeds. It may also be due to biotic and abiotic stress tolerance induced in plants by thiourea and *Trichoderma.* Similar results were also observed by Oyebamiji *et al*. (2024), Negi *et al*. (2019) and Dayma *et al*. (2024) in french bean (*Phaseolus* *vulgaris* L.).

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| Table 1. Effect of seed priming treatments on growth parameters in balsam |
|  | **Plant Height (cm)** | **Plant Spread (cm)** |
| **Treatment****Genotype** | **T1** | **T2** | **T3** | **T4** | **T5** | **T1** | **T2** | **T3** | **T4** | **T5** |
| **JB-1** | 71.60 | 76.71 | 74.42 | 76.54 | 77.93 | 64.09 | 76.93 | 70.07 | 79.25 | 70.42 |
| **JB-2** | 74.20 | 75.62 | 75.00 | 85.02 | 87.90 | 71.88 | 73.05 | 84.88 | 82.21 | 74.97 |
| **JB-3** | 74.00 | 75.59 | 74.32 | 82.51 | 82.10 | 68.99 | 71.60 | 83.34 | 78.48 | 67.33 |
| **JB-4** | 74.60 | 74.74 | 77.68 | 85.20 | 86.70 | 73.77 | 74.34 | 84.67 | 83.03 | 74.87 |
| **JB-5** | 69.90 | 78.08 | 77.69 | 77.70 | 78.70 | 71.48 | 79.91 | 70.20 | 83.15 | 73.14 |
| **Mean** | 72.90 | 76.15 | 75.82 | 81.39 | 82.67 | 70.04 | 75.17 | 78.63 | 81.22 | 72.16 |
| **C.D. (0.05)** |  |  |  |  |  |  |  |  |  |  |
| **G** | 3.02 |  |  |  |  | 3.67 |  |  |  |  |
| **T** | 3.02 |  |  |  |  | 3.67 |  |  |  |  |
| **G × T** | N/A |  |  |  |  | 8.20 |  |  |  |  |
| T1 = Control, T2 = *Trichoderma*, T3 = Thiourea, T4 = *Trichoderma* + Thiourea, T5 = Hydropriming |

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| Table 2. Effect of seed priming treatments on growth and seed parameters in balsam |
|  | **Number of leaves per plant** | **Number of pods per plant** |
| **Treatment****Genotype** | **T1** | **T2** | **T3** | **T4** | **T5** | **T1** | **T2** | **T3** | **T4** | **T5** |
| **JB-1** | 358.27 | 479.24 | 610.40 | 632.44 | 464.46 | 202.75 | 224.33 | 229.26 | 305.67 | 257.17 |
| **JB-2** | 321.48 | 550.48 | 589.65 | 625.36 | 531.26 | 206.40 | 289.71 | 298.32 | 308.69 | 256.12 |
| **JB-3** | 426.31 | 489.88 | 588.54 | 608.42 | 464.79 | 178.58 | 288.36 | 241.41 | 265.01 | 290.15 |
| **JB-4** | 371.19 | 536.63 | 582.29 | 637.73 | 526.60 | 252.85 | 295.52 | 304.92 | 315.84 | 250.70 |
| **JB-5** | 369.07 | 503.57 | 607.35 | 586.65 | 494.87 | 256.13 | 148.57 | 278.00 | 315.88 | 252.72 |
| **Mean** | 369.26 | 511.96 | 595.64 | 618.12 | 496.39 | 219.34 | 249.30 | 270.38 | 302.22 | 261.37 |
| **C.D. (0.05)** |  |  |  |  |  |  |  |  |  |  |
| **G** | N/A |  |  |  |  | 11.92 |  |  |  |  |
| **T** | 55.77 |  |  |  |  | 11.92 |  |  |  |  |
| **G × T** | N/A |  |  |  |  | 26.66 |  |  |  |  |
| T1 = Control, T2 = *Trichoderma*, T3 = Thiourea, T4 = *Trichoderma* + Thiourea, T5 = Hydropriming |

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| Table 3. Effect of seed priming treatments on flowering parameters in balsam |
|  | **Total flowers per plant** | **Days to flowering** |
| **Treatment****Genotype** | **T1** | **T2** | **T3** | **T4** | **T5** | **T1** | **T2** | **T3** | **T4** | **T5** |
| **JB-1** | 208.54 | 228.73 | 267.62 | 273.13 | 212.49 | 49.32 | 53.34 | 51.30 | 49.67 | 48.22 |
| **JB-2** | 234.22 | 273.89 | 289.60 | 297.35 | 264.48 | 48.84 | 52.09 | 47.56 | 49.57 | 49.14 |
| **JB-3** | 228.36 | 240.27 | 265.74 | 298.77 | 220.06 | 55.69 | 51.94 | 48.01 | 47.78 | 48.66 |
| **JB-4** | 260.92 | 289.43 | 298.87 | 302.73 | 284.40 | 50.08 | 47.78 | 47.45 | 47.78 | 50.91 |
| **JB-5** | 239.85 | 252.18 | 288.00 | 245.08 | 229.66 | 54.22 | 50.84 | 50.53 | 48.91 | 52.38 |
| **Mean** | 234.38 | 256.90 | 281.96 | 283.41 | 242.22 | 51.63 | 51.00 | 48.97 | 48.74 | 49.86 |
| **C.D. (0.05)** |  |  |  |  |  |  |  |  |  |  |
| **G** | 25.76 |  |  |  |  | 1.85 |  |  |  |  |
| **T** | 25.76 |  |  |  |  | 1.85 |  |  |  |  |
| **G × T** | N/A |  |  |  |  | 4.14 |  |  |  |  |
| T1 = Control, T2 = *Trichoderma*, T3 = Thiourea, T4 = *Trichoderma* + Thiourea, T5 = Hydropriming |

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| Table 4. Effect of seed priming treatments on seed parameters in balsam |
|  | **Number of seeds per pod** | **Number of seeds per plant** |
| **Treatment****Genotype** | **T1** | **T2** | **T3** | **T4** | **T5** | **T1** | **T2** | **T3** | **T4** | **T5** |
| **JB-1** | 7.78 | 9.48 | 10.07 | 11.14 | 8.26 | 1,787.23 | 2,020.41 | 2,181.67 | 3,257.22 | 2,236.44 |
| **JB-2** | 9.68 | 8.83 | 9.83 | 11.93 | 9.53 | 2,217.33 | 2,339.85 | 2,830.54 | 3,116.95 | 2,015.67 |
| **JB-3** | 8.51 | 7.88 | 10.60 | 10.87 | 7.99 | 2,205.19 | 1,901.78 | 2,079.57 | 3,077.31 | 2,479.72 |
| **JB-4** | 8.64 | 9.86 | 11.62 | 12.34 | 9.30 | 1,867.29 | 2,660.73 | 2,772.35 | 2,653.97 | 3,082.44 |
| **JB-5** | 8.42 | 9.35 | 9.43 | 11.82 | 8.77 | 1,959.53 | 2,328.31 | 2,684.28 | 2,784.00 | 1,740.66 |
| **Mean** | 8.60 | 9.08 | 10.31 | 11.62 | 8.77 | 2,007.31 | 2,250.22 | 2,509.68 | 2,977.89 | 2,310.99 |
| **C.D. (0.05)** |  |  |  |  |  |  |  |  |  |  |
| **G** | 0.72 |  |  |  |  | 133.84 |  |  |  |  |
| **T** | 0.72 |  |  |  |  | 133.84 |  |  |  |  |
| **G × T** | N/A |  |  |  |  | 299.29 |  |  |  |  |
| T1 = Control, T2 = *Trichoderma*, T3 = Thiourea, T4 = *Trichoderma* + Thiourea, T5 = Hydropriming |

Fig. 1 Effect of seed priming treatments on flowering duration in balsam

**Conclusion**

The present study demonstrates that seed priming significantly enhances the growth, flowering, and seed yield attributes of balsam (Impatiens balsamina). Among the treatments, the combination of *Trichoderma* and thiourea consistently outperformed other treatments across all parameters, including plant height, spread, leaf number, flowering duration and seed yield. These findings highlight the potential of integrated seed priming approaches to improve plant vigour, uniformity and productivity in ornamental crops.

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