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SEED PRIMING WITH GIBBERELLIC ACID ENHANCES EARLY VIGOR, PHYSIOLOGICAL EFFICIENCY AND FLOWERING PERFORMANCE IN ZINNIA (*ZINNIA ELEGANS* JACQ.)

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ABSTRACT

Seed priming is widely used to improve stand establishment and stress resilience in field crops, yet its potential remains underexploited in ornamentals such as *Zinnia elegans,* where uniform emergence and extended vase life are critical for market value. This study evaluated the comparative effects of gibberellic acid (GA_3) and 1-naphthaleneacetic acid (NAA) seed priming on germination, seedling physiology, and flowering performance of zinnia. Experiments were conducted in a completely randomized design under both growth chamber and pot conditions, and included measurements of germination percentage and seedling vigor, morpho physiological traits, relative water content and net assimilation rate, biochemical attributes (total chlorophyll, chlorophyll a and b, α-amylase), and flowering and yield traits, including flower number, seed set, and shelf life. Priming with GA_3 at 40 mg markedly enhanced germination, seedling vigor indices, and yield attributes, indicating a strong effect on early growth and reproductive output. In contrast, GA_3 at 10 mg and NAA at 8 mg were more effective in improving relative water content, chlorophyll status, flowering behavior, and postharvest longevity. These results demonstrate that judicious choice of priming treatment can differentially target establishment versus flowering and shelf life, and confirm that hormone-based seed priming enhances physiological efficiency, thereby translating into superior flowering performance and floral yield in zinnia.

***Key words*:** Seed priming; gibberellic acid; NAA; *Zinnia elegans*; germination; seedling vigor; flowering performance

Introduction

Zinnia (*Zinnia elegans* Jacq.) is an important ornamental species grown widely as both a cut flower and bedding plant, valued for its large, colourful inflorescences, extended flowering period, and adaptability to warm climates (Bandurska *et al.*, 2023). Commercial production and landscaping, however, are frequently constrained by poor or uneven germination, delayed emergence, and non-uniform stands, which compromise crop scheduling, plant uniformity, and overall flower quality (Ahmad *et al.*, 2017). Enhancing early seedling vigour is therefore critical for achieving rapid, uniform establishment and reliable flowering performance in this crop (Powell, 2020). Seed priming, defined as controlled hydration that advances pre-germinative metabolic processes without permitting radicle protrusion, has proven effective in improving germination speed, synchrony, and early growth in several horticultural species, but its targeted use in zinnia remains underexplored (Hasanoviæ & Karalija, 2025). Hormone-based priming with gibberellic acid (GA3) and 1-naphthaleneacetic acid (NAA) is particularly promising because GA_3 stimulates hydrolytic enzyme activity, reserve mobilization, and cell elongation, while NAA modulates root development, vegetative growth, and flowering behaviour through auxin-regulated pathways (Taiz *et al.*, 2015; Rhaman *et al.*, 2021). Yet, few studies have integrated seed-level responses with downstream changes in plant water status, photosynthetic capacity, and flowering and yield traits in *Z. elegans* (Coêlho *et al.*, 2025). This study therefore aimed to evaluate the effects of GA_3 and NAA based seed priming on germination, early seedling growth, key physiological attributes, and flowering performance of zinnia under growth chamber and pot conditions, to identify priming strategies that couple improved establishment with enhanced floral yield and quality.

Materials and Methods

Experimental site and design

The study was conducted during the rabi season under controlled growth chamber conditions and in a pot culture experiment at the Department of Plant Physiology, Agricultural Biochemistry, Medicinal and Aromatic Plants, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India. Both experiments followed a completely randomized design (CRD) with an equal number of replications per treatment to permit valid statistical comparison of means.

Seed priming treatments

Seeds of *Zinnia elegans* were subjected to six treatments: untreated control (unprimed), hydropriming with distilled water, two concentrations of gibberellic acid (GA_3; 10 mg and 40 mg), and two concentrations of 1 naphthaleneacetic acid (NAA; 5 mg and 8 mg). The same treatment structure was imposed in both the growth chamber and pot experiments to enable comparison of responses across environments.

Seed priming protocol

For priming, seeds were soaked in the respective solutions for a fixed duration sufficient to allow controlled hydration without visible radicle emergence. After soaking, seeds were thoroughly washed with distilled water to remove excess chemical residues, surface blotted, and air dried at room temperature to approximately their initial moisture content before sowing in trays (growth chamber) or pots.

Observations recorded

Germination and seedling vigor were assessed by recording germination percentage, root and shoot length, and calculating standard seed vigor indices at early seedling stages under both growth conditions. Physiological and biochemical traits included leaf relative water content (RWC), net assimilation rate (NAR), total chlorophyll content (and its fractions), and á amylase activity as indicators of water status, carbon gain, and reserve mobilization. Flowering behavior and yield attributes were evaluated by recording days to first flowering, plant height and branching pattern, number of flowers per plant, fresh and dry flower weight, and shelf life of harvested flowers under pot conditions.

Statistical analysis

Data from both experiments were subjected to analysis of variance (ANOVA) appropriate for a completely randomized design to test the significance of treatment effects. Correlation analysis was performed to quantify relationships among germination and vigor traits, physiological and biochemical variables, and

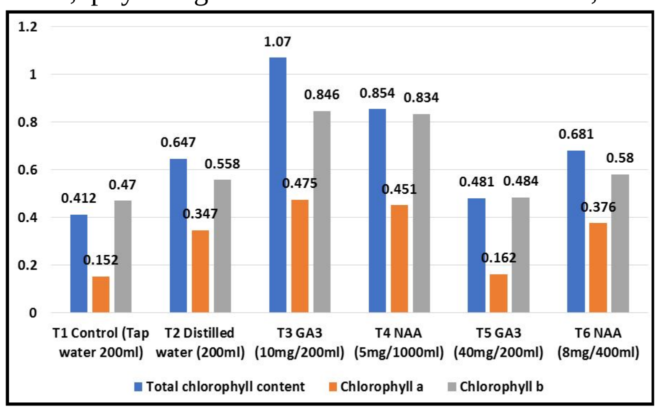

Fig. 1: Effect of seed priming on total chlorophyll, chlorophyll a, and chlorophyll b (mg/g fresh weight) of Zinnia under pot condition.

Table 1: Effect of seed priming on Germination rate (%), seed vigour index I and seed vigour index II of Zinnia under growth chamber and pot condition.

Treatment	Germination rate (%)		Seed vigor index I		Seed vigor index II	
	Growth chamber	Pot condition	Growth chamber	Pot condition	Growth chamber	Pot condition
T_1 Control (Tap water 200ml)	40	40	1.57	4.43	4.463	1.48
T_2 Distilled water (200ml)	46.67	50	1.68	4.667	4.583	1.767
T_3 GA_3 (10mg/200ml)	60	90	4.343	7.39	8.39	5.633
T_4 NAA (5mg/1000ml)	70	80	3.607	6.047	5.7	2.633
T_5 GA_3 (40mg/200ml)	90	60	5.587	8.447	7.48	4.703
T_6 NAA (8mg/400ml)	80	76.67	2.567	5.737	6.547	3.853
C.D.	1.848	1.989	1.459	0.564	0.347	0.438
SE(m)	0.593	0.638	0.468	0.181	0.111	0.141

Table 2: Effect of seed priming on Relative water content and on Net assimilation rate (g g^{-1} day^{-1}) of Zinnia under pot condition.

Treatment	Relative water content			Net assimilation rate (g g^{-1} day^{-1})		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1 Control (Tap water 200ml)	88.92	90.85	86.933	0.037	0.027	0.017
T_2 Distilled water (200ml)	93.127	95.2	91.2	0.045	0.035	0.021
T_3 GA_3 (10mg/200ml)	106.167	108.477	104.4	0.053	0.043	0.033
T_4 NAA (5mg/1000ml)	110.167	110.977	106.773	0.065	0.051	0.045
T_5 GA_3 (40mg/200ml)	216.41	218.427	214.35	0.078	0.064	0.054
T_6 NAA (8mg/400ml)	221.267	223.06	219.453	0.058	0.059	0.046
C.D.	14.063	14.125	14.405	0.012	0.015	0.016
SE(m)	4.514	4.534	4.624	0.004	0.005	0.005

flowering and yield attributes, in order to identify traits associated with improved floral performance.

Results

Effect of seed priming on germination and seedling vigor

Seed priming significantly affected germination and early seedling growth of *Zinnia elegans* under both growth chamber and pot conditions. Hormonal priming with GA_3 consistently outperformed hydropriming and the unprimed control for germination percentage, seedling length, and vigor indices. GA_3 at 40 mg produced the highest germination and vigor index values, reflecting marked improvements in both root and shoot elongation relative to other treatments. GA_3 at 10 mg also enhanced germination and seedling vigor compared with control and NAA treatments, but its effects were generally lower than those of 40 mg GA_3, indicating a dose-dependent response (Table 1).

Physiological and biochemical responses to priming

Priming treatments significantly influenced leaf relative water content and net assimilation rate, with hormone-based priming showing clear advantages. GA_3 at 10 mg and NAA at 8 mg maintained higher RWC and improved net assimilation rate compared with control and hydropriming, indicating better plant water status and carbon gain. Total chlorophyll (and its fractions) increased under GA_3 and NAA primed seeds, with GA_3 at 10 mg particularly associated with higher chlorophyll levels. α-amylase activity increased in hormonally primed seedlings, especially under GA_3 at 40 mg, consistent with enhanced reserve mobilization during early growth (Table 2-4) (Fig. 1 & 2).

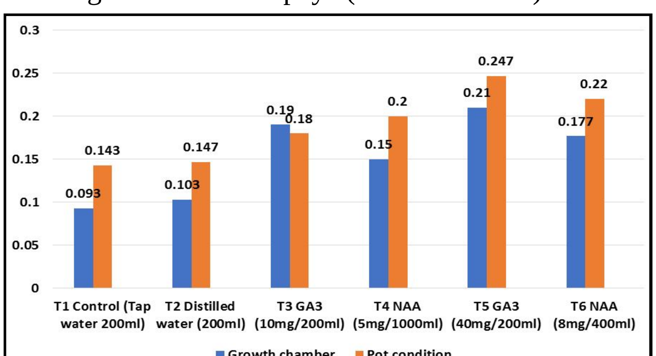

Fig. 2: Effect of seed priming on alpha amylase of Zinnia under growth chamber and pot condition.

Flowering behavior and yield attributes

Seed priming altered flowering behaviour and yield-related traits under pot conditions (Fig. 3). NAA at 8 mg and GA_3 at 10 mg tended to reduce days to first flowering compared with the control, indicating accelerated reproductive onset. GA_3 at 40 mg produced taller plants with more branches and leaves, which translated into higher flower number per plant and greater floral biomass (fresh and dry flower weight) than other treatments. Shelf life of harvested flowers improved most notably under GA_3 at 10 mg and NAA at 8 mg, whereas unprimed and hydroprimed seeds produced flowers with shorter postharvest longevity (Table 5).

Correlation analysis

Correlation analysis revealed strong positive associations between seedling vigor indices and several physiological and yield traits. Higher vigor indices were positively correlated with chlorophyll content, relative water content, net assimilation rate, and plant height, as

Table 3: Effect of seed priming on total chlorophyll, chlorophyll a, and chlorophyll b (mg/g fresh weight) of Zinnia under pot condition.

Treatment	TCC	Ca	Cb
T_1 Control (Tap water 200ml)	0.412	0.152	0.47
T_2 Distilled water (200ml)	0.647	0.347	0.558
T_3 GA_3 (10mg/200ml)	1.07	0.475	0.846
T_4 NAA (5mg/1000ml)	0.854	0.451	0.834
T_5 GA_3 (40mg/200ml)	0.481	0.162	0.484
T_6 NAA (8mg/400ml)	0.681	0.376	0.58
C.D.	0.022	0.055	0.029
SE(m)	0.007	0.018	0.009

TCC: Total chlorophyll content; Ca: Chlorophyll a; Cb: Chlorophyll b

Table 4: Effect of seed priming on alpha amylase of Zinnia under growth chamber and pot condition.

Treatment	Growth chamber	Pot condition
T_1 Control (Tap water 200ml)	0.093	0.143
T_2 Distilled water (200ml)	0.103	0.147
T_3 GA_3 (10mg/200ml)	0.19	0.18
T_4 NAA (5mg/1000ml)	0.15	0.2
T_5 GA_3 (40mg/200ml)	0.21	0.247
T_6 NAA (8mg/400ml)	0.177	0.22
C.D.	0.04	0.037
SE(m)	0.013	0.012

well as with flower number per plant, floral biomass, and flower shelf life. Chlorophyll content and α amylase activity also showed positive correlations with key yield components, supporting a progression from enhanced early germination and vigor to improved physiological performance and, ultimately, higher flowering capacity and floral yield.

Discussion

Hormonal seed priming and early metabolic activation

The consistent improvement in germination and seedling vigor under GA_3 and NAA based priming indicates that seeds entered imbibition with a higher degree of metabolic readiness than unprimed and hydroprimed lots (Paparella *et al.*, 2015; Pagano *et al.*, 2023). Controlled hydration in the presence of growth regulators likely accelerated the activation of hydrolytic enzymes, particularly α amylase, facilitating more rapid conversion of stored starch into soluble sugars to fuel embryo growth (Szopiñska & Politycka, 2016; Chandel *et al.*, 2023). Such priming induced advancement of early metabolic events is a well-established mechanism by which seeds traverse the lag phase of germination before radicle protrusion, resulting in faster, more uniform emergence once they encounter favorable conditions (Surabhi *et al.*, 2018; Shikari *et al.*, 2025).

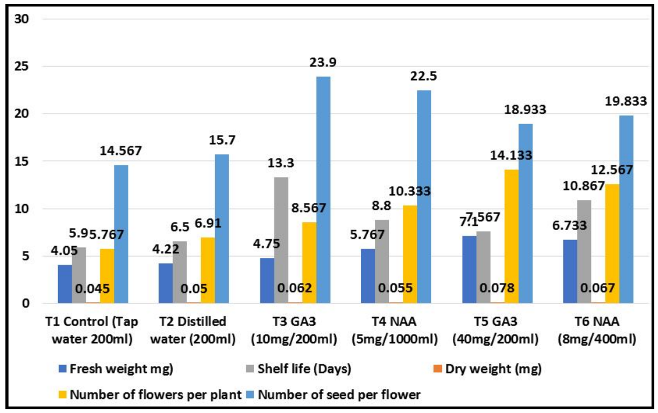

Fig. 3: Effect of seed priming on Fresh weight(mg), Dry weight (mg), Number of seed per flower, Shelf life (Days) and Number of flowers per plant of Zinnia under pot condition.

GA_3-mediated improvement in physiological efficiency

The higher chlorophyll content and net assimilation rate in plants derived from GA_3 primed seeds, especially at the lower dose, suggest that hormonal conditioning at the seed stage had persistent effects on the photosynthetic apparatus (Ahmad *et al.*, 2017; Sedaghatnoor & Zakibakhsh-Mohammadi, 2019; Anwar, *et al.*, 2020). GA_3 is known to promote chloroplast development and leaf expansion, and the observed increases in chlorophyll concentration and NAR are consistent with a greater photosynthetic surface and enhanced carbon gain per unit leaf area (Surabh *et al.*, 2018; Al-Chalabi, 2020; Asif Mahamud *et al.*, 2025). Concurrent improvements in relative water content indicate that primed plants maintained a more favorable leaf water status, which would stabilize stomatal conductance and sustain photosynthesis, thereby supporting continuous biomass accumulation in the early growth phase (Choudhury & Bordolui, 2023; Thakur & Dhatt, 2024).

Translation of early vigor into flowering and yield performance

The superiority of GA_3, particularly at 40 mg, for

Table 5: Effect of seed priming on Fresh weight(mg), Dry weight (mg), Number of seed per flower, Shelf life (Days) and Number of flowers per plant of Zinnia under pot condition.

Treatment	Fresh weight (mg)	Dry weight (mg)	Shelf life (Days)	Number of flowers per plant	Number of seed per flower
T_1 Control (Tap water 200ml)	4.05	0.045	5.9	5.767	14.567
T_2 Distilled water (200ml)	4.22	0.05	6.5	6.91	15.7
T_3 GA_3 (10mg/200ml)	4.75	0.062	13.3	8.567	23.9
T_4 NAA (5mg/1000ml)	5.767	0.055	8.8	10.333	22.5
T_5 GA_3 (40mg/200ml)	7.1	0.078	7.567	14.133	18.933
T_6 NAA (8mg/400ml)	6.733	0.067	10.867	12.567	19.833
C.D.	0.845	0.017	1.559	1.767	5.926
SE(m)	0.271	0.005	0.5	0.567	1.902

plant stature, branching, and floral biomass points to a clear translation of early vigor into structural capacity to support reproductive output (Chowdhury *et al.,* 2023; Abass *et al.,* 2025). Plants with longer seedlings, stronger root–shoot systems, and higher physiological efficiency are better positioned to intercept light, exploit soil resources, and allocate assimilates towards inflorescence initiation and development (Bassel, 2016; Surabhi *et al.,* 2018; Anwar *et al.,* 2020). The reduction in days to first flowering under GA_3 at 10 mg and NAA at 8 mg, together with increased flower number and higher fresh and dry flower weight under GA_3 at 40 mg, fits the classic pattern in which robust vegetative growth advances floral transition and sustains a larger sink size during flowering (Chauhan *et al.,* 2014; Surabhi *et al.,* 2018; Madhani *et al.,* 2025).

Differential and dose-dependent responses of GA_3 and NAA

The contrasting responses to GA_3 doses underscore the importance of concentration in hormonal priming strategies. GA_3 at 40 mg was more effective in promoting absolute vigor traits and yield attributes, reflecting its strong effect on cell elongation and canopy expansion, whereas 10 mg GA_3 tended to favor physiological balance, as indicated by higher chlorophyll content, improved RWC, and better shelf life (Ahmad *et al.,* 2017; Surabhi *et al.,* 2018; Ahlawat *et al.,* 2024). NAA at 8 mg, in turn, appeared more influential on traits linked to flowering behavior and water relations, such as earlier flowering and improved RWC, consistent with auxin-mediated regulation of root architecture, source–sink relations, and hormonal crosstalk during reproductive transition (Radhika *et al.,* 2023; Sharma *et al.,* 2025). These trait specific and dose dependent responses highlight that GA_3 and NAA do not act redundantly; rather, they target partially distinct developmental processes that can be leveraged according to production goals.

Practical implications for ornamental seed management

From a management perspective, the results demonstrate that hormonal seed priming offers a practical, pre sowing intervention to improve stand establishment and floral performance in zinnia. GA_3 at higher concentration is suitable where maximizing plant size and flower yield is the priority, as in cut flower or loose flower production, whereas GA_3 at lower concentration and NAA at moderate levels are more appropriate where uniformity, timely flowering, and extended shelf life are critical, as in potted or landscape uses. Because priming can be implemented with relatively simple infrastructure and does not alter downstream cultural practices, it provides an accessible tool to enhance uniformity, predictability, and market quality not only in zinnia but also in other seed propagated ornamentals with similar establishment constraints.

Conclusion

GA_3 based seed priming emerged as a robust approach to enhance germination, early seedling vigour, and flowering performance in *Zinnia elegans*, outperforming hydropriming and unprimed seed lots. The study demonstrated that these gains were underpinned by a well-defined physiological basis, including increased á amylase activity, improved leaf water status, and higher chlorophyll content and net assimilation rate, collectively supporting stronger vegetative growth and subsequent floral yield. Responses to GA_3 and NAA were clearly dose and trait specific, with higher GA_3 favouring structural vigour and yield, and lower GA_3 and moderate NAA concentrations better supporting physiological balance, flowering behaviour, and shelf life. For ornamental growers and nursery producers, hormone based seed priming thus represents a simple, low cost, pre sowing intervention that can be integrated into existing seed handling to improve stand uniformity, predictability of flowering, and overall floral output in zinnia and related ornamentals.

References

Abass, M., Wani A.H. and Malik K.M. (2025). Effect of growth regulator and nutrient spray to improve the growth, flowering and seed production of zinnia (*Zinnia elegans* Jacq.). *Plant Arch.*, **25(1)**, 2120–2130.

Ahlawat, B., Bahadur V. and Choudhary S.K. (2024). Effect of different levels of gibberellic acid (GA_3) on growth and yield of two varieties of cucumber (*Cucumis sativus* L.). *Int. J. Res. Agron.*, **7(6)**, 568–573.

Ahmad, I., Saleem A.M., Mustafa G., Ziaf K., Afzal I. and Qasim M. (2017). Seed halopriming enhances germination performance and seedling vigor of *Gerbera jamesonii* and *Zinnia elegans*. *Sarhad J. Agric.*, **33(2)**, 199–205.

Al-Chalabi, A.T.M. (2020). Effect of gibberellic acid (GA_3) on growth and some characteristics of ornamental plants: a review. *Future J. Agric.*, **3**, 1–4.

Amir, M., Prasad D., Khan F., Khan A., Ahmad B. and Astha A. (2024). Seed priming: an overview of techniques, mechanisms and applications. *Plant Sci. Today*.

Anwar, A., Yu X. and Li Y. (2020). Seed priming as a promising technique to improve growth, chlorophyll, photosynthesis and nutrient contents in cucumber seedlings. *Not. Bot. Horti Agrobot. Cluj-Napoca*, **48(1)**, 116–127.

Asif Mahamud, M., Imran S., Paul N.C., Rabbi R.H.M., Jahan N. and Sarker P. *et al.* (2025). An overview and current progress of gibberellic acid-mediated abiotic stress alleviation in plants. *Plant Soil Environ.*, **71(7)**, 453–479.

Bandurska, H., Bres W., Zieleziñska M. and Mieloszyk E. (2023). Does potassium modify the response of zinnia (*Zinnia elegans* Jacq.) to long-term salinity? *Plants*, **12(7)**, 1439.

Bassel, G.W. (2016). Seed vigour and crop establishment: extending performance beyond adaptation. *J. Exp. Bot.*, **67(3)**, 567–591.

Chandel, A., Thakur M., Rakwal A., Chauhan S. and Bhargava B. (2023). Exogenous applications of gibberellic acid modulate the growth, flowering and longevity of calla lily. *Heliyon*, **9(5)**, e16319.

Chauhan, R.V., Kava K.P., Babariya V.J., Pansuria P.B. and Savaliya A.B. (2014). Effect of gibberellic acid on flowering and cut flower yield in gerbera under protected condition. *Asian J. Hortic.*, **9(2)**, 404–407.

Choudhury, A. and Bordolui S.K. (2023). Stimulatory effect of hormonal seed priming in plant tolerance to resist abiotic stress: a review. *J. Agric. Food Sci. Biotechnol.*, **3(1)**, 140–152.

Chowdhury, R.S., Kumar V., Bhattacharya S., Mallick P., Ghosh A., Bhattacharjee S. and Kothari S.K. (2023). Effect of gibberellic acid (GA_3) on vegetative and reproductive growth and yield characters of cucumber under coastal region of West Bengal, India. *Int. J. Plant Soil Sci.*, **35(21)**, 90–96.

Coêlho, E.d.S., Ribeiro J.E.d.S., Silva E.F.d., Lima J.V.L., Gomes I.J. and Oliveira P.H.d.A. *et al.* (2025). Melatonin improves drought tolerance in *Zinnia elegans* through osmotic adjustment and stomatal regulation. *Agronomy*, **15(11)**, 2571.

Hasanovic, M. and Karalija E. (2025). Seed priming beyond stress adaptation: broadening the agronomic horizon. *Agronomy*, **15(8)**, 1829.

Madhani, D.P., Patel K.D., Jakhotra K.K. and Zankat S.B. (2025). Impact of GA_3, NAA and ethrel on growth, flowering and sex expression of ridge gourd (*Luffa acutangula* L.). *Int. J. Hortic. Food Sci.*, **7(6)**, 44–47.

Pagano, A., Macovei A. and Balestrazzi A. (2023). Molecular dynamics of seed priming at the crossroads between basic and applied research. *Plant Cell Rep.*, **42(4)**, 657–688.

Paparella, S., Araújo S.S., Rossi G., Wijayasinghe M., Carbonera D. and Balestrazzi A. (2015). Seed priming: state of the art and new perspectives. *Plant Cell Rep.*, **34(8)**, 1281–1293.

Powell, A.A. (2020). Seed quality is crucial to successful seedling production in horticulture. *Acta Hortic.*, **1273**, 289–298.

Radhika, Gupta P. and Kumar V. (2023). Effect of different priming treatments on germination, growth and development of seedlings of China aster (*Callistephus chinensis*). *Pharma Innov. J.*, **12(8)**, 2111–2114.

Rahmawati, Syam'un E., Riadi M., Ulfa F. and Anshori M.F. (2024). Effect of GA_3 as a priming agent on the growth of shallot (*Allium ascalonicum* L.) seedling. *Aust. J. Crop Sci.*, **18(3)**, 125–129.

Rhaman, M.S., Imran S., Rauf F., Khatun M., Baskin C.C., Murata Y. and Hasanuzzaman M. (2021). Seed priming with phytohormones: an effective approach for the mitigation of abiotic stress. *Plants*, **10(1)**, 37.

Sedaghatnoor, S. and Zakibakhsh-Mohammadi P. (2019). Effect of time of application and amounts of progesterone and gibberellic acid on the growth of *Zinnia elegans*. *Rev. Chapingo Ser. Hortic.*, **25(1)**, 1–10.

Sharma, S., Sharma D., Thakur S., Katoch V., Kumari N. and Lohia S. (2025). Plant growth regulators: their impact on cucurbits. *Plant Arch.*, **25(Suppl. 1)**, 963–970.

Shikari, A.B., Dikilitas M., Baran B. and Mishra A. (2025). Mechanisms of priming in enhancing stress tolerance. In: Patel, M. K., Tran, L.-S. P., Pandey, S. and Mishra, A. (eds.), *Exogenous priming and engineering of plant metabolic and regulatory genes*. Academic Press, 205–213.

Surabhi, V.K., Raikar S.D. and Channaveerswami A.S. (2018). Studies on influence of gibberellic acid (GA_3) on growth, seed yield and quality of zinnia (*Zinnia elegans* Jacq.). *Int. J. Pure Appl. Biosci.*, **6(3)**, 548–552.

Szopiñska, D. and Politycka B. (2016). The effects of hydro- and osmopriming on the germination, vigour and hydrolytic enzymes activity of common zinnia (*Zinnia elegans* Jacq.) seeds. *Folia Hortic.*, **28(1)**, 3–11.

Taiz, L., Zeiger E., Møller I. M. and Murphy A. (2015). *Plant physiology and development*. 6th edn. Sinauer Associates.