# GERMINATION AND PLANT GROWTH RESPONSES IN *OCIMUM* SPP. TO SEED PRETREATMENTS


***by***

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**KERALA, INDIA**


**2020**

## DECLARATION

I, hereby declare that this thesis entitled **"GERMINATION AND PLANT GROWTH RESPONSES IN *OCIMUM* SPP. TO SEED PRETREATMENTS"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship or other similar title, of any other University or Society.

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## CERTIFICATE

Certified that this thesis entitled **"GERMINATION AND PLANT GROWTH RESPONSES IN *OCIMUM* SPP. TO SEED PRETREATMENTS"** is a record of research work done independently by Mr. Akhil Raj B. C. (2018-12-037) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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## LIST OF ABBREVATIONS

| | |
|---|---|
| % | Per cent |
| @ | At the rate |
| µM | Micro molar |
| $^0$C | Degree Celsius |
| CD | Critical difference |
| cm | Centimeter |
| CRD | Completely Randomized Design |
| *et al*. | And others |
| Fig. | Figure |
| g | Gram |
| HI | Harvest index |
| $L^{-1}$ | Per litre |
| GA | Gibberellic acid |
| TDZ | Thidiazuron |
| IAA | Indole-3 acetic acid |
| BA | Benzyl adenine |
| NAA | Naphthalene Acetic Acid |
| $gL^{-1}$ | Gram per litre |
| h | Hour |
| cfu | Colony Forming Unit |
| mL | Millilitre |
| min | Minute |
| DAS | Days after sowing |
| ha | Hectare |
| $^0$E | Degree East |
| $^0$N | Degree North |
| SE | Standard Error |

| | |
|---|---|
| MSL | Mean Sea Level |
| FYM | Farm Yard Manure |
| SA | Salicylic Acid |
| PG | Phloroglucinol |
| N | Nitrogen |
| P | Phosphorus |
| K | Potassium |
| PGPR | Plant Growth Promoting Rhizobacteria |
| mg/L | Milligrams per litre |
| PPM | Parts per million |
| mM | Milli molar |
| kg | Kilo gram |
| T. No. | Treatment Number |
| SC | Scarification |
| WS | Water soaking |
| HW | Hot water |
| CSA | Concentrated Sulphuric Acid |
| Gn (%) | Germination per cent |
| S (%) | Survival per cent |
| GI | Germination Index |
| SL | Shoot length |
| RL | Root length |
| Sdl L | Seedling Length |
| AI | Allometric Index |
| SVI | Seedling Vigour Index |
| CH | Chitosan |
| *BP* | *Bacillus pumilus* |
| *BA* | *Bacillus amyloliquefaciens* |
| *PF* | *Pseudomonas fluorescens* |
| *BV* | *Bacillus velezensis* |

# INTRODUCTION

# 1. INTRODUCTION

The *Ocimum*, one of the largest genus of the family Lamiaceae encompasses aromatic annual or perennial herbs and shrubs native to the tropical and subtropical regions of the world. The genus comprises of more than 150 species (Pandey *et al.*, 2014), that are distributed throughout the tropical and warm temperate regions of the world, especially Asia, Africa, and Central and South America (Simon *et al.*, 1990; Moghaddam *et al*., 2015). The essential oils from *Ocimum* spp find diverse uses in pharmaceutical, cosmetic, perfumery and food industries. In India, basil is cultivated over an area of 25,000 ha and it accounts for an annual production of about 250- 300 t (Smitha *et al*., 2014).

*Ocimum tenuiflorum* L. (syn. *O. sanctum* L.), popularly known as Tulsi, Holy basil or Sacred basil, is an important essential oil bearing medicinal herb. It is indigenous to the Indian subcontinent and distributed throughout the tropical regions of Southeast Asia (Kirtikar and Basu, 1984). It is used in the treatment of respiratory disorders and general debility (Kumar *et al*., 2004). It is commercially cultivated for its shoots in hot and humid regions of India. The essential oil from this species contains eugenol, as the major chemical constituent, which contributes to the therapeutic activity of the plant. The essential oil from *O. tenuiflorum* is well exploited in the flavouring and pharmaceutical industries (Smitha *et al.*, 2014; Malav *et al*., 2015).

*Ocimum basilicum* L., commonly known as sweet basil or Indian basil, is an industrially important source of essential oil and aroma chemicals. This has been used in the treatment of headaches, diarrhoea, respiratory and kidney disorders (Joshi, 2014). *O. basilicum* is also a widely used culinary herb. The essential oils are extracted from the leaves and the flowering tops. *O. basilicum* has a distinctive aroma and flavor due to the presence of benzenoids and terpenoids. (Abdollah *et al*., 2013). Its essential oil is widely used in high grade

perfumes, aromatherapy, flavoring liquors, soups, and sauces, and as herbal spice, fly repellant, in dental and oral products and medicine (Bahl *et al*., 2018).

*O. tenuiflorum* and *O. basilicum* are the most cultivated and exploited species of the genus *Ocimum.* The species being seed propagated, is liable to exhibit erratic germination and establishment in the field. Seed germination and seedling vigour influences plant stand, establishment and growth. According to Rehman *et al.* (2015), seedling vigour influences the plant growth processes that have a profound reflection on yield. Hence, efficient seed germination is important in the cultivation of the species.

A rapid and uniform emergence and root growth is an inevitable requisite for the successful establishment of seedlings and subsequent crop stand. Seed priming would enable efficient germination with the imbibition of water by the quiescent dry seed and resultant elongation of the embryonic axis. The growth of the seedlings would happen subsequent to the mobilization of the major storage reserves and results in visible germination indicated by the emergence of the radicle, penetrating structures surrounding the embryo. (Bewley, 1997; Galhaut *et al.,* 2014).

Seed priming or pretreatment using plant growth promoting agents would evoke a range of biotic and physiological responses in the seeds and the seedlings, which would reflect in seed germination, seedling vigour, plant establishment, crop stand and subsequently, in the yield.

In this context, the present study entitled “Germination and plant growth responses in *Ocimum* spp. to seed pretreatments” has been undertaken with the objective of standardizing pretreatment of seeds for enhanced germination and plant growth in *Ocimum tenuiflorum* and L. *Ocimum basilicum* L.

# REVIEW OF LITERATURE

# 2. REVIEW OF LITERATURE

The study on "Germination and plant growth responses in *Ocimum* spp. to seed pretreatments" was carried out at the Department of Plantation Crops and Spices, College of Agriculture, Vellayani with the objective to standardize pretreatment of seeds for enhanced germination and plant growth in *Ocimum tenuiflorum* L. and *Ocimum basilicum* L.

The genus *Ocimum* encompasses therapeutically valuable perennial or annual aromatic herbs or shrubs. *Ocimum tenuiflorum and Ocimum basilicum* are the two most important species which are widely distributed and domesticated. Both the species are conventionally seed propagated. Physical manipulation and pretreatments of seeds using various growth promoting agents could have affirmative effect on seedling establishment, crop stand and subsequently, on the yield.

The literature related to the germination and plant growth responses due to various pretreatments in medicinal and aromatic plants are reviewed in this chapter. Wherever the literature in medicinal and aromatic plants are lacking, the literature related to other plant species are also reviewed.

## 2.1 PRETREATMENT AND PRIMING OF SEEDS

The primary aim of seed pretreatment is to enhance germination, reduce mean germination time and improve growth and vigor of seedlings. Seed pretreatments or priming treatments, would either enhance or facilitate the process of water imbibition that initiates germination. Ellis and Roberts (1981) are of the view that pretreatments are found successful in plants of economic significance like medicinal plants and small seeded plants that require quick and uniform emergence of the seedlings for proper crop establishment and good yield. According to Roa and Philipse (1993), low germination per cent and the

heterogeneity in seedling emergence have a reflective influence on plant growth performance and subsequent biomass production, which could be overcome by seed pretreatments or seed priming treatments.

According to Gupta (2003), one of the main impediments in the successful cultivation of medicinal and aromatic plants is that the plants which readily germinate in their natural habitat may not readily germinate when tried to domesticate elsewhere. This makes quality enhancement of seeds *via* seed pretreatments inevitable.

Seed pretreatments and priming are pre-sowing treatments which would lead to a physiological state that facilitates efficient germination of seeds. The seed treatments are mostly based on seed imbibition. Seeds are often dehydrated and stored until sowing. Subsequent to sowing, primed seeds are observed to have a faster and more synchronized germination resulting in more vigorous seedlings than those obtained from unprimed seeds (Lutts *et al.*, 2016).

According to Bradford (1986), many vegetables and small seeded grasses have been observed to have enhanced germination and synchronized seedling emergence on priming the seeds before sowing. Seed priming also improves seedling growth in water stressed conditions as reported by Kaur *et al.* (2002). It has also been found to improve the grain yield and yield components in *Nigella sativa* (Chobeigi *et al.*, 2015).

The pre-sowing seed treatments comprise of enhancement techniques that enable the seed to mobilize its own resources along with the augmentation of external resources to obtain maximum enhancement in establishment of plant stand and yield. The seed enhancement techniques encompass physical, biochemical and biological treatments of the seeds prior to sowing (Nagaraj *et al.*, 2018).

## 2.2 EFFECT OF SEED PRETREATMENT ON GERMINATION AND PLANT GROWTH

### 2.2.1 Effect of Physical Pretreatments on Germination and Plant Growth

The physical pretreatments of seed include scarification using sand paper, water soaking, hot water treatment and sulphuric acid treatment etc.

#### *2.2.1.1 Seed Pretreatment via Scarification*

Scarification is a mechanism to overcome external dormancy in seeds. It a method which disrupts the impermeable seed coat providing the entry of water and oxygen into the seeds. In nature, hard seed coats are cracked or softened by fire, extreme temperatures, digestive acids in the stomachs of animals, or by the abrasion of blowing sand. Once the seed coat is disrupted, oxygen and water enter the seeds and initiate germination. The choice of the method of scarification depends on the species and its seed coat. The method chosen should be such that it does not damage the endosperm, cotyledons, or embryo during the treatment (Luna *et al.*, 2014).

Mechanical scarification of *Ocimum americanum* seeds by gently filing with a fine grade sand paper for 3 min, enhanced the seed germination (Amritphale *et al*., 1984). It was concluded that the reduced resistance of the seed coat by scarification might have altered the balance between the restrictive seed coat and the expansive force of the embryonic axis, resulting in enhanced germination.

Seeds of *Bowiea volubilis* subjected to mechanical scarification (using sandpaper) demonstrated 100 per cent germination within a mean germination time of six days, due to disruption of its hard seed coat by scarification (Kulkarni *et al*., 2005).

However, scarification treatment was ineffective in enhancing germination in *Cistus* spp. and *Tuberaria lignosa* (Thanos *et al.,* 1992*).* Travlos *et al*. (2007) also reported that mechanical scarification inhibited germination in *Spartium junceum* seeds.

According to Zaman *et al*. (2011), mechanical scarification of seeds of *Convolvulus oxyphyllus* using sand paper enhanced the germination to 97 per cent over the control, which had a germination of only 3 per cent. But, he observed that in *Teucrium oliverianum*, the scarification treatment decreased the germination per cent considerably.

Talei *et al*. (2012) reported an earlier and higher germination (71.33 per cent at the third day after the scarification) when *Andrographis paniculata* seeds were scarified using sandpaper. The germination increased up to 94 per cent in 20 days of sowing.

Mohan *et al.* (2012) observed a higher germination of 85 per cent in sand scarified seeds of *Cassia absus* against the control, which recorded only 5 per cent germination.

The seeds of *Amorphophallus mulleri* when scarified using sand paper produced more sprouts than non-scarification treatment. The scarified seeds could have more access to water and oxygen, which enhanced seed germination (Harijati and Widoretno, 2018).

#### *2.2.1.2 Seed Pretreatment via Water Soaking*

Water soaking or hydropriming is a simple, economic and safe technique of soaking seeds in water for enhancing the ability of seeds towards osmotic adjustment, enhancing germination, seedling establishment and crop production (Kaur *et al*., 2002, Golezani *et al*., 2008).

*Terminalia chebula* seeds when exposed to water soaking for 48 h and 24 h recorded a higher germination of 66.70 and 60 per cent, respectively (Hossain *et al*., 2005). Farahani and Maroufi (2011) evaluated the effect of different periods

of exposure (0, 6 and 12 h) to hydropriming on the quality seedling production in basil (*Ocimum basilicum* L.). The highest germination (90.66 per cent) and seedling vigour (2.99) were achieved in hydropriming exposure for 12 h.

Seeds of *Cassia alata* when soaked in water for 48 h gave a higher germination of 80.2 per cent followed by 24 h soaking which recorded a germination of 76.80 per cent. However at 72h soaking, the germination was reduced to 68.60 per cent (Thirupathi *et al*., 2012).

The seeds of sunflower, *Helianthus annus,* when subjected to hydroprimimg for 12 h, recorded a significant enhancement in seedling vigour (8.43) and germination per cent (90.66) compared to the non-primed seeds. It was also observed that priming after 12 h failed to improve germination in *H. annus* (Farahani *et al*., 2011).

A higher germination of 80 per cent was recorded under dark conditions at 15°C with cold-water pre-treatment with mean germination time of 11.3 days in *Rheum emodi* (Polygonaceae) seeds. These higher results were obtained over the GA and the control treatments (Kandari *et al*., 2012).

***2.2.1.3 Seed Pretreatment Using Hot Water***

Rita *et al.* (2011) observed that when seeds of *Andrographis paniculata* were exposed to hot water (50$^{o}$C) for 5, 10 and 15 min, a higher germination per cent (93) was observed for 5 min exposure than that at 10 and 15 min, which recorded lower germination of 67 and 47 per cent, respectively.

Anandhi and Rajamani (2012) demonstrated that glory lily seeds soaked in hot water (100$^{o}$C) for one hour recorded a higher germination of 32.75 per cent, early seed germination (48.35 days) and seedling vigor index (565.92), when compared to chemical treatments involving gibberellic acid, potassium nitrate and thiourea.

Mohan *et al.* (2012) reported that hot water treatment of seeds of *Cassia angustifolia, Ocimum sanctum, Withania somnifera* and *Cassia absus* enhanced

the germination per cent to 92, 84, 70 and 50 per cent respectively, compared to a germination per cent of 76, 80, 64 and 5 per cent, respectively, in the control.

*Rheum emodi* (Polygonaceae) seeds incubated under 16:8 h alternate light: dark conditions at 15°C recorded the highest germination (83.30 per cent) with a reduced mean germination time (MGT) of 8 d following hot-water pre-treatment (Kandari *et al*., 2012). According to Soliman and Abbas (2013), germination of 92 per cent was observed in seeds subjected to hot water (100°C) soaking for 6 min in *Cassia fistula*.

Missanjo *et al*. (2014) opined that when *Acacia polyacantha* seeds were immersed in hot water (100$^{o}$C) for 5 min, germination improved to 76 per cent over the control, which recorded a germination of 42 per cent.

#### *2.2.1.4 Seed Pretreatment Using Concentrated Sulphuric Acid*

Concentrated sulfuric acid has been used to break physical dormancy in many species (Elahifard *et al*., 2005; Ghadiri and Niazi, 2005; Fang *et al*., 2006; Babashpour *et al*., 2011; Joshi and Pant, 2010). Olatunji *et al.* (2012) opined that the highly desiccant effect of the acid on the seed load would allow for easier water uptake and oxygen diffusion which would enhance promotion of seed germination and seedling growth.

Gupta *et al*. (2002) observed that 20 per cent $H_2SO_4$ treatment enhanced the germination to 84-86 per cent, and a seedling survival of 80 per cent was also recorded in field sown *Asparagus racemosus*. Karam and Gebre (2004) opined that seeds of *Cercis siliquastrum* when treated with concentrated sulfuric acid for 15 min enhanced germination by breaking the hard seed coat.

Aduradola and Adejomo (2005) reported that seeds of *Erythronphleum suaveolens* soaked in concentrated $H_2SO_4$ inhibited germination and reduced percentage germination, which could be due to probable damage to the embryo by the acid.

Joshi and Pant (2010) opined that $H_2SO_4$ scarification for 2 h enhanced germination and growth characteristics in *Canna indica*. Soliman and Abbas (2013) observed a germination of 96 per cent in seeds of *Cassia fistula* treated with $H_2SO_4$ for 2 min. *Viola odorata*, a hardy herbaceous medicinal plant, recorded low germination under normal laboratory conditions due to hard seed coat and dormancy. Seeds when treated with concentrated sulfuric acid for 60 min gave a germination of 49.99 per cent (Barekat *et al*., 2013). Imani *et al.* (2014) demonstrated a higher germination of 95 per cent, on treating the seeds of *Canna indica* with concentrated $H_2SO_4$ for three and four hours.

Higher germination of 97.2, 95.1, 93.4, 90.01 and 81.4 per cent, were obtained in *Innula racemosa, Rheum webbianum, Carum carvi, Saussurea lappa* and *Bunium persicum* respectively, when seeds were pretreated with acid ($H_2SO_4$ for 5 min) over the control treatment (Bhardwaj *et al*., 2016).

### 2.2.2 Effect of Hormonal Seed Priming on Germination and Plant Growth

The priming and pre-sowing treatments involving the use of plant growth regulators (PGRs) and hormones could improve seed performance in various crop species (Lee *et al*., 1998). Hormonal priming involves soaking the seeds in the solution of hormones *viz.,* Gibberellic acid, Auxins, Cytokinins *etc*, which play a major role in improving seed germination and seedling vigour. PGRs enhance seed germination capacity, improve biomass yield, and confer resistance to biotic and abiotic stresses (Papadopoulos *et al*., 2006). Seed priming with PGRs is considered as an efficient agro practice in annual crops due to its easiness in application and resultant higher vigor and production (Silva *et al*., 2019).

#### *2.2.2.1 Seed Priming with Gibberellic Acid (GA)*

GAs are generally synthesized by seeds and their role in germination is brought about by the hydrolysis of storage nutrients in the seeds and have a direct effect on embryo growth (Lecat *et al*., 1992). Halter *et al*. (2005) is of the view that gibberellins (GAs) play a major role in the termination of seed dormancy.

Genova *et al*. (1997) observed that *Atropa belladonna* L. seeds treated with optimal concentration of gibberellic acid (1.00 mg $L^{-1}$) for 24 h recorded a higher germination of 89.50 per cent.

In glory lily, the maximum number of leaves and root length were recorded in the plants obtained from the seeds soaked in $GA_3$ at a concentration of 250 ppm (Anandhi and Rajamani, 2012).

$GA_3$ treatment was more effective in enhancing seed germination parameters compared to IAA, IBA and NAA. $GA_3$ at 100 mg $L^{-1}$ significantly increased the final germination from 22.30 and 33.30 per cent (control) to 74.00 and 65.60 per cent, in peppermint and sweet basil, respectively, while a lower concentration of $GA_3$ at 50 mg $L^{-1}$ increased the final germination per cent of coriander from 27 (control) to 52.3 per cent (Elhindi *et al*., 2016).

Emem *et al*. (2017) reported that seeds of *Cucumis melo* when treated with $GA_3$ at 300 and 400 ppm greatly enhanced the germination per cent and seedling vigour. They also opined that at higher concentration, expression of enzymes might have stimulated the physiological and metabolic activities within the seed, which in turn would have made way for the reduction in the physical restriction imposed by the seed coat and promotion of embryo growth.

Hussain and Jha (2014) reported that the germination of $GA_3$ treated *Rauvolfia tetraphylla* seeds improved to 56.66 per cent compared to 31.26 per cent in untreated seeds.

In *Rauvolifia serpentina*, overnight soaking of seeds with $GA_3$ (1000 mg $L^{-1}$) resulted in earliness in germination and enhanced speed of germination. The same treatment recorded a higher germination of 50 per cent over the control treatment which had a germination of 11 per cent. The $GA_3$ treatment also resulted in 46.94 per cent reduction in number of days to complete germination, 633.93 per cent increase in speed of germination and 354.55 per cent increase in germination per cent over the control (Phatak *et al*., 2017).

Phatak *et al*. (2018) reported that overnight soaking of *Rauvolfia serpentina* seeds with $GA_3$ (1000 mg $L^{-1}$) recorded significantly higher seedling length (19.61 cm) and seedling vigour index 1072.31 compared to the control which recorded a seedling length of 13.89 cm and a vigour index of 199.38.

In a study by Zare *et al*. (2011), it was observed that *Ferula asafoetida* seeds treated with $GA_3$ 2000 ppm solution showed a germination of 34 per cent and the same in combination with 60 days of chilling treatment gave a germination of 91.66 per cent germination; while the seeds without $GA_3$ 2000 ppm recorded a germination of 1.05 (control) and 68 per cent (chilling treatment alone). These results indicated that $GA_3$ played a significant role in alleviating dormancy in *F. asafoetida* seeds.

Yang *et al.* (2011) reported that $GA_3$ could significantly reduce germination time and increase the germination rate in *Gentiana rigescens*. According to Zhang *et al*. (2012), seeds of *G. rigescens* when soaked under sterile conditions in $GA_3$ (0.2 mg $mL^{-1}$ for 24 h), seed germination increased from 10.0 to 62 per cent and plumule length, from 4.73 to 7.47 mm.

Priming of *Lawsonia inermis* seeds with $GA_3$ @ 100 ppm for 1 h recorded maximum germination (88 per cent), shoot length (4.8 cm), root length (1.7 cm), and seedling vigour index (27.28) compared to the control (76, 3.2, 1.2, and 20.52, respectively) (Ambika *et al*., 2015).

Shahrajabian *et al*., (2019) demonstrated that anise (*Pimpinella anisum L.*) seeds when treated with $GA_3$ recorded 37.91 per cent germination, 2.185 mm seedling length, 11.18 days of mean germination time and a seedling vigour index of 1.056 against the control treatment, which recorded 14.22 per cent germination, 1.463 mm seedling length, 10.44 days of mean germination time and a seedling vigour index of 0.329.

In a study, *Cyclamen africanum* and *Cyclamen cyprium* seeds were primed with $GA_3$ at three different concentrations, *viz*. 50 mg $L^{-1}$, 100 mg $L^{-1}$ and 150 mg

$L^{-1}$. In *C. africanum*, application of $GA_3$ @ 50 mg $L^{-1}$ was observed to be favorable for both seed germination (80 per cent) and seedling development, while the seeds primed with $GA_3$ @ 100 mg $L^{-1}$ recorded early germination, but the germination per cent was similar to that of the control. In *C. cypriumm*, best seedling development was obtained in seeds primed with GA@ 100 mg $L^{-1}$, with a germination of 60 per cent. The seeds primed with $GA_3$ @ 50 mg $L^{-1}$ germinated early, but they had a weakly developed petiole and tuber. Seeds primed with $GA_3$ @ 150 mg $L^{-1}$ did not germinate in both the species (Cipcigan *et al*., 2020).

#### *2.2.2.2 Seed Priming with Indole Acetic Acid (IAA)*

Indole acetic acid is reported to play a role in promoting seed germination in various crop species (Slavov *et al*., 2004; Pieruzzi *et al*., 2011). Exogenous auxin could stimulate seed germination in species such as *Sapindus trifoliatus* and *Albizzia lebbeck* (Naidu *et al*., 2000; Tomar, 2008).

According to Leadem (1987), IAA stimulated seed germination under stress conditions, but normally it had little or no effect on seed germination in most crop species. IAA is reported to have a conflicting effect on seed germination with different crop species (Silva *et al*., 2005).

According to Zhao and Zhong (2013), germination of *Cunninghamia lanceolata* was significantly improved when seeds were treated with $10^{-4}$ M IAA. Fuping and Xiaoting (2013) observed that seed treatment with IAA @ 25 mg $L^{-1}$ improved seed germination and seedling growth in *Impatiens balsamina.*

Soaking seeds in IAA $10^{-4}$ M accelerated seed germination and seedling growth in *Pinus massoniana*. The germination per cent, mean germination time and seedling length were 1.55, 0.71 and 1.65 times over the control (Guangwu and Xuwen, 2014).

Ramaih *et al.* (2003) opined that exogenous application of IAA delayed seed germination in wheat. In a study, Liu *et al*. (2013) revealed auxin induction of seed dormancy by enhancing ABA signal transduction.

According to Shuai *et al.* (2017), IAA seed treatment significantly delayed the seed germination process in soybean, and the germination speed was two- to three- fold slower than that of the control. The inhibitory effect of IAA on seed germination was concentration-dependent, with the more perceptible delayed germination being detected at higher concentrations.

***2.2.2.3 Seed Priming with Benzyl Adenine (BA)***

The hormone Benzyl Adenine belongs to the class of cytokinins which not only evoke cell division, but also other plant growth and developmental processes including seed germination, shoot initiation and growth ( Dewitte *et al*., 1999; Werner *et al*., 2001).

According to Sharma *et al*. (1976), oat seeds primed with 10 ppm and 100 ppm of BA enhanced seed germination to 44 and 57 per cent, respectively, over the control value of 28 per cent, after 15 days of sowing.

Singh (2004) demonstrated that seeds of zinnia (*Zinnia elengans*) when subjected to pre-sowing treatments with BA 30 ppm, gave higher germination percentage (86 per cent), speed of germination (5.3) and root length (4.63 cm).

Ghamery and Mousa (2017) evaluated the effect of seed priming with 6 concentrations of BA ranging from 5 to 55 ppm, for 6, 12, 18, 24, 36 and 48 h in *Nigella sativa* and *Allium cepa* seeds. In *Nigella sativa* seeds, the highest concentration of BA @ 55 ppm for 6h and 48 h, recorded an improved germination of 89.30 and 98.70 per cent respectively, over the control, which recorded 80 per cent germination. In *Allium cepa*, the germination of 87.3 per cent was observed in seeds primed with BA @ 5 ppm for 6 h, and 100 per cent in seeds primed with BA @ 55 ppm for 48 h.

Silva *et al*. (2019) demonstrated that the application of BA in seed treatment reduced nodulation, shoot dry mass, pod number and yield in bean crop.

Mangena (2020) opined that BA primed soyabean seeds took longer to emerge compared to hydroprimed seeds. However, growth, yield and biomass of BA primed plants were observed to be higher (number of branches per plant- 7.32, 100 seed weight- 22.6 g, overall biomass fraction- >40.5%) compared to plants developed from hydroprimed seeds (number of branches- 3.61, seed weight- 19.2 g, biomass- <12%) under similar growth conditions.

#### *2.2.2.4 Seed Priming with Thidiazuron (TDZ)*

Thidiazuron (N-phenyl-N-1,2,3-thiadiazol-5-yl urea) is a non-purine cytokinin that could evoke responses similar to natural cytokinins. TDZ is believed to be the best synthetic cytokinin, applied in plant *in vitro* or *in vivo* that promotes the regeneration of numerous plant species. It has a profound role in *ex vitro* generation and multiplication of plant species recalcitrant to propagation (Thomas and Katterman, 1986; Gross man, 1991; Faisal *et al*., 2005).

The exogenous application of TDZ influences the concentration of endogenous levels of plant growth regulators in certain dicot species. Purine and cytokinin metabolisms pathways are influenced by its exogenous application (Capelle *et al*., 1983; Laloue and Fox, 1989). TDZ mediates diverse physiological effects *viz.*, efficient seed germination, accelerated bud break, initiation and stimulation of sprouting, growth and development of cotyledons etc. (Lin *et al*., 1994). According to them, seed treatment with TDZ at 200 µM could improve seed germination in *Pyrus serotine*.

Rinaldi and Lambardi (1998) were of the view that thidiazuron, with cytokinin-like activity, stimulated germination of olive seeds. It has been observed to promote seed germination in seeds of *Striga asiatica* (Babiker *et al*., 1993), lettuce (Baskakov *et al*., 1981) and *Pyrus* spp. (Lin *et.al.*, 1994).

TDZ increases ethylene biosynthesis, which has a profound role in seed germination and in release of endogenous dormancy (Lambardi *et al.*, 1994; Rinaldi *et al*., 1994)

Rinaldi (2000) observed that TDZ improved the germination to 57 per cent and 87 per cent in two cultivars of Olive, Moraiolo and Canino, respectively. The germination was brought about by the stimulation of embryo growth, irrespective of ethylene biosynthesis. TDZ treatment of seeds evoked ethylene biosynthesis in the cultivar Canino, but not in Moraiolo.

According to Nikolic *et al*. (2006), TDZ and BA occupy a prime place in promoting seed germination. TDZ @ 0.22 µM and BA @ 0.22 µM concentration could induce 80-90 per cent germination in the seeds of *Lotus corniculata* under *in vitro* condition.

Seed treatment of *Arachis hypogea* by soaking the seeds in TDZ 22.7 µM prior to sowing increased the days to germination, decreased the shoot and root elongation, delayed the flowering and lowered the yield (Singh *et al*., 2008).

The promotive effects on seed germination by TDZ have been reported in *Digitalis purpurea*. TDZ @ 2.5 µM gave a germination of 41.7 per cent under *in vitro* conditions. It was found effective at lower concentrations, while at a higher concentration, it was observed to be toxic to the seeds with reduced germination (Patil *et al*., 2012).

### 2.2.3 Effect of Biostimulant Seed Priming on Germination and Plant Growth

Seed priming using biostimulants is a seed enhancement technique used to promote seed germination, uniform seedling growth, vigour and establishment, and to suppress diseases. They increase the germination rate and overall seedling emergence. Seed coating technology has been used as a promising and effective approach for enhancing establishment and yield of plant species (Snapp *et al*., 2008).

Biostimulants are materials that can enhance plant growth when applied to plants or seeds, but are not included in the group of fertilizers, pesticides, or soil amendments. They encompass biopolymers, plant extracts, plant derived compounds *etc*. Seed treatments require even reduced amounts of active ingredients than foliar treatments, principally due to the limited surface area treated. The biostimulant seed coating enhances germination and plant growth when compared to non-treated seeds (Schmitt *et al*., 2009; Rouphael and Colla, 2018).

### *2.2.3.1 Seed Priming with Chitosan*

Chitosan is a large cationic polysaccharide and natural biopolymer obtained by deacetylation of chitin, a major component of the shells of crustaceans such as crab, shrimp, insect cuticle and fungi cell wall (Sudarshan *et al*., 1992; Wojdyła, 2001; Chawla *et al*., 2015). Chitosan is a natural, biodegradable, safe, environment friendly and inexpensive compound with varied applications in agriculture (Hamed *et al*., 2016).

Chitosan is observed to improve soil fertility, enhance plant nutrient uptake, photosynthesis *etc*. (Dzung and Thang, 2004; Dzung, 2007). Chitosan was initially characterized as a plant elicitor by Limpanavech *et al*. (2008). Chitosan has been proven to stimulate plant growth, and to induce abiotic and biotic stress tolerance in various horticultural species (Malerba and Cerana, 2016).

Chitosan has been used as a seed priming material to enhance seed germination, seedling growth, and to protect seeds against pathogens under stressful conditions in many crop species (Lian-Ju *et al*., 2014; Samarah *et al*., 2016).

Seed soaking with chitosan increased the germination rate, length and weight of hypocotyls and radicle in rapeseed (Sui *et al*., 2002). Zhou *et al*. (2002) observed that chitosan primed seeds increased germination per cent in peanut. Similarly, Shao *et al*. (2005) reported that maize seeds soaked with chitosan

increased the germination per cent. Kim *et al*. (2005) demonstrated that seed treatment and root dipping in 1 per cent chitosan prior to transplanting resulted in increased growth and secondary metabolite production in sweet basil.

Shao *et al*. (2005) reported that treating seeds with chitosan reduced the mean germination time, enhanced the seedling length, seedling vigour and seed germination under stress in *Zea mays.*

Manjunatha *et al*. (2008) reported that seed priming with chitosan enhances seed germination and seedling vigour in pearl millet.

Cho *et al.,* (2008) reported that sunflower seeds treated with chitosan 0.5 per cent for 18 h gave a higher germination of 66 per cent over the control treatment, which recorded 53 per cent germination. Seedlings recorded a higher length of 9.22 cm compared to 6.16 cm in control.

Guan *et al*. (2009) demonstrated that chitosan treated maize seeds improved the germination and seedling growth. According to them, this effect was due to reduced malonyldialdehyde content, altered membrane permeability, enhanced soluble sugars and proline contents, as well as activities of enzymes, peroxidase and catalase.

According to Madavi and Rahimi (2013), *Carum copticum* seeds pretreated with chitosan significantly improved the germination per cent and seedling vigour index. Seeds pretreated with 0.2 per cent chitosan recorded a germination of 80 per cent against 52 per cent in the control treatment. The seedling vigour index and seedling length increased with increasing concentration of chitosan.

Chitosan primed isabgol (*Plantago ovata*) seeds demonstrated significant effect on germination percent, shoot and root length. Germination per cent enhanced with increase in chitosan concentration. The highest germination of 63.33 per cent was observed in 0.2 per cent chitosan, while the control treatment devoid of chitosan showed a germination of 41.67 per cent. Shoot and root length

increased significantly at 0.2 and 0.5 per cent chitosan, with higher values of 5.45 cm and 3.65 cm, respectively at 0.2 per cent chitosan level (Mahdavi, 2013).

Chitosan primed seeds of *Capsicum annum* were found to germinate faster with decreased mean time of germination and longer seedlings. Seed priming with 0.01 per cent chitosan showed only a slight increase in germination per cent (89.5) over the control (82.5). The chitosan treatment reduced the mean germination time to 4.1- 4.2 days compared to untreated seeds, which recorded a mean germination time of six days. Seed treatment with chitosan significantly increased the seedling length also, compared to untreated seeds. Mean seedling lengths were 8.6 cm in chitosan treatment, compared to 6.9 cm for untreated seeds (Samara *et al.,* 2020).

***2.2.3.2 Seed Priming with Salicylic Acid (SA)***

Salicylic acid is a natural plant derived phenolic compound that has profound influence on several physiological processes and defense responses in plants (Shi and Zhu, 2008). Under both abiotic stress and non-stress conditions, salicylic acid acts as a signaling molecule that affects many physiological and biochemical processes. SA influences seed germination, establishment of seedling, cell growth and development, the activity of enzymes, and synthesis of flavonoids and photosynthetic process (Vlot *et al*., 2009).

Maia *et al.* (2000) demonstrated that salicylic acid increased germination per cent in soybean seedlings, besides stimulating the length of roots and increasing the green biomass. Szepesi, (2005) observed an increase in the per cent of germination in tomato seeds, when treated with 0.5 mM salicylic acid. Guo *et al*. (2009) observed that pretreatment of rice seeds with salicylic acid led to increased resistance in plants.

Kerbauy (2008) opined that salicylic acid inhibits germination. Tavares *et al.* (2014) observed that the seed treatment of rice with salicylic acid @ 130 mg $L^{-}$

[1]at seed dose of 2 mL $kg^{-1}$ did not affect germination and seed vigor, but caused a substantial increase in seed yield.

According to Zohra *et al.* (2016) influence of salicylic acid on seed germination depends on its concentration. At low concentrations (up to 0.25 mM), there was a decrease in germination rate which lasted until the sixth day in *Ocimum gratissimum*. At a higher concentration of 1 mM, there was an early stimulation of germination. At this higher concentration, the germination rate went up from 62 to 72 per cent in the 2nd day, and from 88 to 100 per cent on the 6th day.

The exogenous application of SA @ 0.0, 0.5, 1.0, and 3.0 mM to faba bean seeds showed a significant increase in seed germination and seedling growth except at higher concentrations. The highest seed germination, seedling vigour index and seedling length was recorded in 0.5 mM SA treated seeds than higher concentrations. At higher concentrations of 1.0 and 3.0 mM, inhibitory effects on germination as well as seedling growth (reduced shoot as well as root growth) was observed compared to control. It was also noted that seed priming of faba beans with a low concentration of SA speeded up the germination time and enhanced the establishment of seedlings (Soliman *et al*., 2016).

*Trigonella foenumgraecum* seeds when primed with 2800 µM SA, significantly enhanced the germination to 100 per cent from 41 per cent in the control. The highest seedling length, plumule dry weight and seedling dry weight were observed in the seeds treated with 2800 µM SA (Moghaddam *et al*., 2018).

Seed-priming of *Oryza sativa* with SA @ 100 ppm did not affect the germination per cent under non-stressed condition but increased under water stress. However, under both conditions, an increase in seedling vigour index and seedling dry weight with a reduction in mean germination time were observed, compared to the non primed seeds. Seedlings of SA-primed seeds had a significantly higher root and shoot length than non-primed seeds under both conditions (Shatpathy *et al*., 2018).

Alamri *et al.* (2018) in his study in wheat seedlings reported that treatment of SA increased the germination by 9.07 per cent, vigor index by 26.01 per cent and mean germination time by 31.55 per cent over the respective controls. Salicylic acid treatment also proved to be beneficial in improving seedling height.

#### *2.2.3.3 Seed Priming with Phloroglucinol*

Phloroglucinol which has synergistic effect with auxin is frequently used in plant tissue culture as a biostimulant, which increases shoot growth, multiplication and better root induction. It was reported to elicit plant growth promotion in terms of enhanced root and shoot growth in mung bean and maize seedlings (Geelen and Xu, 2020).

Phloroglucinol (1,3,5-trihydroxybenzene), which is a degradation product of a phenolic compound, phloridzin, has growth enhancing properties. Phloroglucinol increased shoot formation in several horticultural crops. When added to rooting media along with auxin, it further stimulated the rooting process. Phloroglucinol demonstrates both cytokinin-like and auxin-like activity, which might be the reason for its stimulatory effects (Silva *et al*., 2013). Its application has been reported to enhance seedling and root growth in maize by Rengasamy *et al*. (2015a, 2015b).

Seeds primed with phloroglucinol @ $10^{-6}$ M gave better survival rate (60 per cent), shoot length (17.7 mm), root length (29.3 mm) and seedling vigour index (713) over the non-primed control (20 per cent, 6.8 mm, 13.2 mm and 381 respectively) in *Ceratotheca triloba* (Masondo *et al*., 2018).

### 2.2.4 Effect of Biopriming of Seeds on Germination and Plant Growth

Biopriming of seeds is the priming technique which involves hydration using any biological component (Ashraf and Foolad, 2005). Biopriming treatment potentially enables to promote quick and even germination as well as better plant growth (Moeinzadeh *et al*., 2010). According to Abuamsha *et al*. (2011), it is the soaking of seeds in a bacterial suspension for a precalculated period of time in

order to allow the bacterial imbibition into the seed. Seed priming with living bacterial inoculum increases speed and uniformity of germination. It also ensures fast and uniform crop establishment, thereby improving harvest quality and yield. Seed biopriming allows the bacteria to enter or adhere to the seeds and also acclimatize the bacteria in the prevalent conditions (Mahmood *et al*., 2016).

Biopriming technique exploits beneficial microorganisms to protect against pathogens and to enhance plant growth. Plant growth promoting rhizobacteria (PGPR) comprising of the species of the genera *Pseudomonas* and *Bacillus* are used for biopriming. The plant seeds when exposed to these organisms helps in enhancing germination and seedling vigor as well as in controlling diseases caused by soil and seed borne pathogens (Rodriguez *et al*., 2015). *Bacillus pumilus, Bacillus amyloliquefaciens, Pseudomonas fluorescens etc*. have been found to enhance plant growth even under abiotic stresses (Mahmood *et al*., 2016).

Various *Bacillus* spp. have been shown to enhance the growth of agricultural crops and model plants, through different mechanisms of plant growth-promotion (Kloepper *et al.,* 2004; Hernandez *et al.,* 2009). *Bacillus* has been reported to have plant growth promoting capacity in crops of economic importance (Widnyana and Javandira, 2016).

#### *2.2.4.1 Biopriming using Bacillus pumilus species*

Tomato seeds when primed with *P. fluorescens* and *B. pumilus* grown in coconut water enabled improved rooting and plant growth promotion (Anith, 2009).

On inoculating the seeds of *Atriplex lentiformis* separately with *Bacillus pumilus* and *Azospirillum brasilense*, it was observed that the seeds inoculated with *B. pumilus* had significantly enhanced germination, shoot length, root length and number of leaves per plant, compared to that of *Azospirillum brasilense* (Bashan *et al.,* 2010). Martínez *et al.* (2013) demonstrated that the inoculation of

tomato seeds with the *Bacillus* strains increased the germination upto 5 to 6 per cent.

Akinrinlola *et al.* (2018) observed that corn seeds primed with *Bacillus pumilus* R 174 enhanced the plant growth by recording a 41 per cent increase in shoot height, 126 per cent increase in shoot fresh weight and 117 per cent in root fresh weight.

### *2.2.4.2 Biopriming using Bacillus amyloliquefaciens*

Plant growth promoting activity of *B. amyloliquefaciens* is well documented in various studies (Schmiedeknecht *et al*., 1998; Grosch *et al*., 1999; Bochow *et al*., 2001; Idriss *et al*., 2002; Yao *et al*., 2006).

Idris *et al*. (2004) demonstrated that the elongation of maize seedlings were significantly enhanced in the presence of diluted *B. amyloliquefaciens* culture filtrates. Idris *et al.* (2007) reported that biosynthesis of IAA by the PGPR, *B. amyloliquefaciens* has an effect on its ability to enhance plant growth.

Talboys *et al.* (2014) demonstrated that seed dressing using *B. amyloliquefaciens* stimulated root production in *Triticum aestivum*. It resulted in a significant enhancement in the length of the seminal root (by 39.1%) and first order lateral root (by 51.0%) per plant. They also opined that auxin secretion by *B. amyloliquefaciens* could increase the exudation of organic carbon and promote root growth.

Gowtham *et al.* (2018) reported that seed treatment of chilli with *B. amyloliquefaciens* recorded maximum enhancement in seed germination (84.75 per cent) and seedling vigor (1423.8) along with an increase in vegetative growth parameters *viz*., plant height (18.32 cm), shoot fresh biomass (3.52 g), dry biomass (1.53 g) and number of leaves (15.25 per plant) at 30 DAS compared to the untreated control.

### *2.2.4.3 Biopriming using Pseudomonas fluorescens*

*Pseudomonas fluorescens* promotes growth and development of plants in addition to inducing resistance (Ramamoorthy *et al*., 2001, Desai *et al*., 2002, Gnanamanickam *et al*., 2002). Biopriming is seen as an ideal delivery system to induce resistance by biocontrol agents and alleviate physiological and pathological stresses, thereby enhancing plant growth (Conrath *et al*., 2002). *Pseudomonas* spp. improve plant growth by enhancing nutrient absorption (e.g., N, P, K) and providing hormones in the rhizosphere, while also protecting against phytopathogenic organisms (Villegas *et al*., 2002 ; Duda and Orlikowski, 2004).

Raj *et al.* (2004) reported that biopriming of pearl millet seeds with *P. fluorescens* enhanced the germination, seedling vigour, plant height, leaf area, tillering capacity, seed weight and yield, in comparison with the untreated control. *P. fluorescens* treated seeds recorded 92 per cent germination and a vigour index of 1231, as compared to the control with 86 per cent germination and vigour index of 794. The number of days to flowering was also advanced by 5 days in bioprimed seeds.

Moeinzadeh *et al.* (2010) observed that *P. fluorescens* enhanced seed parameters like germination index, germination per cent, germination rate and vigor index and also seedling growth indices including root length, shoot height, dry and wet weight of seedlings and numbers of lateral roots in *Helianthus annus*. The treated seeds recorded a germination of 94.44 per cent and vigour index of 11.64 against the untreated control which recorded 81.67 per cent germination and 7.64 vigour index.

Rodriguez *et al*. (2015) demonstrated that when hydroprimed seeds of *Abies hickelii* were inoculated with rhizobacteria, *P. fluorescens* strain JUV8, the highest (91) per cent of germination was achieved against 62 per cent germination in seeds, which were subjected to hydropriming only. Seeds bioprimed with *P. fluorescens* showed enhanced seedling height, stem diameter and root length.

Basavaraj *et al.* (2019) demonstrated that the seedlings derived from *P. fluorescens* primed seeds exhibited maximum seed germination of 83.50 per cent and seedling vigour index in pearl millet against the control seedlings that offered 70 per cent seed germination and 834.5 seedling vigour index. Seeds treated with *P. fluorescens* also showed improved vegetative and reproductive parameters. A 20 to 80 per cent increase in plant growth parameters and advancement of flowering by 5 days was observed upon treatment with *P. fluorescens* compared to control.

#### *2.2.4.4 Biopriming using Bacillus velezensis*

*Bacillus velezensis* is a Gram-positive bacterium, used in agriculture to promote plant growth and control pathogenic microorganisms by producing some secondary metabolites or antibiotics, and efficient colonization of plants (Chen *et al*., 2007; Jeukens *et al*., 2015; Adeniji and Babalola, 2019).

*B. velezensis* BAC03 promoted plant growth by secreting several substances such as indole-3-acetic acid and ammonia (Meng *et al*., 2016). According to Hwangbo *et al*. (2016), *B. velezensis*, a phosphate-solubilizing bacterium isolated from the rhizosphere soil of rice, was reported to promote plant growth. *B. velezensis* GH1-13 was reported to benefit plant growth by nutrient uptake and secreting secondary metabolites such as IAA to promote the system development of plant roots (Kim *et al*., 2017). Fan *et al.* (2018) reported the plant growth promotion and biocontrol activity by *B. velezensis.*

Chen *et al.* (2019) observed enhancement in seedling height (40.3 cm), seedling dry weight (2.59 g), root length (15.2 cm) and root dry weight (0.51 g) in *B. velezensis* inoculated on pre-germinated seeds of peanut, over the unincoculated control treatment (35.7 cm, 2.23g, 12.1 cm and 0.43 g, respectively).

*B. velezensis* treatment could significantly promote the growth of *Malus hupehensis* in pot experiments. The seedlings of *M. hupehensis,* showed an

enhancement in height and basal diameter 30 days after the treatment, at the rate of 17.05 and 15.56 per cent, respectively. At 75 days after treatment, fresh weight and dry weights of the aerial parts recorded an increase by 17.1 and 18.20 per cent, respectively compared to the untreated control (Wang *et al*., 2020).

# MATERIALS AND METHODS

# 3. MATERIALS AND METHODS

The present study "Germination and plant growth responses in *Ocimum* spp. to seed pretreatments*"* was carried out at the Department of Plantation Crops and Spices, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala during 2018-2020. The objective of the study was to standardize pretreatment of seeds for enhanced germination and plant growth in *Ocimum basilicum* L. and *Ocimum tenuiflorum* L.

The study was carried out in two phases:

Phase 1- Pretreatment of seeds for enhanced germination

Phase 2- Evaluation of transplanted seedlings for enhanced plant growth

The materials used and the methodology adopted for the studies are discussed in this chapter.

## 3.1 LOCATION

The study was conducted at College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, located at $8^0$ 28' 28" N latitude and $76^0$ 57'47" E longitude, at an altitude of 28 m above mean sea level.

## 3.2 SOURCE OF PLANTING MATERIAL

The seeds of *Ocimum tenuiflorum* and *Ocimum basilicum* used for the study were sourced from Indian Institute of Horticultural Research, Bengaluru.

## 3.3 PHASE I- PRETREATMENT OF SEEDS FOR ENHANCED GERMINATION

The seeds of both the species of *Ocimum* were subjected to various treatments *viz.*, physical treatments, hormonal priming, biostimulant priming and biopriming (using microbes) prior to sowing. The seeds subjected to germination

without any pretreatments were taken as the control. The seeds after pretreatments were sown in protrays filled with potting mixture composed of coirpith compost and FYM in the ratio 1:1. The seedlings were maintained in the protrays upto 30 days after sowing to study the effect of pretreatments on germination. The experiments were laid out in Completely Randomised Design. Each treatment was replicated thrice and each replication consisted of 50 seeds.

### 3.3.1 Physical Treatments

The seeds were subjected to various physical treatments such as scarification (using sandpaper), water soaking (overnight), hot water (65$^{o}$C) treatment for 10 min and concentrated $H_2SO_4$ treatment for 1 min to study their effect on seed germination. The time of exposure to various physical treatments is presented in Table 1. The treated seeds were immediately sown in portrays.

Table 1: Physical treatments

| **Treatment** | **Physical pretreatments** |
|---|---|
| $T_1$ | Scarification (using sand paper) |
| $T_2$ | Water soaking (overnight) |
| $T_3$ | Hot water treatment (65$^{o}$C for 10 min) |
| $T_4$ | Concentrated sulphuric acid treatment (1 min) |
| $T_5$ | Control |

### 3.3.2 Hormonal Priming

The seeds were treated with different concentrations of various hormones *viz.*, Gibberellic acid ($GA_3$), Benzyl Adenine **(**BA**)**, Indole-3-acetic acid (IAA) and Thidiazuron (TDZ) for 24 h prior to sowing. After 24 h, seeds were immediately sown in protrays to study the effect of hormonal priming on germination. The treatments for hormonal priming of seeds are presented in Table 2.

Table 2: Treatments of hormonal priming

| Treatments | Hormones |
|---|---|
| $T_1$ | $GA_3$ @ 1500 µM |
| $T_2$ | $GA_3$ @ 3000 µM |
| $T_3$ | IAA @ 0.1 µM |
| $T_4$ | IAA @ 1.0 µM |
| $T_5$ | BA @ 100 µM |
| $T_6$ | BA @ 300 µM |
| $T_7$ | TDZ @ 200 µM |
| $T_8$ | TDZ @ 400 µM |
| $T_9$ | Control |

### 3.3.3 Biostimulant Priming

The seeds were soaked in different concentrations of various biostimulants *viz*., chitosan, salicylic acid and phloroglucinol for 3 h. The chitosan solutions were prepared by dissolving chitosan in 0.25 per cent glacial acetic acid, salicylic acid solution by dissolving 0.20 per cent ethanol and phloroglucinol in distilled water. Immediately after the treatments, seeds were sown in protrays to study their effect on seed germination. The treatments of biostimulant priming are presented in Table 3.

Table 3: Treatments of biostimulant priming

| Treatments | Biostimulants |
|---|---|
| $T_1$ | Chitosan @ 5g $L^{-1}$ |
| $T_2$ | Chitosan @ 10 $gL^{-1}$ |
| $T_3$ | Salicylic acid @ 1500 µM |
| $T_4$ | Salicylic acid @ 3000 µM |
| $T_5$ | Phloroglucinol @ 1 µM |
| $T_6$ | Phloroglucinol @ 10 µM |
| $T_7$ | Control |

### 3.3.4 Biopriming

The seeds were primed with bacterial cultures of *Bacillus* spp and *Pseudomonas fluorescens.* The cultures of bacteria used for biopriming were obtained from Department of Agricultural Microbiology, College of Agriculture, Vellayani, Thiruvananthapuram. The cultures of *Bacillus* spp were cross streaked on nutrient agar media and *Pseudomonas fluorescens* on Kings B medium. After 48 h of incubation at 28$^{o}$C, the plates were drenched with 10 ml of sterile water to get a suspension of bacterial isolates. The OD values of the suspension cultures at 600 nm measured in spectrophotometer was made to 0.5 by adding sterile water as required to maintain the suspension @ $10^8$ cfu/ml. The seeds were immersed for 24 h in the bacterial suspension of the following bacteria, after which the seeds were sown in protrays with potting mixture composed of coirpith compost and FYM in the ratio of 1:1 for germination. The treatments used for biopriming of seeds are given in Table 4.

Table 4: Treatments of biopriming

| Treatments | Microorganisms |
|---|---|
| $T_1$ | *Bacillus pumilus*VLY17@ $10^8$cfu ml$^{-1}$ |
| $T_2$ | *Bacillus amyloliquefaciens*VLY24@ $10^8$cfu ml$^{-1}$ |
| $T_3$ | *Pseudomonas fluorescens*PN026@ $10^8$ cfu ml$^{-1}$ |
| $T_4$ | *Bacillus velezensis*PCSE10@ $10^8$ cfu ml$^{-1}$ |
| $T_5$ | Control |

### 3.3.5 Observations on the Effect of Pretreatments on Seed Germination

#### *3.3.5.1 Germination per cent*

Germination per cent is an estimate of viability of a population of seeds. Seeds were sown in 50 cell protrays at the rate of one seed per cell and observed for germination upto 10 days, after which no seed germination was

observed in both the *Ocimum* species. The germination per cent was calculated by the following equation

$$\text{Germination per cent} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds initially sown}} \times 100$$

***3.3.5.2 Survival per cent***

The survival per cent was recorded daily from the day of first germination to the end of the experiment on seed germination.

$$\text{Survival \%} = \frac{\text{Number of surviving plants at end of the study}}{\text{Number of planted seeds}} \times 100$$

***3.3.5.3 Germination Index***

The seeds showing radicle protrusion were counted for the number of seeds germinated each day. Germination index was calculated using the following formula (AOSA, 1988),

$$\text{Germination index} = \frac{X1}{Y1} + \frac{X2 - X1}{Y2} + \ldots\ldots\ldots \frac{Xn - Xn-1}{Yn}$$

X1- Number of seeds germinated at first count

X2- Number of seeds germinated at second count

Xn- Number of seeds germinated on $n^{th}$ day

Y1- Number of days from sowing to first count

Y2-Number of days from sowing to second count

Y3-Number of days from sowing to nth count

***3.3.5.4 Mean Germination Time***

Mean germination time (MGT) is a measure of the rate and time-spread of germination. MGT was computed using the formula described by Schelin *et al.* (2003).

$$\text{Mean germination time (MGT)} = \frac{\Sigma f_i n_i}{\Sigma N}$$

fi = Day during germination period

ni = Number of germinated seeds on fi

N = Total number of germinated seeds

***3.3.5.5 Shoot Length***

Three seedlings were randomly selected from each replication and using a ruler or measuring tape**,** length was measured from the base to the highest point of the plant at 30 days after sowing.

***3.3.5.6 Root Length***

Three seedlings were randomly selected per replication and uprooted carefully. The root length was calculated from the base of the plant to the tip of primary roots at 30 days after sowing.

***3.3.5.7 Allometric Index***

The shoot length and root length recorded at 30 days after sowing were used to calculate the allometric index using the formula described by Hosseini *et al.* (2013).

$$\text{Allometric Index} = \frac{\text{Root length}}{\text{Shoot length}}$$

***3.3.5.8 Seedling Vigour Index***

The seedling vigour index was estimated using the following formula suggested by Vashisth and Nagarajan (2010).

Seedling vigour index = Germination per cent × Seedling length

**3.3.6. Statistical Analysis**

The experiments in the first phase of the study were laid out in completely randomized design (Panse and Shukhatme, 1985). The data generated from the experiments were subjected to analysis of variance (ANOVA).

## 3.4 PHASE 2: EVALUATION OF TRANSPLANTED SEEDLINGS FOR ENHANCED PLANT GROWTH

Thirty day old seedlings of *O. tenuiflorum* and *O. basilicum* obtained from pretreated seeds of phase I experiments were transplanted in grow bags. Ten seedlings in three replicates planted in grow bags were grown organically and evaluated for plant growth and yield. The seedlings from untreated seeds were taken as control.

UV stabilized grow bags of size of 40 cm × 24 cm × 24 cm with 600 gauge thickness and 15 kg capacity were used for raising the *Ocimum* plants. The planting medium used in phase 2 experiments consisted of a mixture of soil and FYM (1.52 % N, 0.72 % P and 0.40 % K) in the ratio 2:1 on volume basis. Each grow bag was filled with 13 kg of the medium.

The seedlings of *Ocimum* spp. were transplanted into planting holes made at a depth of 5-6 cm in grow bags. The seedlings were irrigated once daily upto one month after planting and on alternate days, thereafter. The weeds that emerged in the grow bags were removed, as and when noticed. The plants were given staking at 45 DAP to provide support and to maintain them erect. The plants were maintained upto 90 days, at which they were harvested.

### 3.4.1 Morphological Parameters

Three plants from each replication of each treatment were tagged as observational plants. The morphological observations were recorded at 30 DAS (at transplanting), 60 DAS and 90 DAS (at harvest).

#### *3.4.1.1 Plant Height*

The height of the plant was measured from the base to the tip of the plant. The mean values were recorded and expressed in centimetre (cm).

#### *3.4.1.2 Number of Branches*

The total number of branches arising from the main branch of each observational plants were counted and the mean values were recorded.

#### *3.4.1.3 Stem Girth*

The girth of the stem was recorded by measuring the circumference at the collar region using a thread and ruler. The mean girth was calculated and expressed in cm.

#### *3.4.1.4 Number of Nodes*

The nodes are the points on a stem where the leaves and branches originate. The total number of nodes per plant were counted and mean value recorded.

### 3.4.2 Phenological Parameters

#### *3.4.2.1 Days to Flower Initiation*

The days to flower initiation was recorded by counting the number of days taken from sowing to the initiation of the first flower.

#### *3.4.2.2 Days to Fruit set*

The days to fruit set was recorded by counting the number of days taken from initiation of the first flower to fruit set.

#### *3.4.2.3 Days to Fruit Maturity*

The days to fruit maturity was recorded by counting the number of days taken from the fruit set to fruit maturity. The fruit maturity is indicated by the blackening of the nutlets.

### 3.4.3 Yield Parameters

The yield parameters were recorded at the time of harvest, at 90 days after sowing.

#### *3.4.3.1 Total Leaf Biomass*

The fresh weight of all the leaves (including the petiole) present in the plant at the time of harvest was recorded. The samples were dried to a constant weight in a hot air oven at temperature of 70 ± 5$^{o}$C. The fresh and dry weights were expressed in g plant$^{-1}$.

#### *3.4.3.2 Total Stem Biomass*

The fresh weight of the stem present in the plant at the time of harvest was recorded. The samples were dried to a constant weight in a hot air oven at temperature of 70 ± 5$^{o}$C. The fresh and dry weights were expressed in g plant$^{-1}$.

#### *3.4.3.3 Total Shoot Biomass*

The shoot biomass is indicative of the yield of the plant, as the herbage, including leaves and stem is utilised for essential oil extraction. The fresh weight of the above ground portion of the plant at the time of harvest was recorded. The samples were dried to a constant weight in a hot air oven at temperature of 70 ± 5$^{o}$C. The fresh and dry weights were expressed in g plant$^{-1}$.

#### *3.4.3.4 Harvest Index*

The harvest index was determined using the formula,

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}}$$

The economic yield is indicated by the weight of aerial portion of the plant on dry weight basis and biological yield by the weight of the whole plant on dry weight basis.

### 3.4.4 Incidence of Pest and Diseases

The incidence of pests and diseases during the crop period was observed and recorded.

### 3.4.5 Statistical Analysis

The experiments in the study were laid out in completely randomized design (Panse and Shukhatme, 1985). The data generated from the experiments were subjected to analysis of variance technique (ANOVA).

# RESULTS

# 4. RESULTS

The study entitled “Germination and plant growth responses in *Ocimum* spp. to seed pretreatments” was carried out during 2018-2020 at the Department of Plantation Crops and Spices, College of Agriculture, Vellayani. The experiments were laid out in the Instructional Farm, College of Agriculture, Vellayani. The data collected from the field experiments were statistically analysed and the results are presented in this chapter.

## 4.1.1 PHASE 1: PRETREATMENTS OF SEEDS FOR ENHANCED GERMINATION IN *OCIMUM TENUIFLORUM*

### 4.1.1.1 Effect of Physical Pretreatment of Seeds on Germination and Seedling Growth Parameters in *O. tenuiflorum*

The various physical pretreatments *viz*., scarification, water soaking (overnight), hot water (65$^{o}$C for 10 min) and concentrated $H_2SO_4$ (1 min) were tried to study the effect on seed germination parameters in *O. tenuiflorum*. The data on the effect of physical treatments on various parameters is presented in Table 5.

#### *4.1.1.1.1 Germination per cent*

The seeds exposed to concentrated sulphuric acid for 1min ($T_{4)}$ recorded maximum germination of 85.33 per cent, which was significantly higher than all other treatments tried. The lowest (57.33 per cent) germination was observed in scarification treatment ($T_1$). This was on par with the treatments $T_2$, $T_3$ and $T_5$.

#### *4.1.1.1.2 Survival per cent*

Significant variation was observed among various physical pretreatments with respect to survival per cent. $T_4$ (seeds treated with concentrated sulphuric acid) recorded maximum survival of 85.33 per cent. The lowest (57.33 per cent)

survival rate was observed in $T_1$ (scarification), which was on par with the treatments $T_2$, $T_3$ and $T_5$.

#### *4.1.1.1.3 Germination Index*

The data indicated that various physical treatments tried had no significant influence on germination index.

#### *4.1.1.1.4 Mean Germination Time*

As in the case of germination index, no statistically significant variation was observed among physical treatments tried, on mean germination time.

#### *4.1.1.1.5 Shoot Length*

Shoot length exhibited significant variation among the physical treatments tried (Fig. 1). The treatment $T_3$ (hot water treatment of the seeds) recorded the highest shoot length of 17.17 cm which was on par with $T_1$ and $T_2$. The lowest shoot length (10.53 cm) was observed in the control. This was on par with $T_4$.

#### *4.1.1.1.6 Root Length*

Significant variation was observed among the physical treatments with respect to root length (Fig. 1). Similar to shoot length, the highest root length (10.66 cm) was recorded on hot water treatment ($T_3$), which was on par with $T_1$ and $T_2$. The lowest root length (6.73 cm) was observed in the control. This was observed to be on par with $T_2$ and $T_4$.

#### *4.1.1.1.7 Seedling Length*

Significant variation was observed among the physical treatments with respect to seedling length (Plate 1 and Fig. 1). $T_3$ (hot water treatment) recorded the highest length (27.83 cm) which was on par with $T_1$ and $T_2$. The lowest seedling length (17.26 cm) was observed in the control ($T_5$). This was observed to be on par with $T_4$.

#### *4.1.1.1.8 Allometric Index*

The data indicated that various physical treatments tried had no significant influence on allometric index.

#### *4.1.1.1.9 Seedling Vigour Index*

The seedling vigour index was calculated one month after sowing. The seedling vigour index was observed to be higher (19.67) in $T_3$ (hot water treatment), which was on par with $T_2$ and $T_4$ .The lowest (10.84) seedling vigour index was observed in the control.

### 4.1.1.2 Effect of Hormonal Seed Priming on Germination and Seedling Growth Parameters in *O. tenuiflorum*

The seeds were subjected to pretreatments with hormones *viz*., $GA_3$@1500 µM, $GA_3$ @ 3000 µM, IAA @ 0.1 µM, IAA @ 1.0 µM, BA @ 100 µM, BA @ 300 µM, TDZ @ 200 µM and TDZ @ 400 µM to study the effect on seed germination and seedling parameters in *O. tenuiflorum*. The data are presented in Table 6.

#### *4.1.1.2.1. Germination per cent*

Germination per cent showed significant variation among the various hormonal pretreatments tried. Treatment with $GA_3$ @ 1500 µM ($T_1$) recorded maximum germination of 96 per cent, which was on par with $T_2$. The lowest (13.33 per cent) germination rate was observed in TDZ @ 200 µM ($T_7$). This was on par with $T_4$ and $T_6$.

#### *4.1.1.2.2 Survival per cent*

A similar trend as in germination per cent was observed in survival per cent also, as all the seeds which germinated survived till the end of the study. Treatment with $GA_3$ @ 1500 µM ($T_1$) recorded maximum survival of 96 per cent, which was on par with $T_2$. The lowest (13.33 per cent) survival rate was observed in TDZ @ 200 µM ($T_7$). This was on par with $T_4$ and $T_6$.

#### *4.1.1.2.3 Germination Index*

Significant variation was observed among the hormonal pretreatments with respect to germination index. $GA_3$ @ 3000 µM treatment ($T_2$) recorded significantly higher germination index of 26.03, which was on par with $GA_3$ @ 1500 µM ($T_1$) .The lowest (3.31) germination index was observed in TDZ @ 200 µM ($T_7$). This was on par with $T_3$, $T_4$ and $T_6$.

***4.1.1.2.4 Mean Germination Time***

Mean germination time also exhibited significant variation among the hormonal pretreatments. Seeds treated with $GA_3$ @ 3000 µM ($T_2$) recorded the lowest mean germination time of 4.55 days, which was on par with $T_1$. The maximum (7.55 days) mean germination time was observed in TDZ @ 200 µM ($T_7$). This was on par with $T_3$, $T_4$, $T_6$ and $T_8$.

***4.1.1.2.5 Shoot Length***

The shoot length was measured one month after sowing. Significant variation was observed among the hormonal treatments with respect to shoot length (Fig. 2). Seedlings developed from the treatment with $GA_3$ @ 1500 µM ($T_1$) recorded a significantly higher shoot length of 19.03 cm. The lowest 10.53 cm shoot length was observed in the treatment involving IAA @ 0.1 µM ($T_3$) and control. This was on par with $T_4$, $T_6$ and $T_7$.

***4.1.1.2.6 Root Length***

The root length was measured by uprooting the plant one month after sowing. Seedlings from the treatment $T_1$ ($GA_3$ @ 1500 µM) recorded the highest (10.60 cm) root length, compared to all other treatments. The lowest root length (5.56 cm) was observed in $T_2$ ($GA_3$ @ 3000 µM), which was on par with $T_3$, $T_4$, $T_5$, $T_6$, $T_7$, $T_8$ and control (Fig. 2).

***4.1.1.2.7 Seedling Length***

The treatment with $T_1$ ($GA_3$ @ 1500 µM) recorded the highest seedling length of 29.63 cm, followed by TDZ 400 Mm (21.50 cm) and BA 100 µM (21.05 cm). The lowest (16.56 cm) shoot length was observed in $T_3$ (IAA @ 0.1 µM), which was on par with $T_2$, $T_4$, $T_6$, $T_7$ and control (Plate 2 and Fig. 2).

#### *4.1.1.2.8 Allometric Index*

Among the hormonal pretreatments, significant variation was observed in allometric index. Treatment with $T_6$ (BA @ 300 µM) recorded the highest allometric index of 0.66, which was on par with $T_1$, $T_3$, $T_4$, $T_7$ and $T_9$ (Control). The lowest allometric index (0.46) was observed in $T_2$ ($GA_3$ @ 3000 µM). This was on par with $T_1$, $T_5$ and $T_8$.

#### *4.1.1.2.9 Seedling Vigour Index*

Significant variation was observed in seedling vigour index, among the hormonal pretreatments. The treatment, $T_1$ ($GA_3$@1500 µM) recorded the maximum (28.42) seedling vigour index and the lowest (2.34) in $T_7$ (TDZ @ 200 µM), which was on par with $T_3$ and $T_6$.

### 4.1.1.3 Effect of Biostimulant Priming on Seed Germination and Seedling Growth Parameters in *O. tenuiflorum*

The seeds were exposed to pretreatments using biostimulants *viz*., chitosan @ 5 $gL^{-1}$, chitosan @ 10 $gL^{-1}$, salicylic acid @ 1500 µM, salicylic acid @ 3000 µM, phloroglucinol @ 1 µM and phloroglucinol @ 10 µM to study the effect on seed germination and seedling parameters in *O. tenuiflorum*. The data on their effect on various parameters are depicted in Table 7.

#### *4.1.1.3.1 Germination per cent*

Germination per cent exhibited significant variation among the biostimulant pretreatments. The control recorded maximum germination of 62.66 per cent. The lowest germination rate of 7.33 per cent was observed in $T_6$ (phloroglucinol @ 10µM), which was on par with $T_1$, $T_2$, $T_4$, $T_5$ and $T_6$.

#### *4.1.1.3.2 Survival per cent*

Similar trend as in germination per cent was observed with respect to survival per cent also. The control recorded significantly higher survival per cent (62.66) than all other treatments. The lowest survival rate of 7.33 per cent was observed in $T_6$ (phloroglucinol @ 10 µM), which was on par with $T_1$, $T_2$, $T_4$, $T_5$ and $T_6$.

#### *4.1.1.3.3 Germination Index*

The control treatment recorded significantly higher germination index (18.88) compared to all other biostimulant treatments. $T_6$ (phloroglucinol @ 10 µM) exhibited the lowest germination index of 1.27, which was on par with $T_1$, $T_4$ and $T_5$ .

#### *4.1.1.3.4 Mean Germination Time*

The data indicated that various treatments tried had no significant influence on mean germination time.

#### *4.1.1.3.5 Shoot Length*

A significantly higher (19.46 cm) shoot length was recorded in $T_3$ (salicylic acid @ 1500 µM). The lowest (10.02 cm) shoot length was observed in $T_4$ (salicylic acid @ 3000 µM), which was on par with $T_5$ and control (Fig. 3).

#### *4.1.1.3.6 Root Length*

Significant variation was observed in root length among the various biostimulants treatments tried (Fig. 3). $T_1$ (chitosan @ 5g $L^{-1}$) recorded the highest root length of 13.00 cm. The lowest (6.73 cm root length) was observed in the control, which was on par with $T_2$, $T_4$, $T_5$ and $T_6$.

#### *4.1.1.3.7 Seedling Length*

A significantly higher (31.29 cm) seedling length was recorded in $T_3$ (salicylic acid @ 1500 µM).This was on par with $T_1$. The lowest (17.12 cm) seedling length was observed in $T_4$ (salicylic acid @ 3000 µM), which was on par with $T_2$, $T_5$, $T_6$ and control (Plate 3 and Fig. 3).

***4.1.1.3.8 Allometric Index***

$T_1$ (chitosan @ $5gL^{-1}$) recorded maximum allometric index of 0.86 and the lowest index was observed in $T_3$ (salicylic acid @ 1500µM). This was on par with $T_2$, $T_5$, $T_6$ and control.

***4.1.1.3.8 Seedling Vigor Index***

Significant variation was observed among the various treatments for this parameter. $T_3$ (salicylic acid @ 1500 µM) recorded the highest seedling vigour index of 11.46, which was on par with $T_7$ (control). The lowest (1.49) seedling vigour index was observed in $T_6$ (phloroglucinol @ 10 µM) and this was on par with $T_1$, $T_2$, $T_4$ and $T_5$.

**4.1.1.4 Effect of Biopriming on Seed Germination and Seedling Growth Parameters in *O. tenuiflorum***

The effect of biopriming on seed germination and seedling parameters in *O. tenuiflorum* was studied by exposing the seeds to suspension culture of the microbes *viz.*, *Bacillus pumilus* VLY17, *Bacillus amyloliquefaciens* VLY24, *Pseudomonas fluorescens* PN026 and *Bacillus velezensis* PCSE10 for 24 h. The data is presented in Table 8.

***4.1.1.4.1 Germination per cent***

Significant variation was observed among the biopriming treatments. $T_1$ (*B. pumilus*) recorded the highest germination of 72.66 per cent, which was on par with control. The lowest (26 per cent) germination was observed in $T_3$ (*P. fluorescens*) which was on par with $T_2$.

***4.1.1.4.2 Survival per cent***

The biopriming treatments significantly influenced survival per cent. $T_1$ (*B. pumilus*) recorded highest survival rate of 72.66 per cent, which was on par with control. The lowest germination of 26 per cent was observed in $T_3$ (*P. fluorescens*). This was on par with $T_2$.

#### *4.1.1.4.3 Germination Index*

This parameter also exhibited significant variation among the various biopriming treatments tried. $T_5$ (Control) showed maximum germination index of 18.88 and the lowest (5.52) index was observed in $T_2$ (*B. amyloliquefaciens*), which was on par with $T_3$.

#### *4.1.1.4.4 Mean Germination Time*

Significant variation was observed among the biopriming treatments with respect to mean germination time. $T_4$ (*B. velezensis*) recorded highest mean germination time of 7.8 days, which was on par with $T_2$ and $T_3$. The least value (4.68 days) was recorded in the control treatment.

#### *4.1.1.4.5 Shoot Length*

Shoot length exhibited significant variation among the biopriming treatments tried (Fig. 4). Seedlings from the treatment $T_3$ (*P. fluorescens*) recorded the highest shoot length of 13.78 cm, which was on par with those from the treatment $T_1$ (*B. pumilus*). The lowest (10.53 cm) shoot length was observed in control.

#### *4.1.1.4.6 Root Length*

Significant variation was exhibited in root length, among the biopriming treatments tried (Fig. 4). Seedlings from the treatment, $T_2$ (*B. amyloliquefaciens*) recorded the highest root length of 9.83 cm, which was on par with $T_1$, $T_3$ and $T_4$. The lowest (6.73 cm) shoot length was observed in the control treatment.

The data showed that better shoot and root length was obtained in all biopriming treatments over the control.

#### *4.1.1.4.7 Seedling Length*

Seedling length exhibited significant variation among the biopriming treatments tried. The highest seedling length of 22.05 cm was recorded on treatment with $T_3$ (*P. fluorescens*), which was on par with $T_1$, $T_2$ and $T_4$. The lowest (17.26 cm) length was observed in the control treatment (Plate 4 and Fig. 4).

#### *4.1.1.4.8 Allometric Index*

Allometric index exhibited significant variation among the biopriming treatments. Treatment with $T_2$ (*B. amyloliquefaciens*) exhibited the maximum (0.85) allometric index, which was on par with $T_4$. The lowest (0.59) index was recorded in the treatment comprising $T_3$ (*P. fluorescens*). This was on par with the control.

#### *4.1.1.4.9 Seedling Vigor Index*

Significant variation was observed in seedling vigour index among the biopriming treatments. The treatment, $T_1$ (*B. pumilus*) recorded the maximum seedling vigour index of 15.83 and the lowest (5.70) in $T_3$ (*P. fluorescens*), which was on par with $T_2$.

### 4.1.1.5 Effect of Various Pretreatments on Seed Germination and Seedling Parameters in *O. tenuiflorum*

The consolidated data of the effects of various pretreatments on seed germination and seedling growth parameters are depicted in Table 9.

#### *4.1.1.5.1 Germination per cent*

Significant variation was observed in germination per cent among the various pretreatments tried. A maximum germination rate of 96 per cent was observed on treatment with $T_5$ ($GA_3$ @ 1500 µM), which was on par with $T_4$ and $T_6$. The lowest (7.33) germination percent was recorded with $T_{18}$ (phloroglucinol @ 10 µM). This was on par with $T_8$, $T_{11}$, $T_{13}$, $T_{14}$, $T_{16}$, and $T_{17}$.

#### *4.1.1.5.2 Survival per cent*

Similar trend as in germination per cent was observed with survival per cent also. The treatment $T_5$ ($GA_3$ @ 1500 µM) exhibited the highest survival rate of 96 per cent, which was on par with $T_4$ and $T_6$. The lowest (7.33) survival per cent was recorded on using $T_{18}$ (phloroglucinol @ 10 µM), which was on par with $T_8$, $T_{11}$, $T_{13}$, $T_{14}$, $T_{16}$, and $T_{17}$.

#### *4.1.1.5.3 Germination Index*

Significant variation was observed with respect to germination index among the various pretreatments tried. Treatment with $T_6$ ($GA_3$ @ 3000 µM) recorded highest germination index of 26.03, which was on par with $T_5$ ($GA_3$ @ 1500 µM). The lowest (1.27) index was observed in the treatment $T_{18}$ (phloroglucinol @ 10 µM), and was on par with $T_{10}$, $T_{11}$, $T_{12}$, $T_{13}$, $T_{16}$ and $T_{17}$.

#### *4.1.1.5.4 Mean Germination Time*

The highest (7.8 days) mean germination time was observed in $T_{22}$ (*Bacillus velezensis*PCSE10). This was on par with $T_8$, $T_9$, $T_{10}$, $T_{11}$, $T_{12}$, $T_{18}$, $T_{20}$ and $T_{21}$. $T_2$ (water soaking) recorded least number of days (4.48 days) to mean germination, which was on par with $T_1$, $T_3$, $T_4$, $T_5$, $T_6$ and control.

#### *4.1.1.5.5 Shoot Length*

Pretreatments exhibited significant influence on shoot length at one month after sowing. $T_{15}$ (salicylic acid @ 1500µM) recorded highest shoot length of 19.46 cm, which was on par with $T_5$. The lowest shoot length (10.02 cm) was observed in $T_{16}$ (salicylic acid @ 3000 µM).This was on par with $T_4$, $T_7$, $T_8$, $T_{10}$, $T_{11}$, $T_{17}$, $T_{20}$ and control.

#### *4.1.1.5.6 Root Length*

The pretreatments significantly influenced the root length of one month old seedlings. Seedlings from the treatment $T_{13}$ (chitosan @ 5 $gL^{-1}$) recorded the highest root length of 13.00 cm, which was on par with $T_{15}$. The lowest root length (5.56 cm) was recorded in $T_6$ ($GA_3$ @ 3000 µM), which was on par with $T_4$, $T_7$, $T_8$, $T_9$, $T_{10}$, $T_{11}$, $T_{12}$, $T_{13}$, $T_{14}$, $T_{16}$ and control.

#### *4.1.1.5.7 Seedling Length*

Pretreatments exhibited significant influence on seedling length at one month after sowing. The highest seedling length of 31.29 cm was observed on treatment with $T_{15}$ (salicylic acid @ 1500µM), which was on par with $T_5$ and $T_{13}$. The lowest shoot length (16.56 cm) was observed in $T_7$ (IAA @ 0.1 µM), which was on par with $T_4$, $T_6$, $T_7$, $T_8$, $T_{10}$, $T_{11}$, $T_{14}$, $T_{16}$ $T_{17}$ and control.

#### *4.1.1.5.8 Allometric Index*

Pretreatments significantly influenced allometric index in *O. tenuiflorum.* The treatment $T_{13}$ (chitosan @ 5$gL^{-1}$) recorded maximum allometric index of 0.86, which was on par with $T_{19}$, $T_{20}$ and $T_{22}$. The lowest index (0.46) was observed in treatment $T_6$ ($GA_3$ @ 3000 µM) and was on par with $T_2$, $T_5$, $T_6$, $T_7$, $T_8$ and $T_9$.

#### *4.1.1.5.9 Seedling Vigor Index*

The data revealed that the various pretreatments had significantly influenced the seedling vigour index. Treatment with $T_5$ ($GA_3$ @ 1500 µM) recorded the highest vigour index of 28.42 and the lowest vigour index (1.49) was observed in $T_{18}$ (phloroglucinol @ 10µM) which was on par with $T_7$, $T_8$, $T_{10}$, $T_{11}$, $T_{14}$, $T_{16}$ and $T_{17}$.

### 4.1.2 EVALUATION OF TRANSPLANTED SEEDLINGS OF *O. TENUIFLORUM* FOR ENHANCED PLANT GROWTH

### 4.1.2.1 Morphological Parameters

The results of the effect of various seed pretreatments (physical, hormonal, biostimulant and biopriming) on morphological parameters *viz.*, plant height, number of branches, stem girth and number of nodes, are presented in this section. The observations were recorded at 30 DAS (at transplanting), 60 DAS and 90 DAS (at harvest).

#### 4.1.2.1.1 Effect of Physical Seed Treatments on Morphological Parameters in Transplanted *O. tenuiflorum*

##### *4.1.2.1.1.1 Plant Height*

The result of the effect of physical pretreatments on plant height in transplanted *O. tenuiflorum* is presented in Table 10. Significant variation in plant height was observed among the physical treatments tried at all stages of observation.

At 30 DAS after sowing, $T_3$ (hot water) treatment recorded the maximum plant height of 17.17 cm which was on par with $T_1$ and $T_2$. The lowest plant height (10.53 cm) was observed in the control. This was on par with $T_4$.

Similarly, at 60 DAS also, the highest plant height (38.35 cm) was recorded in the treatment $T_3$ (Hot water), which was on par with the treatments $T_1$ and $T_2$. The lowest plant height (19.66 cm) was recorded in control plant which was on par with $T_4$.

At 90 DAS, a significantly higher plant height (109.06 cm) was observed in the treatment $T_2$ (water soaking). This was found to be on par with $T_1$ and $T_3$. Treatment with con. $H_2SO_4$ ($T_4$) recorded the lowest plant height (63.06 cm).

The same trend as in 30 DAS was observed at 60 DAS, also. But at 90 DAS, the plant height was found to be the lowest in the treatment $T_4$ and control plants recorded a significantly higher plant height compared to $T_4$.

##### *4.1.2.1.1.2 Number of Branches*

The result of the effect of physical pretreatments on number of branches is presented in Table 10. Only the main branch was observed at 30 DAS. No branch arose from the main shoot at this stage.

However, significant variation was observed in number of branches at 60 and 90 DAS. At 60 DAS, the highest number of branches (9.99) was recorded in the treatment $T_1$ (scarification). This was found to be on par with $T_2$, $T_3$ and $T_4$. The control plants exhibited the lowest (4.44) number of branches.

At 90 DAS, significantly higher number of branches (45.33) was observed in the seedlings from $T_3$ (hot water treatment). This was found to be on par with $T_2$. $T_4$ (con. $H_2SO_4$ treatment) exhibited the lowest (24) number of branches which was observed to be on par with control.

***4.1.2.1.1.3 Stem Girth***

The result of the effect of physical pretreatments on stem girth is presented in Table 11. Among the physical treatments tried, significant variation was observed in stem girth at 30 DAS. At 30 DAS, $T_1$ (scarification) exhibited higher basal stem girth (0.84 cm) among the various treatments. The lowest stem girth (0.68 cm) was recorded in control treatment, which was found to be on par with $T_4$.

At 60 and 90 DAS, the physical treatments had no significant influence on basal stem girth.

***4.1.2.1.1.4 Number of Nodes***

Table 11 shows the effect of physical pretreatments on number of nodes. At 30 DAS, $T_3$ (Hot water treatment) recorded the highest (12.66) number of nodes, which was on par with $T_1$, $T_2$ and $T_4$. The lowest (7.10) number was observed in the control plants. At 60 DAS, the physical treatments had no significant influence on number of nodes; while at 90 DAS, $T_2$ (Water soaking) recorded significantly higher (242.67) number of nodes, which was on par with $T_1$, $T_3$ and $T_4$. The control treatment exhibited lowest (206.6) number of nodes.

#### 4.1.2.1.2 Effect of Hormonal Seed Priming on Morphological Parameters in Transplanted *O. tenuiflorum*

##### *4.1.2.1.2.1 Plant height*

The result of effect of hormonal seed priming on plant height is presented in Table 12. Among the various hormonal treatments, significant variation in plant height was observed at 30, 60 and 90 DAS (at harvest) in plant height. At 30 DAS, $T_1$ ($GA_3$ @ 1500 µM) recorded the highest plant height of 19.03 cm. The lowest (10.53 cm) plant height was observed in $T_5$ (BA @ 100 µM) and control. These were on par with $T_6$, $T_7$ and $T_8$.

At 60 days after sowing, $GA_3$ @ 1500 µM ($T_1$) recorded significantly superior plant height (40.21cm).The lowest (16.60 cm) height was observed in $T_7$ (TDZ @ 200 µM) which was on par with $T_2$, $T_5$, $T_6$, $T_8$ and control.

At 90 days after sowing, $T_8$ (TDZ @ 400 µM) recorded the highest plant height of 108.56 cm, which was on par with $T_1$, $T_6$ and $T_7$. The lowest (75.69 cm) height was observed in $T_4$ (IAA @ 1 µM) which was on par with $T_2$, $T_5$ and control.

##### *4.1.2.1.2.3 Number of Branches*

The result of the effect of hormonal pretreatment on number of branches is presented in Table 12. No branching from the main shoot was observed at 30 DAS. Significant variation in number of branches was observed at 60 and 90 DAS among various hormonal pretreatments tried. At 60 DAS, the highest number of branches (16.22) was recorded using the treatment $T_3$ (IAA @ 0.1 µM). The treatment $T_5$ (BA @ 100 µM) exhibited the lowest (1.77) number of branches. This was on par with $T_6$, $T_7$ and control.

At 90 DAS, significantly higher number of branches (45.33) was observed in the plants of the treatment $T_5$ (BA @ 100 µM). This was found to be on par with $T_1$, $T_3$ and $T_8$. The treatment involving BA @ 300 µM ($T_6$) treatment

exhibited the lowest (24) number of branches, which was on par with $T_2$, $T_4$, $T_7$ and control.

#### *4.1.2.1.2.4 Stem Girth*

The result of the effect of hormonal pretreatments on stem girth is presented in Table 13. In the first, second and third month after sowing, the data indicated that various treatments tried had no significant influence on basal stem girth.

#### *4.1.2.1.2.5 Number of Nodes*

Table 13 indicates that hormonal seed priming had a significant influence on the number of nodes at all stages of observation. At 30 DAS, plants in the treatment $T_2$ ($GA_3$ @ 3000 μM) recorded the highest (10.44) number of nodes, which was on par with $T_1$, $T_3$, $T_4$, $T_5$ and $T_6$. The lowest (7.10) number was observed in the control treatment, which was on par with $T_4$, $T_7$, and $T_8$.

At 60 DAS, the treatment $T_1$ ($GA_3$ @ 1500 μM) recorded higher number of nodes (44.22), which was on par with $T_3$ and $T_4$. The lowest number (22.44) was exhibited by $T_7$, which was found to be on par with $T_5$, $T_6$, $T_8$ and control. Further, at 90 DAS, $T_8$ (TDZ @ 400 μM) exhibited higher (284.66) number of nodes, which was on par with $T_2$ and $T_7$. The control treatment exhibited the lowest (206.6) number of nodes.

### 4.1.2.1.3 Effect of Biostimulant Seed Priming on Morphological Parameters in Transplanted *O. tenuiflorum*

#### *4.1.2.1.3.1 Plant Height*

The result of effect of biostimulant pretreatments on plant height is presented in Table 14. At 30 DAS, significantly higher (19.46 cm) plant height was recorded in $T_3$ (salicylic acid @ 1500µM). The lowest (10.02 cm) plant height was observed in $T_4$ (salicylic acid @ 3000µM), which was on par with $T_5$ and $T_7$.

At 60 DAS, plants in the treatment $T_3$ (salicylic acid @ 1500µM) showed the maximum height of 28.16 cm, which was on par with $T_2$ and $T_5$. The lowest height (18.14 cm) was recorded in $T_1$ (chitosan @ $5gL^{-1}$), which was on par with $T_4$, $T_6$ and control.

At 90 DAS (harvest stage), plants in the treatment $T_1$ (chitosan @ $5gL^{-1}$) were observed to have the highest plant height of 89.90 cm, which was on par with $T_3$ and control. The lowest plant height was (59.43cm) recorded in $T_6$ (phloroglucinol @ 10µM), which was on par with $T_5$.

***4.1.2.1.3.2 Number of Branches***

The effect of biostimulant seed priming on number of branches is presented in Table 14. The main stem did not produce any branches at 30 DAS. At 60 DAS, the highest number (12.10) of branches was recorded in the plants derived from the treatment $T_3$ (salicylic acid @ 1500µM). This was found to be on par with $T_6$. The control exhibited the lowest (4.44) number of branches.

At 90 DAS, significantly higher number of branches (31) was observed in the plants derived from the treatment $T_4$ (salicylic acid @ 3000µM). This was found to be on par with $T_2$ and $T_3$. The plants derived from phloroglucinol @ 10µM ($T_6$) treated seeds exhibited the lowest (19.33) number of branches, which was found to be on par with $T_1$, $T_5$ and control.

***4.1.2.1.3.3 Stem Girth***

The effect of biostimulants seed priming on stem girth is presented in Table 15. At 30 DAS, plants derived from $T_6$ (phloroglucinol @ 10µM) exhibited higher stem girth (0.81 cm) and was found to be on par with $T_1$, $T_3$, $T_4$ and $T_5$.

The lowest stem girth (0.67 cm) was recorded in $T_2$ (chitosan @10 g $L^{-1}$), which was found to be on par with $T_1$, $T_3$ and control.

At 60 DAS, plants from the treatment, $T_3$ (salicylic acid @ 1500µM) recorded a significantly higher stem girth of 1.73 cm. The lowest girth (0.88 cm) was recorded in $T_1$ (chitosan @ 5g$L^{-1}$) and was on found to be on par with control.

At 90 DAS, the biostimulant treatments had no significant influence on stem girth.

***4.1.2.1.3.4 Number of Nodes***

Table 15 shows the effect of biostimulant seed priming on number of nodes. At 30 DAS, these treatments did not show any significant variation with respect to number of nodes. However, this parameter varied significantly among the treatments at 60 and 90 DAS.

At 60 DAS after sowing, $T_5$ (phloroglucinol @ 1µM) recorded the maximum number of nodes of 38.66, which was on par with $T_2$, $T_3$, $T_4$ and $T_6$. The minimum number of nodes (21.33) was observed in $T_1$ (Chitosan @ 5g$L^{-1}$), which was on par with control.

At 90 DAS, the treatment $T_1$ (Chitosan @ 5g$L^{-1}$) recorded higher (259.33) number of nodes, on par with $T_2$, $T_3$, $T_4$, $T_5$ and $T_6$. The control treatment exhibited lowest (206.6) number of nodes.

**4.1.2.1.4 Effect of Seed Biopriming on Morphological Parameters in Transplanted *O. tenuiflorum***

***4.1.2.1.4.1 Plant Height***

The result of the effect of biopriming on plant height is presented in Table 16. The biopriming treatments showed significant variation in plant height at 30 DAS. Plants developed from the treatment, $T_3$ (*P. fluorescens*) recorded the highest shoot length of 13.788 cm. The lowest (10.53 cm) shoot length was observed in control. At 60 and 90 DAS, plant height did not show any significant variation among the biopriming treatments tried.

***4.1.2.1.4.2 Number of Branches***

The effect of biopriming on number of branches is presented in Table 16. No branching was observed at 30 DAS. At 60 DAS, plants derived from $T_3$ (*P. fluorescens*) recorded significantly higher (10.22) number of branches. *B. velezensis* ($T_4$) exhibited the lowest (2.21) number of branches. However, at 90 DAS, no significant variation was observed among the treatments with respect to number of branches.

#### *4.1.2.1.4.3 Stem Girth*

The effects of biopriming on stem girth have been tabulated in Table 17. In the first month after sowing, plants from the treatment, $T_3$ (*P. fluorescens*) exhibited higher basal stem girth (0.98 cm), which was on par with $T_4$. The lowest stem girth (0.68 cm) was recorded in the control treatment. At 60 and 90 DAS, the biopriming treatments had no significant influence on stem girth.

#### *4.1.2.1.4.4 Number of Nodes*

Table 17 depicts the effect of biopriming on number of nodes in transplanted *O. tenuiflorum*. At 30 DAS, biopriming treatments had no significant influence on the number of nodes.

At 60 DAS, plants from the treatment $T_3$ (*P. fluorescens*) were observed to have significantly higher number (42) of nodes. The lowest (21.99) value was recorded in $T_2$ (*B. amyloliquefaciens*), which was found statistically on par with $T_4$ and control.

At 90 DAS, plants derived from the treatment $T_3$ (*P. fluorescens*) recorded higher (260) number of nodes, which was on par with $T_1$, $T_2$ and $T_4$. The control treatment exhibited the lowest (206.6) number of nodes.

### 4.1.2.1.5 Effect of Various Seed Pretreatments on Morphological Parameters in Transplanted *O. tenuiflorum*

#### *4.1.2.1.5.1 Plant Height*

The effect of various pretreatments on plant height is presented in Table 18. Significant variation was observed in plant height among the pretreatments at all stages of observation.

At 30 DAS, $T_{15}$ (salicylic acid @ 1500µM) recorded the highest plant height of 19.46 cm, which was on par with $T_5$. The lowest plant height (10.02 cm) was observed in $T_{16}$ (salicylic acid @ 3000µM).This was on par with $T_4$, $T_7$, $T_8$, $T_{10}$, $T_{11}$, $T_{17}$, $T_{20}$ and control..

At 60 DAS, the highest shoot length (40.21 cm) was recorded in the $T_5$ ($GA_3$ @ 1500 µM), which was on par with the treatment $T_3$. The lowest shoot length (16.60 cm) was recorded in $T_{11}$ (TDZ @ 200 µM) which was on par with $T_4$, $T_6$, $T_9$, $T_{10}$, $T_{12}$, $T_{13}$, $T_{16}$, $T_{18}$, $T_{20}$ and control.

At 90 DAS, significantly higher plant height (109.06 cm) was observed in $T_2$ (water soaking). This was found to be on par with $T_1$, $T_3$, $T_5$, $T_{10}$, $T_{11}$ and $T_{12}$. $T_{18}$ (phloroglucinol @ 10µM) exhibited the lowest (59.43 cm) plant height and this was found statistically on par with $T_4$ and $T_{17}$.

***4.1.2.1.5.2 Number of Branches***

The effects of various pretreatments on the number of branches have been presented in Table 18. No branching was observed in any of the treatment plants at 30 DAS. However, at 60 DAS, the significantly higher number of branches (16.22) was recorded in T7 (IAA @ 0.1 µM). The treatment BA @ 100 µM ($T_9$) exhibited lowest (1.77) number of branches. This was found to be on par with $T_{11}$, $T_{12}$, $T_{22}$ and control.

At 90 DAS, significantly higher number of branches (45.33) was observed in $T_3$ (hot water) and $T_9$ (BA @ 100 µM). This was found to be on par with $T_5$, $T_7$, $T_{12}$ and $T_{21}$. $T_{18}$ (phloroglucinol @ 10µM) exhibited the lowest (19.33) number of branches which was observed to be on par with $T_4$, $T_8$, $T_{10}$, $T_{11}$, $T_{13}$, $T_{14}$, $T_{15}$, $T_{17}$ and control.

***4.1.2.1.5.3 Stem Girth***

The effect of various pretreatments on stem girth is presented in Table 19. At 30 DAS, $T_{21}$ (*Pseudomonas fluorescens* PN026) exhibited higher basal stem girth (0.98 cm) which was on par with $T_{20}$ and $T_{22}$. The lowest stem girth (0.67 cm) was recorded in $T_{14}$ (Chitosan @ 10 $gL^{-1}$) treatment, which was found to be on par with $T_2$, $T_3$, $T_4$, $T_7$, $T_{12}$, $T_{13}$, $T_{15}$ and control.

At 60 DAS, the highest stem girth (1.73 cm) was recorded in $T_{15}$ (salicylic acid @ 1500 µM) and was found to be statistically on par with $T_1$, $T_3$, $T_5$, $T_{14}$, $T_{16}$, and $T_{17}$. The treatment, $T_{10}$ (BA @ 300 µM) exhibited the lowest stem girth of 0.65 cm, which was on par with $T_4$, $T_6$, $T_8$, $T_9$, $T_{11}$, $T_{12}$, $T_{13}$ and control.

At 90 DAS, stem girth did not show any significant variation among the various pretreatments tried.

***4.1.2.1.5.3 Number of Nodes***

Table 19 shows the effect of various pretreatments on the number of nodes. At all stages of observation, this parameter exhibited significant variation among the pretreatments tried. At 30 DAS, $T_3$ (hot water treatment) recorded the highest (12.66) number of nodes, which was on par with $T_1$, $T_2$, $T_4$, $T_6$, $T_{17}$, $T_{18}$, $T_{19}$, $T_{20}$, $T_{21}$ and $T_{22}$. The lowest (7.10) number was observed in control. This was on par with $T_5$, $T_7$, $T_8$, $T_9$, $T_{10}$, $T_{11}$, $T_{12}$, $T_{13}$, $T_{14}$, $T_{15}$ and $T_{16}$.

At 60 DAS, $T_5$ ($GA_3$ @ 1500 µM) recorded the highest number of nodes of 44.22, which was on par with $T_4$, $T_7$, $T_8$, $T_{17}$, $T_{18}$ and $T_{21}$. The lowest (21.33) value was observed in the treatment involving chitosan @ 5$gL^{-1}$ ($T_{13}$). This was on par with $T_9$, $T_{10}$, $T_{11}$, $T_{12}$, $T_{20}$, $T_{22}$ and control.

At 90 DAS, $T_{12}$ (TDZ @ 400 µM) recorded higher (284.66) number of nodes, which was on par with $T_6$, $T_{13}$ and $T_{21}$. The control treatment exhibited the lowest (206.6) number of nodes and was found to be statistically on par with $T_4$.

**4.1.2.2 Phenological Parameters**

The results of the effect of various seed pretreatments on phenological parameters *viz.*, days to flower initiation, days to fruit set and days to maturity, of transplanted *O. tenuiflorum* are presented in this section.

#### 4.1.2.2.1 Effect of Physical Seed Pretreatments on Phenological Parameters in Transplanted *O. tenuiflorum*

The data on the effect of physical treatments on phenological parameters are presented in Table 20. The data indicated that various physical treatments tried had no significant influence on days to flower initiation, days to fruit set and days to maturity.

#### 4.1.2.2.2 Effect of Hormonal Seed Pretreatments on Phenological Parameters of Transplanted *O. tenuiflorum*

The data on the effect of hormonal seed treatments on phenological parameters are presented in Table 21. $T_3$ (IAA @ 0.1 µM) recorded minimum (59.55 days) number of days to flower initiation, which was statistically on par with $T_8$. The control treatment recorded more number of days (67 days) till flower initiation. This was on par with $T_1$, $T_2$, $T_4$, $T_5$, $T_6$ and $T_7$. However, the days to fruit set and fruit maturity did not show any significant variation among the hormonal treatments tried.

#### 4.1.2.2.3 Effect of Biostimulant Seed Priming on Phenological Parameters of Transplanted *O. tenuiflorum*

The data on the effect of biostimulant seed priming on phenological parameters are presented in Table 22. The data indicated that various treatments tried had no significant influence on days to flower initiation, days to fruit set and days to fruit maturity.

#### 4.1.2.2.4 Effect of Biopriming of Seeds on Phenological Parameters of Transplanted *O. tenuiflorum*

The results of the effect of biopriming of seeds on phenological parameters are presented in Table 23. The data indicated that various treatments tried had no significant influence on days to flower initiation, days to fruit set and days to maturity.

### 4.1.2.2.5 Effect of Various Seed Pretreatments on Phenological Parameters of Transplanted *O. tenuiflorum*

The data on the effect of seed pretreatments on days to flower initiation, fruit set and maturity are presented in Table 24. It was observed that the treatments had significant effect on days to flower initiation. The plants derived from the treatments $T_1$ (scarification), $T_7$ (IAA @ 0.1 µM) and $T_{20}$ (*B. amyloliquefaciens*) recorded the least number of days (59.56) to flower initiation, which was on par with $T_2$, $T_3$, $T_4$, $T_5$, $T_6$, $T_9$, $T_{11}$, $T_{12}$, $T_{13}$, $T_{14}$, $T_{16}$, $T_{17}$ and $T_{18}$. The highest number of days (67) to flower initiation was observed in the control and was found to be on par with $T_4$, $T_5$, $T_6$, $T_8$, $T_9$, $T_{10}$, $T_{11}$, $T_{14}$, $T_{15}$, $T_{16}$, $T_{18}$, $T_{19}$, $T_{21}$ and $T_{22}$. The pretreatments of seeds did not show any significant variation with respect to days to fruit set and fruit maturity.

### 4.1.2.3. Yield Parameters

The effect of various seed pretreatments (physical, hormonal, biostimulant and biopriming) on yield parameters *viz*., total leaf biomass (fresh and dry), total stem biomass (fresh and dry), total shoot biomass (fresh and dry) and harvest index are presented in this section. The observations were recorded at harvest stage (90 DAS).

### 4.1.2.3.1 Effect of Physical Seed Pretreatments on Yield Parameters in Transplanted *O. tenuiflorum*

The data on the effect of physical seed pretreatments on yield parameters are presented in Table 25 and Plate 5.

#### *4.1.2.3.1.1 Total Leaf Biomass*

$T_2$ (water soaking) recorded the highest fresh leaf biomass of 66.93 g, which was on par with $T_1$ and $T_3$. The lowest weight (34.07g) was observed in $T_4$ (Con. $H_2SO_4$). This was found to be on par with the control. Dry leaf biomass was observed to be maximum (13.06 g) in $T_2$ and was found to be par with $T_1$, $T_3$ and control. The lowest value (6.54 g) was observed in $T_4$ (Conc. $H_2$ $SO_4$), which was also observed to be on par with the control.

#### *4.1.2.3.1.2 Total Stem Biomass*

Among the pretreatments, significant variation was observed in total stem biomass, both on fresh weight and dry weight basis. $T_3$ (hot water treatment) recorded a higher fresh (65.00 g) and dry (18.56 g) stem biomass. This was found to be on par with $T_2$ and $T_4$ in both the cases. The control treatment recorded the lowest fresh (35 g) and dry (10.02 g) stem biomass, which was statistically on par with $T_1$ on fresh and dry weight basis.

#### *4.1.2.3.1.3 Total Shoot Biomass*

Among the pretreatments, $T_3$ (hot water treatment) recorded the highest total fresh shoot biomass (130.10 g) and dry shoot biomass (31.22 g), which were on par with $T_1$ and $T_2$. The lowest values in terms of fresh weight (78.96 g) and dry weight (18.52 g) was observed in the control treatment. These were found to be on par with $T_1$ and $T_4$ (Fig. 5).

#### *4.1.2.3.1.4 Harvest Index*

As shown in Table 25, physical seed pretreatments had a significant effect on harvest index. The treatments, $T_2$ (water soaking) and $T_3$ (hot water) exhibited the highest value of 0.91 for harvest index which was on par with $T_1$. And the lowest (0.83) value was observed in $T_4$ (Conc. $H_2$ $SO_4$).

### 4.1.2.3.2 Effect of hormonal seed priming on yield parameters in transplanted *O. tenuiflorum*

The data on the effect of hormonal seed priming on yield parameters are presented in Table 26 and Plate 6.

#### *4.1.2.3.2.1 Total Leaf Biomass*

Significant variation was observed with respect to both fresh and dry leaf biomass. The highest leaf biomass (99.10g, 19.15 g) was obtained in $T_1$ ($GA_3$ @ 1500 µM) in terms of both fresh and dry weight. These were found to be on par with $T_8$. The lowest values were recorded in $T_2$, fresh weight (42.46 g) and dry weight (8.22 g). These were on par $T_4$, $T_7$ and control.

#### *4.1.2.3.2.2 Total Stem Biomass*

The treatment $T_5$ (BA @ 100 µM) recorded the highest stem fresh weight (116.5 g) which was on par with $T_8$. The lowest stem fresh weight (35g) was recorded in the control. The highest stem dry weight (33.34 g) was recorded by $T_5$ and was on par with $T_8$. The control treatment recorded lowest value of stem dry weight (10.02 g).

#### *4.1.2.3.2.3 Total Shoot Biomass*

$T_1$ ($GA_3$ @ 1500 µM) recorded the highest total fresh shoot biomass (193.50 g) and $T_5$ recorded the highest dry shoot biomass (47.23 g). The fresh shoot biomass was found to be on par with $T_5$ and $T_8$. The highest dry shoot biomass was on par with $T_1$ and $T_8$. The lowest values in terms of fresh weight (78.96 g) and dry weight (18.52 g) were recorded in the control treatment (Fig. 6).

#### *4.1.2.3.2.4 Harvest Index*

Seed priming with $GA_3$ @ 1500 µM ($T_1$) and $T_6$ (BA@ 300 µM) recorded the highest value (0.92) for harvest index and was on par with $T_3$, $T_5$, $T_8$ and control. The lowest harvest index (0.83) was recorded by $T_7$ (TDZ @ 200 µM), which was found to be on par with $T_2$, $T_3$, $T_4$ and $T_8$.

### 4.1.2.3.3 Effect of Biostimulant Seed Priming on Yield Parameters in Transplanted *O. tenuiflorum*

The data on the effect of biostimulant seed priming on yield parameters are presented in Table 27 and Plate 7.

#### *4.1.2.3.3.1 Total Leaf Biomass*

$T_1$ (chitosan @ 5gL$^{-1}$) recorded the highest fresh (95.93 g) and dry (18.60 g) weight which was on par with $T_3$. The lowest fresh leaf weight (43.96 g) and dry weight (8.49 g) was recorded by the control treatment.

#### *4.1.2.3.3.2 Total Stem Biomass*

It is evident from the data that stem biomass exhibited significant variation among the biostimulants treatments tried. $T_3$ (salicylic acid @ 1500µM) recorded the highest total stem fresh weight (129.70 g) and dry weight (37.08 g). The lowest fresh stem biomass (35 g) and dry stem biomass of (10.02 g) was recorded in the control treatment.

#### *4.1.2.3.3.3 Total Shoot Biomass*

$T_3$ (salicylic acid @ 1500µM) recorded significantly higher fresh and dry shoot biomass (217.50 g and 54.10 g respectively), which was found to be on par with $T_1$. The lowest values for fresh and dry shoot biomass (78.96 g and 18.52 g, respectively) were recorded in the control treatment (Fig. 7).

#### *4.1.2.3.3.4 Harvest Index*

The highest harvest index (0.91) was recorded by the treatment $T_2$ (chitosan @ 10 gL$^{-1}$). This was on par with $T_1$, $T_3$, $T_5$ and $T_7$. $T_4$ and $T_6$ recorded the lowest (0.88) harvest index.

### 4.1.2.3.4 Effect of Seed Biopriming on Yield Parameters in Transplanted *O. tenuiflorum*

The data on the effect of seed biopriming on yield parameters are indicated in Table 28 and Plate 8.

#### *4.1.2.3.4.1 Total Leaf Biomass*

Significant variation was observed in total leaf biomass, among the biopriming treatments done. The highest fresh (69.83 g) and dry (13.57 g) leaf biomass was observed in $T_2$ (*B. amyloliquifaciens*), which was found to be on par with $T_4$. The lowest values were recorded in $T_3$ (*P. fluorescens)* in terms of fresh

weight (31.8 g) and dry weight (6.16 g). These values were on par with the control.

#### *4.1.2.3.4.2 Total Stem Biomass*

The treatments showed significant variation in the case of total stem biomass. The highest stem biomass in terms of fresh (114.4 g) and dry (32.67 g) weights was recorded in the treatment $T_3$ (*P. fluorescens).* The control treatment recorded the lowest fresh (35.0 g) and dry (10.02 g) stem biomass.

#### *4.1.2.3.4.3 Total Shoot Biomass*

The treatments showed significant variation in fresh as well as dry shoot biomass of *O. tenuiflorum* (Plate 8 and Fig. 8). The highest shoot fresh (151.33 g) and dry (38.84) biomass was recorded in treatments, $T_2$ (*B. amyloliquifaciens*) and $T_3$ (*P. fluorescens),* respectively. The fresh shoot biomass was observed to be on par with $T_1$, $T_3$ and $T_4$ and dry shoot biomass was on par with $T_2$. The lowest fresh and dry weight was recorded in control treatment.

#### *4.1.2.3.4.4 Harvest Index*

As depicted in Table 28, the treatments failed to produce any significant variation with respect to the harvest index.

### 4.1.2.3.5 Effect of Various Seed Pretreatments on Yield Parameters in Transplanted *O. tenuiflorum*

The data on the effect of various seed pretreatments on yield parameters are presented in Table 29.

#### *4.1.2.3.5.1 Total Leaf Biomass*

The treatments exhibited significant variation with respect to both fresh and dry leaf biomass. The highest values (99.10 g and 19.15 g, respectively) of fresh and dry leaf biomass were observed in $T_5$ ($GA_3$ @ 1500 µM, which were found to be on par with $T_{12}$, $T_{13}$ and $T_{15}$.

#### *4.1.2.3.5.2 Total Stem Biomass*

Among the pretreatments, $T_{15}$ (salicylic acid @ 1500µM) recorded the highest fresh (129.70 g) and dry (37.08 g) stem biomass. The lowest value for stem biomass in terms of fresh weight (35 g) and dry weight (10.02 g) was recorded in the control. These values were found to be on par with $T_1$.

#### *4.1.2.3.5.3 Total Shoot Biomass*

$T_{15}$ (salicylic acid @ 1500µM) recorded significantly higher fresh shoot biomass of 217.50 g and dry shoot biomass of 51.10 g, which was on par with $T_5$ and $T_{13}$. The lowest values for fresh and dry shoot biomass (78.96 g and 18.52 g, respectively) was recorded in the control treatment. This was found to be on par with $T_4$.

#### *4.1.2.3.5.4 Harvest Index*

$T_2$ (water soaking), $T_5$ ($GA_3$ @ 1500µM) and $T_{10}$ (BA @ 300 µM) recorded the highest value (0.92) for harvest index. This was found to be on par with $T_1$, $T_3$, $T_7$, $T_9$, $T_{12}$, $T_{13}$, $T_{14}$, $T_{15}$, $T_{16}$, $T_{17}$, $T_{18}$, $T_{20}$ and control. The lowest value (0.83) was observed in $T_4$ (con. $H_2SO_4$) and $T_{12}$ (TDZ @ 400 µM) with on par values recorded in $T_6$, $T_7$, $T_8$, $T_{11}$, $T_{12}$, $T_{19}$, $T_{20}$, $T_{21}$ and $T_{22}$ IAA @ 1µM) and $T_{21}$ (*P. fluorescens*) which was on par with $T_9$, $T_{12}$ and $T_{19}$.

The present study on the effect of various pretreatments on enhanced seed germination and plant growth in *O. tenuiflorum*, $GA_3$ @ 1500 µM recorded maximum germination per cent, seedling length, seedling vigour, and shoot biomass.

### 4.2.1 PHASE 1: PRETREATMENT OF SEEDS FOR ENHANCED GERMINATION IN *OCIMUM BASILICUM*

#### 4.2.1.1 Effect of Physical Treatments on Seed Germination and Seedling Growth Parameters in *O. basilicum*

The various physical pretreatments *viz*., scarification, water soaking (overnight), hot water (65°C for 10 min) and concentrated $H_2SO_4$ (1 min) were

tried to study the effect on seed germination and seedling parameters in *O. basilicum.* The results of the study are depicted in Table 30.

#### *4.2.1.1.1 Germination per cent*

The data indicated that various physical treatments tried had no significant influence on germination per cent.

#### *4.2.1.1.2 Survival per cent*

A similar trend as in germination per cent was observed in survival per cent also, as all the seeds which germinated survived till the end of the study. The data indicated that various physical treatments tried had no significant influence on germination index.

#### *4.2.1.1.3 Germination Index*

Significant variation was observed in germination index among the various physical pretreatments tried. $T_2$ (Water soaking) recorded maximum germination index of 16.13 and was on par with the treatments $T_3$ and control. The lowest germination index (4.67) was observed in $T_4$ (Con. $H_2SO_4$).

#### *4.2.1.1.4 Mean Germination Time*

The data indicated that the physical treatments tried had significant variation with respect to mean germination time. $T_2$ recorded least mean germination time (4.73 days). This was on par with $T_3$ and control. T1 (Scarification) treatment was observed to give the highest mean germination time of (6.50 days) and this was on par with the treatment $T_4$.

#### *4.2.1.1.5 Shoot Length*

$T_2$ (Water soaking) treatment recorded the highest shoot length of 19.23 cm which was on par with $T_1$, $T_3$ and $T_4$. The lowest (15.27 cm) shoot length was observed in the control treatment (Fig. 9).

#### *4.2.1.1.6 Root Length*

The data indicated that physical treatments did not show any significant variation in root length (Fig. 9).

#### *4.2.1.1.7 Seedling Length*

The data indicated that physical treatments did not show any significant variation in seedling length (Plate 9 and Fig. 9).

#### *4.2.1.1.8 Allometric Index*

No significant variation was observed in allometric index among the various physical treatments tried.

#### *4.2.1.1.9 Seedling Vigour Index*

$T_2$ (Water soaking) treatment recorded the highest vigour index of 18.27 which was on par with $T_1$, $T_3$ and $T_5$. The lowest (10.53) vigour index was observed in the $T_4$ (Conc.$H_2SO_4$) treatment.

### 4.2.1.2 Effect of Hormonal Priming on Seed Germination and Seedling Growth Parameters in *O. basilicum*

The various hormonal treatments *viz*., $GA_3$ @ 1500 µM, $GA_3$ @ 3000 µM, IAA @ 0.1 µM, IAA @ 1 µM, BA @ 100 µM, BA @ 300 µM, TDZ @ 200 µM and TDZ @ 400 µM were tried to study the effect on seed germination and seedling parameters in *O. basilicum,* the results of the study being depicted in Table 31.

#### *4.2.1.2.1 Germination per cent*

$T_6$ (BA @ 300 µM) recorded maximum germination of 80.67 per cent. The lowest (32 per cent) germination rate was observed in $T_3$ (IAA @ 0.1 µM).This was on par with $T_1$, $T_2$, $T_4$, $T_5$, $T_7$ and $T_8$. The control treatment exhibited better germination than all other hormonal treatments except BA @ 300 µM. It was also observed that BA at a lower concentration of 100 µM gave significantly lower germination than control.

#### *4.2.1.2.2 Survival per cent*

Similar results as in germination per cent was recorded for survival per cent also. All the germinated seedlings survived till the end of the experiment. $T_6$ (BA @ 300 µM) recorded maximum germination of 80.67 per cent. The lowest (32 per cent) germination rate was observed in $T_3$ (IAA @ 0.1 µM). This was on par with $T_1$, $T_2$, $T_4$, $T_5$, $T_7$ and $T_8$.

#### *4.2.1.2.3 Germination Index*

$T_6$ (BA @ 300 µM) recorded the highest germination index of 29.33. The lowest (7.13) germination index was observed in $T_3$ (IAA @ 0.1 µM), which was on par with $T_1$, $T_2$, $T_4$, $T_5$ and $T_8$.

#### *4.2.1.2.4 Mean Germination Time*

$T_6$ (BA @ 300 µM) recorded significantly lower (4.10 days) mean germination time than all other treatments. The maximum (5.33 days) mean germination time was observed in $T_8$ (TDZ @ 400 µM). This was on par with $T_1$, $T_2$, $T_3$, $T_4$, $T_5$ and control.

#### *4.2.1.2.5 Shoot Length*

$T_2$ ($GA_3$ @ 3000 µM) recorded significantly higher shoot length of 22.10 cm and the least shoot length of 15.27 cm was observed in the control (Fig. 10).

#### *4.2.1.2.6 Root Length*

$T_2$ ($GA_3$ @ 3000 µM) recorded the highest root length of 16.93 cm and was on par with $T_4$ (IAA @ 1 µM). The lowest root length (12.57cm) was observed in, $T_8$ (TDZ @ 400 µM) which was on par with $T_1$, $T_5$, $T_6$, $T_7$ and control (Fig. 10).

#### *4.2.1.2.7 Seedling Length*

$T_2$ ($GA_3$ @ 3000 µM) recorded significantly higher length of 39.03 cm (Plate 10 and Fig. 10). The lowest seedling length of 28.30 cm was observed in the control. This was found statistically on par with $T_1$, $T_7$ and $T_8$.

#### *4.2.1.2.8 Allometric Index*

The data indicated that various hormonal pretreatments tried had no significant influence on allometric index.

#### *4.2.1.2.9 Seedling Vigor Index*

The highest seedling vigor index (25.75) was observed in $T_6$ (BA @ 300 µM). The lowest value (10.28) was observed in $T_1$ ($GA_3$ @ 1500 µM). This was on par with $T_3$, $T_4$, $T_5$, $T_7$ and $T_8$.

### 4.2.1.3 Effect of Biostimulant Priming on Seed Germination and Seedling Growth Parameters in *O. basilicum*

The various biostimulant treatments *viz*., chitosan @ 5 $gL^{-1}$, chitosan @ 10 $gL^{-1}$, salicylic acid @ 1500 µM, salicylic acid @ 3000 µM, phloroglucinol @ 1 µM and phloroglucinol @ 10 µM were tried to study the effect on seed germination parameters in *O. basilicum.* The results are presented in Table 32.

#### *4.2.1.3.1 Germination per cent*

$T_3$ treatment (salicylic acid @ 1500µM) recorded the highest germination per cent of 79.33 per cent. This was on par with $T_4$ and $T_5$. The lowest value of 52 per cent was recorded in $T_2$ (chitosan @10 $gL^{-1}$) which was on par with $T_1$, $T_6$ and control.

#### *4.2.1.3.2 Survival per cent*

$T_3$ (salicylic acid @ 1500 µM) recorded the highest survival per cent of 79.33 per cent. This was on par with $T_4$ and $T_5$. The lowest value of 52 per cent

was recorded in $T_2$ which was on par with $T_1$, $T_6$ and $T_7$. Survival per cent showed similar trend as in the case of germination per cent.

#### *4.2.1.3.3 Germination Index*

The treatment, $T_5$ (phloroglucinol @ 1μM) was observed to record the highest germination index (39.63). The lowest germination index (16.00) was observed in the control which was on par with $T_1$ and $T_2$.

#### *4.2.1.3.4 Mean Germination Time*

The lowest mean germination time (3.23 days) was recorded in $T_5$ (phloroglucinol @ 1 μM) and was on par with $T_6$. Mean germination time (5.20 days) was found to be significantly higher in the control.

#### *4.2.1.3.5 Shoot Length*

The treatment, $T_3$ (salicylic acid @ 1500 μM) recorded the highest (20.37 cm) shoot length, which was observed to be on par with $T_1$ and $T_6$. The lowest shoot length (15.27 cm) was observed in control (Fig. 11).

#### *4.2.1.3.6 Root Length*

The data indicated that various biostimulant pretreatments tried had no significant influence on root length (Fig. 11).

#### *4.2.1.3.7 Seedling Length*

$T_4$ (Salicylic acid @ 3000 μM) recorded the highest (35.66 cm) length, which was observed to be on par with $T_1$, $T_2$, $T_3$, and $T_6$. The lowest seedling length (28.30 cm) was observed in control (Plate 11 and Fig. 11).

#### *4.2.1.3.8 Allometric Index*

The data indicated that various biostimulant pretreatments tried had no significant influence on allometric index.

#### *4.2.1.3.9 Seedling Vigor Index*

` $T_3$ (Salicylic acid @ 1500µM) treatment recorded the highest seedling vigor index (27.92) which was on par with $T_4$. The control treatment recorded the lowest value (16.56). This was on par with $T_2$.

### 4.2.1.3 Effect of Biopriming of Seeds for Enhancing Germination in *O. basilicum*

The result of effect of biopriming of seeds using microbial cultures *viz., Bacillus pumilus* VLY17, *Bacillus amyloliquefaciens* VLY24, *Pseudomonas fluorescens* PN026 and *Bacillus velezensis* PCSE10 is depicted in Table 33.

#### *4.2.1.4.1 Germination per cent*

The highest (82) germination per cent was observed in the treatment, $T_4$ (*B. velezensis*). This was on par with $T_2$ and $T_3$. The lowest germination per cent of 58 per cent was observed in $T_1$ (*B. pumilus*) which was on par with control.

#### *4.2.1.4.2 Survival per cent*

The treatment $T_4$ (*B. velezensis*) recorded the highest survival per cent of 82 per cent. This was on par with $T_2$ and $T_3$. The lowest survival per cent of 58 per cent was observed in $T_1$ (*B. pumilus*), which was on par with the control.

#### *4.2.1.4.3 Germination Index*

$T_4$ (*B. velezensis*) treatment was recorded the highest germination index (42.60) and this was on par with $T_2$. The control recorded the least germination index (16), which was on par with $T_1$.

#### *4.2.1.4.4 Mean Germination Time*

The lowest mean germination time (3.5 days) was recorded in $T_4$ (*B. velezensis*) which was on par with $T_2$ and $T_3$. The control treatment recorded the highest mean germination time of 5.20 days.

#### *4.2.1.4.5 Shoot Length*

The highest shoot length of 20.70 cm was observed in $T_3$ (*P. fluorescens*) which was on par with $T_2$ and $T_4$. The lowest shoot length (15.27 cm) was recorded in the control (Fig. 12).

***4.2.1.4.6 Root Length***

The treatment, $T_2$ **(***B. amyloliquefaciens*) recorded the highest root length of 18.83 cm (Fig. 12). This was on par with $T_3$ and $T_4$. The control treatment recorded the lowest root length (13.03 cm), which was on par with $T_1$.

***4.2.1.4.7 Seedling Length***

The highest seedling length of 38.96 cm was observed in $T_3$ (*P. fluorescens*) which was on par with $T_2$ and $T_4$. The lowest shoot length (28.30 cm) was recorded in the control (Plate 12 and Fig. 12).

***4.2.1.4.9 Allometric Index***

The treatment, $T_2$ **(***B. amyloliquefaciens*) recorded the highest allometric index (0.95). This was on par with the treatments $T_3$ and $T_4$. The lowest allometric index (0.79) was recorded in $T_1$ (*B. pumilus*).

***4.2.1.4.8 Seedling Vigor Index***

The highest seedling vigor index (31.15) was observed in $T_2$ **(***B. amyloliquefaciens*) which was on par with $T_3$ and $T_4$. The control treatment recorded the lowest seedling vigor index 16.56, and was on par with $T_1$.

**4.2.1.4 Effect of Various Pretreatments on Seed Germination and Seedling Growth Parameters in *O. basilicum***

The result of the effect of various pretreatments on seed germination and seedling parameters in *O. basilicum* is indicated in Table 34.

***4.2.1.5.1 Germination per cent***

A significant variation was observed in germination per cent, among the pretreatments. $T_{22}$ (*B. velezensis*) observed maximum germination rate of 82 per cent, which was on par with $T_{10}$ $T_{15}$, $T_{16}$, $T_{17}$, $T_{20}$ and $T_{21}$. The lowest (32 per cent) germination was recorded $T_4$ (Conc.$H_2SO_4$) and $T_7$ (IAA @ 0.1 µM). These were found to be on par with $T_5$, $T_6$, $T_8$, $T_9$, $T_{11}$ and $T_{12}$.

***4.2.1.5.2 Survival per cent***

Similar result as in germination per cent was observed with survival per cent also, as all the germinated seeds survived till the end of the experiment.$T_{22}$ (*B. velezensis*) observed maximum survival rate of 82 per cent, which was on par with $T_{10}$ $T_{15}$, $T_{16}$, $T_{17}$, $T_{20}$ and $T_{21}$. The lowest (32%) survival per cent was recorded $T_4$ (Conc.$H_2SO_4$) and $T_7$ (IAA @ 0.1 µM) This was on par with $T_5$, $T_6$,$T_8$,$T_9$, $T_{11}$ and $T_{12}$.

***4.2.1.5.3 Germination index***

Significant variation was observed with respect to germination index among the various pretreatments tried. $T_{22}$ (*B. velezensis*) recorded the highest germination index of 42.60, which was on par with $T_{17}$ and $T_{20}$. The lowest (4.67) index was observed in $T_4$ (Conc.$H_2SO_4$). This was on par with $T_1$, $T_5$, $T_6$, $T_7$, $T_8$, $T_9$ and $T_{12}$.

***4.2.1.5.4 Mean Germination Time***

$T_{17}$ (phloroglucinol @ 1µM) recorded the least (3.23 days) mean germination time, which was on par with $T_{18}$, $T_{20}$, and $T_{22}$.The highest (6.5 days) mean germination time was observed in $T_1$ (scarification). This was on par with $T_4$.

***4.2.1.5.5 Shoot Length***

The data in table 34 reveals the significant influence of pretreatments on shoot length at one month after sowing. $T_6$ ($GA_3$ @ 3000 µM) recorded the

highest shoot length of 22.10 cm, which was on par with $T_{21}$. The lowest shoot length (15.27 cm) was observed in control.

#### *4.2.1.5.6. Root Length*

The pretreatments significantly influenced root length of one month old seedlings. $T_{20}$ (*Bacillus amyloliquefaciens*VLY24) was observed to have the highest root length of 18.83 cm, which was on par with $T_6$, $T_{16}$, $T_{21}$ and $T_{22}$. The lowest root length (12.57 cm) was recorded in $T_{12}$ (TDZ @ 400 µM), which was on par with $T_1$, $T_2$, $T_5$, $T_7$, $T_9$, $T_{10}$, $T_{11}$, $T_{12}$, $T_{13}$, $T_{16}$, $T_{17}$, $T_{19}$ and control.

#### *4.2.1.5.7 Seedling Length*

The seedling length at one month after sowing, showed significant variation among the pretreatments. $T_6$ ($GA_3$ @ 3000 µM) recorded the highest seedling length of 39.03 cm, which was on par with $T_{20}$, $T_{21}$ and $T_{22}$. The lowest seedling length (28.30 cm) was observed in the control. This was found to be on par with $T_1$, $T_5$, $T_{11}$ and $T_{12}$.

#### *4.2.1.5.8 Allometric Index*

Pretreatments significantly influenced allometric index in *O. basilicum.*$T_{20}$ (*B. amyloliquefaciens*) recorded maximum allometric index of 0.95, which was on par with $T_3$, $T_4$, $T_8$, $T_{14}$, $T_{16}$, $T_{17}$, $T_{21}$, $T_{22}$ and control. The lowest index (0.71) was observed $T_9$ (BA @ 100 µM). This was on par with $T_1$, $T_2$, $T_5$, $T_6$, $T_7$, $T_9$, $T_{10}$, $T_{11}$, $T_{12}$, $T_{13}$, $T_{15}$, $T_{16}$, $T_{18}$ and $T_{19}$.

#### *4.2.1.5.9 Seedling Vigor Index*

The data revealed that various pretreatments of seeds had significantly influenced the seedling vigour index. $T_{20}$ (*B. amyloliquefaciens*) recorded the highest vigour index of 31.15. This was found be on par with $T_{15}$, $T_{16}$, $T_{21}$ and $T_{22}$. The lowest seedling vigour index (10.28) observed in $T_5$ ($GA_3$ @ 1500 µM) which was on par with $T_4$, $T_7$, $T_8$, $T_9$, $T_{11}$and $T_{12}$.

## 4.2.2 EVALUATION OF TRANSPLANTED SEEDLINGS FOR ENHANCED PLANT GROWTH IN *O. BASILICUM*

### 4.2.2.1 Morphological Parameters

The results of the effect of various seed pretreatments (physical, hormonal, biostimulants and biopriming) on morphological parameters *viz.*, plant height, number of branches, stem girth and number of nodes is presented in this section. The observations were recorded at 30 DAS (at transplanting), 60 DAS and 90 DAS (at harvest).

#### 4.2.2.1.1. Effect of Physical Seed Treatments on Morphological Parameters in Transplanted *O. basilicum*

##### *4.2.2.1.1.1. Plant Height*

The effect of physical seed treatment on plant height (cm) of *O. basilicum* were recorded at 30 DAS, 60 DAS and at harvest and are presented in Table 35.

At 30 DAS**,** maximum plant height (19.23 cm) was recorded in $T_2$ (Water soaking) and it was on par with $T_1$, $T_3$ and $T_4$. The lowest plant height (15.27 cm) was recorded under control ($T_5$).

At 60 DAS, the highest plant height was recorded in control ($T_5$) and it was statistically on par with $T_4$ and $T_1$. A significantly lower plant height (24.20 cm) was observed in $T_2$ and it was on par with $T_3$.

At 90 DAS, physical seed treatments had no significance influence on plant height.

##### *4.2.2.1.1.2 Number of Branches*

The effect of physical seed treatments on the number of branches at 60 DAS and harvest stages are given in Table 35. At 30 DAS, no branching from the main shoot was observed. No significant variation was observed on number of

branches due to the physical seed treatments imposed on the plants, during any stages of the crop period.

#### *4.2.2.1.1.3 Stem Girth*

Table 36 shows the effect of physical pretreatments on basal stem girth at 30, 60 and 90 DAS. At 30 DAS and 60 DAS, physical seed treatments did not have any significant influence on stem girth. At 90 DAS, $T_3$ registered a significantly higher basal stem girth (4.00 cm). The lowest stem girth (2.6 cm) was recorded in the plants derived from the treatment $T_5$. This was on par with $T_1$ and $T_2$.

#### *4.2.2.1.1.4 Number of Nodes*

The result of number of nodes at 3 different stages, 30, 60 and 90 DAS are furnished in Table 36. There was no significant difference in the number of nodes due to the different physical seed pretreatments applied in the study.

### 4.2.2.1.2 Effect of Hormonal Seed Priming on Morphological Parameters in Transplanted *O. basilicum*

#### *4.2.2.1.2.1 Plant Height*

The result of plant height at 3 different stages, 30 DAS, 60 DAS and 90 DAS (at harvest) are given in Table 37. At 30 DAS, a significantly higher plant height (22.10 cm) was recorded at $T_2$ ($GA_3$ @ 3000 µM). The shortest plant height (15.27 cm) was recorded in $T_9$ (control).

At 60 DAS, maximum plant height (31.93 cm) was observed in $T_5$ (BA @ 100 µM) and was on par with the treatments $T_3$ (IAA @ 0.1 µM) and $T_6$ (BA @ 300 µM). Plants treated with TDZ @ 200 µM ($T_7$) exhibited the lowest plant height (26.07 cm) which was on par with $T_1$ and $T_9$ (control).

At 90 DAS, no significant difference was observed in plant height among the hormonal seed priming treatments imposed.

#### *4.2.2.1.2.2 Number of Branches*

The mean data on the effect of different hormonal seed priming treatments on number of branches at 60 DAS and harvest stages are presented in Table 37. At 60 DAS, significantly higher number of branches (14.17) were noted in the plants developed from the treatment $T_4$ (IAA @ 1 µM) which was on par with all other treatments except $T_7$ (TDZ @ 200 µM) which recorded the lowest number of branches (10.17). At harvest, no marked variation was recorded on number of branches due to the different hormonal seed priming treatments applied in the study.

#### *4.2.2.1.2.3 Stem Girth*

Effect of different hormonal seed priming treatments on stem girth are furnished in Table 38. At 30 and 60 DAS, there was no significant influence on stem girth due to different hormonal seed priming treatments applied. At harvest, $T_8$ (TDZ @ 400 µM) exhibited a significantly higher stem girth (4.03 cm) and was on par with $T_2$, $T_5$ and $T_6$. The lowest stem girth (2.60 cm) was recorded in control treatment ($T_9$), which was found to be on par with $T_3$ (IAA@ 0.1 µM) and $T_7$ (TDZ @ 200 µM).

#### *4.2.2.1.2.4 Number of Nodes*

Table 38 depicts the effect of hormonal seed priming on number of nodes at 30 DAS, 60 DAS and at harvest in transplanted *O. basilicum.* At all stages, no significant variation was observed on number of nodes due to the different hormonal seed priming treatments.

### 4.2.2.1.3 Effect of Biostimulant Seed Priming on Morphological Parameters in Transplanted *O. basilicum*

#### *4.2.2.1.3.1 Plant Height*

The data on plant height at 30 DAS, 60 DAS and harvest stages are presented in Table 39. Among the various biostimulant seed priming treatments, significant variation was observed at 30 and 60 DAS in plant height. At 30 DAS, $T_4$ (Salicylic acid @ 3000µM) recorded the highest plant length of 20.37 cm and it was on par with treatments $T_1$ and $T_6$. The lowest shoot length (15.27 cm) was observed in $T_7$ (control).

At 60 DAS, the tallest plants (36.03 cm) were observed at $T_5$ (phloroglucinol @ 1µM). The shortest plant height (27.50 cm) was recorded at $T_7$ (Control) which was on par with $T_1$, $T_3$ and $T_4$.

Plant height at harvest stage was found to be statistically on par with all biostimulant seed priming treatments imposed in the study.

***4.2.2.1.3.2 Number of Branches***

The data on the number of branches at different stages (60 DAS and harvest) are provided in Table 39. The various biostimulant seed priming treatments tested in the experiment did not express any significant variation on number of branches at both 60 DAS and harvest stages.

***4.2.2.1.3.3 Stem Girth***

Table 40 shows the effect of biostimulant seed priming on basal stem girth. At 30 DAS, $T_4$ (Salicylic acid @ 3000µM) recorded significantly higher stem girth (1.23 cm) compared to other treatments. The lowest stem girth was noted in $T_2$ and $T_3$ (0.73 cm). All other treatments except $T_4$ were found to be on par with the lowest value.

At 60 DAS, the biostimulant seed priming treatments had significant influence on basal stem girth. $T_1$ (Chitosan @ $5gL^{-1}$) was observed to have a higher stem girth (1.67 cm), which was found on par with $T_4$, $T_5$ and control. The lowest stem girth (1.40) was noted $T_2$ and $T_3$. This was on par with $T_4$, $T_6$ and control

At 90 DAS (harvest), a significantly higher stem girth (4.73 cm) was recorded in $T_2$ (chitosan @ $10gL^{-1}$) which was on par with $T_1$. $T_4$ (salicylic acid @ 3000 µM) exhibited the lowest stem girth (2.43 cm) and it was on par with $T_3$, $T_6$ and $T_7$.

#### *4.2.2.1.3.4 Number of Nodes*

The data recorded on the effect of biostimulant seed priming on number of nodes at different stages (30 DAS, 60 DAS and at harvest) are presented in Table 40. At all stages, no significant difference was observed in number of nodes due to the different biostimulant seed priming treatments applied in the study.

### 4.2.2.1.4 Effect of Biopriming of Seeds on Morphological Parameters in Transplanted *O. basilicum*

#### *4.2.2.1.4.1 Plant Height*

The effects of biopriming of seeds on plant height at 30, 60 and 90 DAS (at harvest) are presented in table 56. At 30 DAS, a significantly higher plant height (20.70 cm) was recorded under $T_3$ (*P. fluorescens*) and it was on par with $T_2$ and $T_4$. $T_5$ (control) recorded the lowest plant height (15.27 cm) compared to all other treatments.

At 60 DAS, significantly taller plants (29.47 cm) were observed in $T_3$ (*P. fluorescens*) and it was statistically on par with $T_2$ and $T_4$. $T_1$ (*B. pumilus*) recorded the shortest plant height (26.40 cm) and it was on par with $T_5$ (control).

At harvest stage, there was no significant effect of biopriming of seeds on plant height.

#### *4.2.2.1.4.2 Number of Branches*

The result of the effect of seed biopriming treatments on number of branches at the two different stages i.e., 60 DAS and at harvest are presented in

table 41. At 60 DAS, there was no significant effect on the number of branches due to various biopriming treatments imposed on the seeds.

At harvest stage, $T_3$ (*P. fluorescens*) registered higher number of branches (20.40) and it was on par with $T_2$ and $T_4$ treatments. The lowest number of branches (12.00) was recorded in $T_1$ (*B. pumilus*) which was on par with $T_5$ (control).

#### *4.2.2.1.4.3 Stem Girth*

The data on the effect of seed biopriming on stem girth is furnished in table 42. Irrespective of the growth stages, biopriming treatments had no significant effect on stem girth.

#### *4.2.2.1.4.4 Number of Nodes*

Table 42 shows the effect of seed biopriming on number of nodes at different stages (30, 60 and 90 DAS (harvest) stages). At 30 DAS, $T_3$ (*P. fluorescens*) registered higher number of nodes (13.33) and it was on par with all other treatments applied in the study except $T_5$ (control), which produced the lowest number of nodes (7.33).

At 60 DAS, $T_1$ (*B. pumilus*) recorded higher number of nodes (60.87) which was on par with treatment $T_4$ (*B. velezensis*). The lowest number of nodes (48.87) was noted in$T_2$ and this was on par with $T_3$ and control.

At harvest stage, $T_3$ (*P. fluorescens*) registered higher number of nodes (205.30) and it was on par with treatments $T_2$ and $T_4$. $T_1$ (*B. pumilus*) recorded the lowest number of nodes (149.33).

### 4.2.2.1.5 Effect of Various Seeds Pretreatments on Morphological Parameters in Transplanted *O. basilicum*

#### *4.2.2.1.5.1 Plant Height*

The effects of seed pretreatments on plant height at 30, 60 and 90 DAS (harvest) are presented in Table 43. At 30 DAS, a significantly higher plant height (22.10 cm) was recorded under $T_6$ ($GA_3$ @ 3000 µM) and it was on par with $T_{21}$. $T_{23}$ (control) recorded the lowest plant height (15.27 cm) compared to all other treatments.

At 60 DAS, significantly taller plants (36.03 cm) were observed under $T_{17}$ (phloroglucinol @ 1µM). $T_2$ (Water soaking) recorded the shortest plant height (24.20 cm) and it was on par with $T_1$, $T_3$ and $T_{11.}$

At harvest stage, there was no significant effect of various pretreatments of seeds on plant height.

***4.2.2.1.5.2 Number of Branches***

The data on the effect of different seed pretreatments on number of branches at 60 DAS and harvest stages are presented in Table 43. At 60 DAS, significantly higher number of branches (15.63) was noted in $T_{17}$ (phloroglucinol @ 1µM) which was on par with $T_1$, $T_2$, $T_3$, $T_6$, $T_7$, $T_8$, $T_9$, $T_{13}$, $T_{14}$, $T_{17}$ and $T_{18}$. The treatment $T_7$ (TDZ @ 200 µM) recorded the lowest number of branches (10.17). This was on par with $T_{15}$, $T_{19}$, $T_{20}$, $T_{21}$, $T_{22}$ and control. At harvest, no marked variation was recorded in the number of branches due to the different seed priming treatments applied in the study.

***4.2.2.1.5.3 Stem Girth***

Table 44 shows the effect of various seed pretreatments on stem girth. At 30 DAS, $T_{16}$ (salicylic acid @ 3000 µM) recorded a significantly higher stem girth (1.23 cm), which was on par with $T_{21}$. The lowest basal stem girth was noted in $T_7$ (0.67 cm). This was found to be on par with $T_1$, $T_2$, $T_3$, $T_4$, $T_8$, $T_{11}$, $T_{13}$, $T_{14}$, $T_{15}$, $T_{17}$, $T_{18}$ and control.

At 60 DAS, the different seed pretreatments had significant influence on stem girth. $T_{13}$ (chitosan @ $5gL^{-1}$) was observed to have a higher stem girth (1.67

cm), which was found to be on par with $T_9$, $T_{10}$, $T_{12}$, $T_{16}$, $T_{17}$, $T_{20}$, $T_{22}$ and control. The lowest stem girth (1.20 cm) was noted in $T_5$ ($GA_3$ @ 1500 µM). This was on par with $T_1$, $T_2$, $T_4$, $T_{11}$, $T_{14}$, $T_{15}$, $T_{19}$ and $T_{21}$

At 90 DAS (harvest), a higher stem girth (4.73 cm) was recorded in $T_{14}$ (Chitosan @ 10g $L^{-1}$) which was on par with $T_{13}$. The treatment, $T_{16}$ (salicylic acid @ 3000µM) exhibited the lowest stem girth (2.43 cm) and it was on par with $T_7$, $T_{11}$, $T_{16}$, $T_{18}$, $T_{19}$, $T_{20}$, $T_{21}$ and control.

***4.2.2.15.4 Number of Nodes***

Table 44 depicts the effect of various seed pretreatments on number of nodes at different stages (30 DAS, 60 DAS and at harvest). At 30 DAS, $T_1$ (scarification) registered higher number of nodes (14.00) and it was on par with $T_2$, $T_3$, $T_{13}$, $T_{14}$, $T_{16}$, $T_{20}$, $T_{21}$ and $T_{22}$. $T_7$ (IAA @ 0.1 µM) produced the lowest number of nodes (6.67), which was found statistically on par with $T_5$, $T_6$, $T_8$, $T_9$, $T_{10}$, $T_{11}$, $T_{12}$, $T_{15}$, $T_{17}$, $T_{18}$, $T_{19}$ and control.

At 60 DAS, $T_{19}$ (*Bacillus pumilus*VLY17) recorded a higher number of nodes (60.87) which was on par with $T_6$, $T_7$, $T_8$, $T_{12}$, $T_{17}$, and $T_{22}$. The lowest number of nodes (44.63) was noted in $T_{11}$ (TDZ @ 200 µM) and this was on par with $T_1$, $T_2$, $T_3$, $T_4$, $T_5$, $T_9$, $T_{10}$, $T_{11}$, $T_{13}$, $T_{14}$, $T_{16}$, $T_{18}$ and $T_{20}$.

At harvest stage (90 DAS), $T_{21}$ (*Pseudomonas fluorescens*PN026) registered the highest number of nodes (205.30) and it was on par with treatments $T_{16}$, $T_{20}$ and $T_{22}$. $T_{19}$ (*Bacillus pumilus*VLY17) recorded the lowest number of nodes (149.33), which was on par with $T_2$, $T_4$, $T_5$, $T_6$, $T_7$, $T_8$, $T_9$, $T_{10}$, $T_{11}$, $T_{12}$, $T_{13}$, $T_{14}$, $T_{15}$, $T_{17}$ and $T_{18}$.

**4.2.2.2 Phenological Parameters**

The result of the effect of various seed pretreatments on phenological parameters *viz.*, days to flower initiation, days to fruit set and days to maturity, of transplanted *O. basilicum* is presented in this section.

#### 4.2.2.2.1 Effect of Physical Seed Pretreatments on Phenological Parameters in Transplanted *O. basilicum*

The data on the effect of physical treatments on days to flower initiation, fruit set and fruit maturity are presented in Table 45. The parameter, days to flower initiation alone showed significant variation among the physical pretreatments tried. Among the treatments, $T_1$ (scarification) recorded the least number of days (58.00 days) for flower initiation which was found to be on par with $T_2$ and $T_3$. However, $T_4$ (Con.$H_2SO_4$) took maximum number of days (73.00 days) to flower initiation, which was observed to be par with $T_2$ and control. The parameters days to fruit set and fruit maturity, did not show any significant variation among the physical seed pretreatments.

#### 4.2.2.2.2 Effect of Hormonal Seed Priming on Phenological Parameters in Transplanted *O. basilicum*

Table 46 represents the data on the effect of hormonal seed pretreatments on days to flower initiation, fruit set and fruit maturity in transplanted *O. basilicum.* The data reveals that no significant variation was observed in these parameters among the various hormonal seed priming treatments.

#### 4.2.2.2.3 Effect of Biostimulant Seed Priming on Phenological Parameters in Transplanted *O. basilicum*

The data on the effect of biostimulant seed priming on days to flower initiation, fruit set and fruit maturity in transplanted *O. basilicum* are presented in table 47. Among the treatments, $T_2$ (chitosan @ 10 $gL^{-1}$) recorded the least number of days (52.00 days) for flower initiation, which was on par with $T_4$. However, $T_6$ (phloroglucinol @ 10 µM) resulted in maximum number of days (68.67 days) to flower initiation, which was found to be on par with $T_1$, $T_3$, $T_5$ and

control. The number of days to fruit set and fruit maturity did not exhibit significant variation among the biostimulants treatments tried.

#### 4.2.2.2.4 Effect of Biopriming of Seeds on Phenological Parameters in Transplanted *O. basilicum*

Table 48 depicts the data on the effect of biopriming of seeds on days to flower initiation, fruit set and maturity. The data reveals that bio priming treatments have shown significant variation only in days to flower initiation, while no significant variation was observed in days to fruit set and fruit maturity. Among the treatments, $T_4$ (*B. velezensis*) recorded the least number of days (48.00 days) to flower initiation. This was on par with $T_2$ (*B. amyloliquefaciens*) and $T_3$ (*P. fluorescens*). However, the maximum number of days (67.67 days) to flower initiation was observed in the control followed by $T_1$ (*B. pumilus*).

#### 4.2.2.2.5 Effect of Seed Pretreatments on Days to Flower Initiation, Fruit Set and Fruit Maturity in Transplanted *O. basilicum*

On perusal of data on the effect of seed pretreatments on phenological parameters in table 49, it was observed that days to flower initiation showed significant variation among the pretreatments, while no significant influence was shown in days to fruit set and days to fruit maturity. The data on the effect of seed pretreatments on days to flower initiation are presented in table 64. Among the various pretreatments tried, $T_{22}$ (*B. velezensis*) recorded the least number of days (48.00 days) for flower initiation. This was on par with $T_8$, $T_{12}$, $T_{14}$, $T_{16}$, $T_{20}$ and $T_{21}$ However, $T_4$ (Conc.$H_2SO_4$) resulted in maximum number of days (73.00 days) to flower initiation. This was observed to be on par with $T_2$, $T_6$, $T_7$, $T_{11}$, $T_{13}$, $T_{15}$, $T_{18}$ and control.

### 4.2.2.3 Yield parameters

The effect of various seed pretreatments (physical, hormonal, biostimulant and biopriming) on yield parameters *viz*., total leaf biomass (fresh and dry), total

stem biomass (fresh and dry), total shoot biomass (fresh and dry) and harvest index are presented in this section. The observations were recorded at harvest stage (90 DAS).

#### 4.2.2.3.1 Effect of Physical Seed Pretreatments on Yield Parameters in Transplanted *O. basilicum*

The data on the effect of physical seed pretreatments on yield parameters in transplanted *O. basilicum* are presented in Table 50 and Plate 13.

##### *4.2.2.3.1.1 Total Leaf Biomass*

The data presented in table 50 indicates that both the leaf fresh weight and dry weight did not exhibit any significant difference among the physical treatments tried.

##### *4.2.2.3.1.2. Total Stem Biomass*

The treatments tried did not show any significant variation with respect to total stem biomass.

##### *4.2.2.3.1.3 Total Shoot Biomass*

The data depicted in Table 50 and Fig. 13 shows that the physical seed pretreatments had no effect on the total shoot biomass in transplanted *O. basilicum.*

##### *4.2.2.3.1.4 Harvest Index*

It is evident from the data depicted in Table 50 that the physical seed pretreatments had no significant effect on harvest index.

#### 4.2.2.3.2 Effect of Hormonal Seed Priming on Yield Parameters in Transplanted *O. basilicum*

The result on the effect of hormonal seed priming on yield parameters in transplanted *O. basilicum* are presented in Table 51 and Plate 14.

#### *4.2.2.3.2.1 Total Leaf Biomass*

Significant variation was observed with respect to both fresh and dry leaf biomass among the hormonal seed priming treatments. The highest leaf biomass (87.23 g, 9.24 g) was obtained in $T_3$ (IAA @ 0.1 µM) in terms of fresh and dry weight, respectively. These were found to be on par with $T_1$, $T_2$ and $T_4$. The lowest values were recorded in $T_8$ (TDZ @ 400 µM) with a fresh weight of 40.90 g and dry weight of 4.33 g. These were observed to be on par with $T_6$ and control.

#### *4.2.2.3.2.2 Total Stem Biomass*

Total stem biomass showed significant effect among the hormonal seed priming treatments. $T_2$ ($GA_3$ @ 3000 µM) recorded the highest stem biomass in terms of fresh weight (67.40 g) and dry weight (9.06 g) The lowest stem fresh weight (24.7 g) and dry weight (3.32 g) was recorded by the control treatment.

#### *4.2.2.3.2.3 Total Shoot Biomass*

$T_2$ ($GA_3$ @ 3000 µM) recorded the highest total shoot (fresh) biomass (146.00 g) and shoot (dry) biomass (17.39 g). The lowest values of total shoot biomass in terms of fresh weight (78.86 g) and dry weight (9.06 g) were recorded in the control treatment. The lowest fresh and dry shoot biomass were found to be on par with $T_5$, $T_6$, $T_7$ and $T_8$ (Fig. 14).

#### *4.2.2.3.2.4 Harvest Index*

Seed priming with IAA @ 0.1 µM ($T_3$) and control recorded the highest value (0.92) for harvest index and was on par with $T_2$, $T_4$, $T_6$ and $T_7$. The lowest harvest index (0.86) was recorded by $T_5$ (BA @ 100 µM), which was found to be on par with $T_8$.

#### 4.2.2.3.3 Effect of Biostimulant Seed Priming on Yield Parameters in Transplanted *O. basilicum*

The results on the effect of biostimulant seed priming on yield parameters in transplanted *O. basilicum* are presented in Table 52 and Plate 15.

##### *4.2.2.3.3.1 Total Leaf Biomass*

A perusal of the data in Table 52 indicates that the biostimulant seed priming treatments have significant influence on total leaf fresh weight. $T_3$ (Salicylic acid @ 1500µM) recorded the highest (79.4 g) fresh and dry (8.41 g) leaf biomass which was on par with $T_2$ and $T_4$. The lowest fresh leaf biomass (54.17 g) and dry leaf biomass (5.74 g) was recorded by the control treatment. This was on par with $T_1$, $T_5$, and $T_6$.

##### *4.2.2.3.3.2 Total Stem Biomass*

The total stem biomass exhibited significant variation among the biostimulants treatments tried. The treatment $T_4$ (salicylic acid @ 3000 µM) recorded the highest total stem fresh weight (59.76 g) and dry weight (8.06 g) which was on par with $T_1$. The lowest fresh stem biomass (24.7 g) and dry stem biomass of (3.32 g) was recorded by the control and found statistically on par with $T_2$.

##### *4.2.2.3.3.3 Total Shoot Biomass*

$T_4$ (salicylic acid @ 3000µM) recorded significantly higher fresh and dry shoot biomass (134.17 and 15.95 g respectively) which were on par with $T_3$. The lowest values for fresh and dry shoot biomass (78.86 g and 9.06 g, respectively) were recorded in the control treatment (Fig. 15).

##### *4.2.2.3.3.4 Harvest Index*

The highest harvest index (0.96) was recorded by the treatment $T_4$ (salicylic acid @ 3000 µM). This was on par with control. $T_2$ and $T_6$ recorded the lowest (0.89) harvest index, which was on par with all other treatments except $T_4$.

#### 4.2.2.3.4 Effect of Seed Biopriming on Yield Parameters in Transplanted *O. basilicum*

The results on the effect of seed biopriming on yield parameters in transplanted *O. basilicum* are indicated in Table 53 and Plate 16.

##### *4.2.2.3.4.1 Total Leaf Biomass*

Significant variation was observed in total leaf biomass, among the biopriming treatments done. The highest fresh (99.60 g) and dry (10.55 g) leaf biomass was observed in $T_4$ (*B. velezensis*). The lowest values were recorded in control in terms of fresh weight (54.17 g) and dry weight (5.74 g). These values were on par with $T_1$.

##### *4.2.2.3.4.2 Total Stem Biomass*

The treatments showed significant variation in the case of total stem biomass. A significantly higher stem biomass in terms of fresh (72.26 g) and dry (9.73 g) weight was recorded in the treatment $T_3$ (*P. fluorescens).* The control treatment recorded the lowest fresh (24.7 g) and dry (3.32 g) stem biomass.

##### *4.2.2.3.4.3 Total Shoot Biomass*

The treatments showed significant variation in fresh as well as dry shoot biomass in *O. basilicum* (Fig. 16). The highest fresh (153.03 g) and dry (17.73 g) shoot biomass were recorded in treatments, $T_4$ (*B.velezensis*) and $T_3$ (*P. fluorescens),* respectively. The fresh shoot biomass was observed to be on par with $T_2$ and $T_3$ and dry shoot biomass was on par with $T_2$ and $T_4$. The lowest values of both fresh (78.86 g) and dry (9.06 g) shoot biomass were observed in the control treatment. The lowest dry shoot biomass value was observed to be on par with that of $T_1$.

##### *4.2.2.3.4.4 Harvest Index*

The treatments, $T_4$ and control recorded the highest harvest index of 0.92, which was on par with all other treatments except $T_2$, which recorded the lowest harvest index (0.87).

**4.2.2.3.5 Effect of Various Seed Pretreatments on Yield Parameters in Transplanted *O. basilicum***

The result on the effect of seed pretreatments on yield parameters in transplanted *O. basilicum* are presented in Table 54.

***4.2.2.3.5.1 Total Leaf Biomass***

The treatments exhibited significant variation with respect to both fresh and dry leaf biomass. The highest values (99.60 g and 10.55 g, respectively) of fresh and dry leaf biomass were observed in $T_{22}$ (*Bacillus velezensis*PCSE10). The highest fresh leaf biomass was found to be on par with that of $T_6$. The lowest leaf biomass, in terms of fresh (40.90 g) and dry (4.33 g) weight was observed in $T_{12}$. The lowest fresh leaf biomass was observed to be on par with that of $T_3$.

***4.2.2.3.5.2 Total Stem Biomass***

Among the pretreatments, $T_{21}$ (*Pseudomonas fluorescens*PN026) recorded the highest fresh (72.26 g) and dry (9.73 g) stem biomass, which were on par with $T_7$ and $T_{16}$. The lowest value for stem biomass in terms of fresh weight (24.7 g) and dry weight (3.32 g) was recorded in the control. These values were found to be on par with $T_1$, $T_2$, $T_5$, $T_6$, $T_9$, $T_{11}$, and $T_{14}$.

***4.2.2.3.5.3 Total Shoot Biomass***

The treatment $T_{22}$ (*Bacillus velezensis*PCSE10) recorded significantly higher fresh shoot biomass of 153.03 g which was on par with $T_6$, $T_{16}$, $T_{20}$ and $T_{21}$ and higher dry shoot biomass of 17.73 g observed in $T_{21}$ (*Pseudomonas fluorescens*PN026) this was on par with $T_7$, $T_{20}$ and $T_{22}$. The lowest values for fresh and dry shoot biomass (78.96 g and 9.06 g, respectively) was recorded in the control treatment. There were found to be on par with $T_1$, $T_2$, $T_3$, $T_4$, $T_9$, $T_{10}$, $T_{11}$, $T_{12}$ and $T_{14}$.

***4.2.2.3.5.4 Harvest Index***

As depicted in Table 54, it is clear that, the treatments $T_{16}$ (salicylic acid @ 3000 μM) recorded the highest value (0.96) for harvest index. This was found to be on par with $T_2$, $T_6$, $T_{13}$, $T_{22}$ and control. The lowest value (0.86) was observed in $T_9$ (BA @ 100 μM), with on par values recorded in $T_1$, $T_4$, $T_7$, $T_8$, $T_{13}$, $T_{15}$, $T_{17}$, $T_{19}$ and $T_{21}$.

The study of the effect of various seed pretreatments of enhanced germination and plant growth in *O. basilicum* demonstrated that biopriming using *Bacillus velezensis* PCSE10, *Bacillus amyloliquefaciens* VLY24 and *Pseudomonas fluorescens* PN026 recorded higher germination per cent, seedling length, seedling vigour index and shoot biomass.

**4.2.3 Incidence of Pest and Diseases**

Immediately after transplanting, leaf roller was observed at random irrespective of the treatments, which could be controlled by hand picking. At 75-80 DAS, a few lace wing bugs (*Cochlochila bullita*) were observed at random, which could also be controlled by picking and killing (Plate 17).

**Table 5. Effect of physical treatments on seed germination and growth parameters of seedling of *Ocimum tenuiflorum***

| T. No. | Physical treatment | Gn (%) | S (%) | GI | MGT (Days) | SL (cm) | RL (cm) | Sdl L (cm) | AI | SVI |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | SC | 57.33±2.63 | 57.33±2.63 | 14.14±0.79 | 5.36±0.6 | 15.15±0.56 | 9.48±0.78 | 24.64±0.96 | 0.62±0.1 | 14.23±1.49 |
| $T_2$ | WS | 70.66±1.32 | 70.66±1.32 | 20.82±0.73 | 4.48±0.4 | 15.78±1.20 | 8.79±0.57 | 24.58±1.30 | 0.56±0.14 | 17.39±1.20 |
| $T_3$ | HW | 70.66±2.38 | 70.66±2.38 | 16.65±1.68 | 4.86±0.50 | 17.17±0.87 | 10.66±1.22 | 27.83±1.49 | 0.61±0.22 | 19.67±1.48 |
| $T_4$ | CSA | 85.33±1.92 | 85.33±1.92 | 21.94±1.64 | 5.14±0.50 | 11.12±0.76 | 7.40±0.56 | 18.52±0.58 | 0.67±0.24 | 15.80±0.88 |
| $T_5$ | Control | 62.66±1.54 | 62.66±1.54 | 18.88±1.07 | 4.68±0.26 | 10.53±0.42 | 6.73±0.59 | 17.26±0.72 | 0.63±0.14 | 10.84±0.84 |
| SEm(±) | | 4.551 | 4.551 | 1.873 | 0.247 | 0.804 | 0.772 | 1.356 | 0.047 | 1.619 |
| C.D. (0.05) | | 14.526 | 14.526 | NS | NS | 2.565 | 2.463 | 4.327 | NS | 5.169 |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; Gn- germination; S- Survival; GI- Germination Index; MGT- Mean Germination Time; SL- shoot length; RL- Root length; Sdl L- Seedling Length; SVI- Seedling Vigour Index; AI- Allometric Index; Each figure represents mean (±SD) of three replications

**Table 6. Effect of hormonal priming on seed germination and growth parameters of seedling of *Ocimum tenuiflorum***

| T. No. | Hormones | Gn (%) | S (%) | GI | MGT (Days) | SL (cm) | RL (cm) | Sdl L (cm) | AI | SVI |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | $GA_3$ @ 1500 µM | 96.00±1.07 | 96.00±1.07 | 25.41±0.62 | 5.07±0.22 | 19.03±0.74 | 10.60±1.08 | 29.63±1.24 | 0.55±0.24 | 28.42±1.12 |
| $T_2$ | $GA_3$ @ 3000 µM | 88.00±1.07 | 88.00±1.07 | 26.03±0.66 | 4.55±0.74 | 12.1±0.71 | 5.56±0.3 | 17.66±0.71 | 0.46±0.24 | 15.55±0.8 |
| $T_3$ | IAA @ 0.1 µM | 30.66±2.33 | 30.66±2.33 | 10.37±1.70 | 5.87±0.74 | 10.53±0.4 | 6.03±0.34 | 16.56±0.22 | 0.57±0.22 | 5.07±0.94 |
| $T_4$ | IAA @ 1 µM | 14.66±1.92 | 14.66±1.92 | 7.68±0.94 | 6.78±0.45 | 11.23±0.7 | 6.76±0.47 | 18.00±0.78 | 0.60±0.14 | 2.66±0.84 |
| $T_5$ | BA @ 100 µM | 46.66±3.04 | 46.66±3.04 | 6.69±1.04 | 6.84±0.53 | 13.91±1.06 | 7.14±1.13 | 21.05±1.51 | 0.50±0.14 | 10.25±1.73 |
| $T_6$ | BA @ 300 µM | 20.66±2.01 | 20.66±2.01 | 4.20 ±0.50 | 7.24 ±0.67 | 10.94±0.22 | 7.33±0.34 | 18.27±0.85 | 0.66±0.24 | 3.74±0.82 |
| $T_7$ | TDZ @ 200 µM | 13.33±1.87 | 13.33±1.87 | 3.31 ±1.10 | 7.55±0.45 | 10.93±0.67 | 6.86±0.38 | 17.79±0.76 | 0.62±0.26 | 2.34±0.74 |
| $T_8$ | TDZ @ 400 µM | 34.66±1.15 | 34.66±1.15 | 3.59±0.77 | 7.26±0.53 | 14.30±0.41 | 7.2±0.45 | 21.50±0.61 | 0.50±0.24 | 7.45±0.59 |
| $T_9$ | Control | 62.66±1.54 | 62.66±1.54 | 18.88±1.07 | 4.68±0.26 | 10.53±0.42 | 6.73±0.59 | 17.26±0.72 | 0.63±0.14 | 10.84±0.84 |
| SEm(±) | | 4.326 | 4.326 | 1.253 | 0.350 | 0.507 | 0.650 | 1.041 | 0.038 | 1.241 |
| C.D. (0.05) | | 12.953 | 12.953 | 3.753 | 1.049 | 1.518 | 1.945 | 3.117 | 0.113 | 3.717 |

T. No. – Treatment Number; GA- Giberellic acid; IAA- Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; Gn- germination; S- Survival; GI- Germination Index; MGT- Mean Germination Time; SL- shoot length; RL- Root length; Sdl L- Seedling Length; SVI- Seedling Vigour Index; AI- Allometric Index; Each figure represents mean (±SD) of three replications

**Table 7. Effect of biostimulant priming on seed germination and growth parameters of seedling of *Ocimum tenuiflorum***

| T. No. | Biostimulant | Gn (%) | S (%) | GI | MGT (Days) | SL (cm) | RL (cm) | Sdl L (cm) | AI | SVI |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | CH@5g$L^{-1}$ | 12.66±1.54 | 12.66±1.54 | 3.08±0.72 | 6.73±0.70 | 15.00±0.94 | 13.00±0.73 | 28.00±1.01 | 0.86±0.1 | 3.49±0.59 |
| $T_2$ | CH@10 g$L^{-1}$ | 16.66±1.32 | 16.66±1.32 | 5.37±0.28 | 5.88±0.60 | 12.15±0.24 | 7.56±0.46 | 19.72±0.5 | 0.62±0.00 | 3.28±0.74 |
| $T_3$ | SA@1500µM | 36.00±2.53 | 36.00±2.53 | 6.88±0.80 | 6.32±0.83 | 19.46±1.04 | 11.83±1.28 | 31.29±1.65 | 0.60±0.14 | 11.46±0.59 |
| $T_4$ | SA@3000µM | 12.00±1.74 | 12.00±1.74 | 2.59±0.74 | 6.59±0.48 | 10.02±0.44 | 7.1±0.33 | 17.12±0.53 | 0.70±0.22 | 2.07±1.69 |
| $T_5$ | PG@1µM | 11.33±0.81 | 11.33±0.81 | 2.07±0.54 | 6.73±0.84 | 11.53±0.37 | 7.6±0.47 | 19.13±0.52 | 0.65±0.1 | 2.17±074 |
| $T_6$ | PG@10µM | 7.33±1.63 | 7.33±1.63 | 1.27±0.74 | 6.75±0.34 | 12.56±0.68 | 7.86±0.47 | 20.43±0.82 | 0.62±0.14 | 1.49±0.38 |
| $T_7$ | Control | 62.66±1.54 | 62.66±1.54 | 18.88±1.07 | 4.68±0.26 | 10.53±0.42 | 6.73±0.59 | 17.26±0.72 | 0.63±0.14 | 10.84±0.84 |
| SEm(±) | | 3.227 | 3.227 | 0.630 | 0.460 | 0.574 | 0.685 | 1.127 | 0.025 | 1.186 |
| C.D. (0.05) | | 9.883 | 9.883 | 1.930 | NS | 1.558 | 2.096 | 3.588 | 0.075 | 3.632 |

T. No. – Treatment Number; CH- Chitosan; SA-Salicylic acid; , PG- Phloroglucinol; Gn- germination; S- Survival; GI- Germination Index; MGT- Mean Germination Time; SL- shoot length; RL- Root length; Sdl L- Seedling Length; SVI- Seedling Vigour Index; AI- Allometric Index; Each figure represents mean (±SD) of three replications

**Table 8. Effect of biopriming on seed germination and growth parameters of seedling of *Ocimum tenuiflorum***

| T. No. | Microbes | Gn (%) | S (%) | GI | MGT (Days) | SL (cm) | RL (cm) | Sdl L (cm) | AI | SVI |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | *BP* | 72.66±2.41 | 72.66±2.41 | 14.91±1.02 | 6.86 ± 0.67 | 12.24±0.47 | 9.33±1.08 | 21.57±1.14 | 0.76±0.1 | 15.83±1.46 |
| $T_2$ | *BA* | 28.00±2.00 | 28.00±2.00 | 5.52±0.72 | 7.78 ± 0.42 | 11.44±0.14 | 9.83±0.34 | 21.27±0.31 | 0.85±0.3 | 5.94±0.9 |
| $T_3$ | *PF* | 26.00±1.74 | 26.00±1.74 | 6.16±0.66 | 7.74 ± 0.36 | 13.78±0.64 | 8.26±0.44 | 22.05±0.76 | 0.59±0.1 | 5.70±0.74 |
| $T_4$ | *BV* | 46.66±2.52 | 46.66±2.52 | 8.88±0.93 | 7.80 ± 0.47 | 11.83±0.61 | 9.5±0.6 | 21.33±0.85 | 0.80±0.1 | 10.03±1.3 |
| $T_5$ | Control | 62.66±1.54 | 62.66±1.54 | 18.88±1.07 | 4.68 ± 0.26 | 10.53±0.42 | 6.73±0.59 | 17.26±0.72 | 0.63±0.14 | 10.84±0.84 |
| SEm(±) | | 4.590 | 4.590 | 0.863 | 0.251 | 0.282 | 0.580 | 0.765 | 0.042 | 1.346 |
| C.D. (0.05) | | 14.650 | 14.650 | 2.755 | 0.802 | 0.900 | 1.853 | 2.443 | 0.134 | 4.298 |

T. No. – Treatment Number; *BP- Bacillus pumilus; BA - Bacillus Amyloliquefaciens; PF- Pseudomonas fluorescens*; *BV-Bacillus velezensis;* SA-Salicylic acid; , PG- Phloroglucinol; Gn- germination; S- Survival; GI- Germination Index; MGT- Mean Germination Time; SL- shoot length; RL- Root length; Sdl L- Seedling Length; SVI- Seedling Vigour Index; AI- Allometric Index; Each figure represents mean (±SD) of three replications

**Table 9. Effect of various pretreatments on seed germination and growth parameters of seedling of *Ocimum tenuiflorum***

| T. No. | Pretreatment | Gn (%) | S (%) | GI | MGT (Days) | SL (cm) | RL (cm) | Sdl L (cm) | AI | SVI |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | SC | 57.33±2.63 | 57.33±2.63 | 14.14±0.79 | 5.36±0.6 | 15.15±0.56 | 9.48±0.78 | 24.64±0.96 | 0.62±0.1 | 14.23±1.49 |
| $T_2$ | WS | 70.66±1.32 | 70.66±1.32 | 20.82±0.73 | 4.48±0.4 | 15.78±1.20 | 8.79±0.57 | 24.58±1.30 | 0.56±0.14 | 17.39±1.20 |
| $T_3$ | HW | 70.66±2.38 | 70.66±2.38 | 16.65±1.68 | 4.86±0.50 | 17.17±0.87 | 10.66±1.22 | 27.8 ±1.49 | 0.61±0.22 | 19.67±1.48 |
| $T_4$ | CSA | 85.33±1.92 | 85.33±1.92 | 21.94±1.64 | 5.14±0.50 | 11.12±0.76 | 7.40±0.56 | 18.52±0.58 | 0.67±0.24 | 15.80±0.88 |
| $T_5$ | $GA_3$ @1500 µM | 96.00±1.07 | 96.00±1.07 | 25.41±0.62 | 5.07±0.22 | 19.03±0.74 | 10.60±1.08 | 29.63±1.24 | 0.55±0.24 | 28.42±1.12 |
| $T_6$ | $GA_3$ @3000µM | 88.00±1.07 | 88.00±1.07 | 26.03±0.66 | 4.55±0.74 | 12.1±0.71 | 5.56±0.3 | 17.66±0.71 | 0.46±0.24 | 15.55±0.8 |
| $T_7$ | IAA @ 0.1 µM | 30.66±2.33 | 30.66±2.33 | 10.37±1.70 | 5.87±0.74 | 10.53±0.4 | 6.03±0.34 | 16.56±0.22 | 0.57±0.22 | 5.07±0.94 |
| $T_8$ | IAA @ 1 µM | 14.66±1.92 | 14.66±1.92 | 7.68±0.94 | 6.78±0.45 | 11.23±0.7 | 6.76±0.47 | 18.00±0.78 | 0.60±0.14 | 2.66±0.84 |
| $T_9$ | BA @ 100 µM | 46.66±3.04 | 46.66±3.04 | 6.69±1.04 | 6.84±0.53 | 13.91±1.06 | 7.14±1.13 | 21.05±1.51 | 0.50±0.14 | 10.25±1.73 |
| $T_{10}$ | BA @ 300 µM | 20.66±2.01 | 20.66±2.01 | 4.20±0.50 | 7.24±0.67 | 10.94±0.22 | 7.33±0.34 | 18.27±0.85 | 0.66±0.24 | 3.74±0.82 |
| $T_{11}$ | TDZ @ 200 µM | 13.33±1.87 | 13.33±1.87 | 3.31±1.10 | 7.55±0.45 | 10.93±0.67 | 6.86±0.38 | 17.79±0.76 | 0.62±0.26 | 2.34±0.74 |
| $T_{12}$ | TDZ @ 400 µM | 34.66±1.15 | 34.66±1.15 | 3.59±0.77 | 7.26±0.53 | 14.30±0.41 | 7.20±0.45 | 21.50±0.61 | 0.50±0.24 | 7.45±0.59 |
| $T_{13}$ | CH @ $5gL^{-1}$ | 12.66±1.54 | 12.66±1.54 | 3.08±0.72 | 6.73±0.70 | 15.00±0.94 | 13.00±0.73 | 28.00±1.01 | 0.86±0.1 | 3.49±0.59 |
| $T_{14}$ | CH @ 10 $gL^{-1}$ | 16.66±1.32 | 16.66±1.32 | 5.37±0.28 | 5.88±0.60 | 12.15±0.24 | 7.56±0.46 | 19.72±0.5 | 0.62±0.00 | 3.28±0.74 |
| $T_{15}$ | SA @ 1500µM | 36.00±2.53 | 36.00±2.53 | 6.88±0.80 | 6.32±0.83 | 19.46±1.04 | 11.83±1.28 | 31.29±1.65 | 0.60±0.14 | 11.46±0.59 |
| $T_{16}$ | SA @ 3000µM | 12.00±1.74 | 12.00±1.74 | 2.59±0.74 | 6.59±0.48 | 10.02±0.44 | 7.10±0.33 | 17.12±0.53 | 0.70±0.22 | 2.07±1.69 |
| $T_{17}$ | PG @ 1µM | 11.33±0.81 | 11.33±0.81 | 2.07±0.54 | 6.73±0.84 | 11.53±0.37 | 7.60±0.47 | 19.13±0.52 | 0.65±0.1 | 2.17±074 |
| $T_{18}$ | PG @ 10µM | 7.33±1.63 | 7.33±1.63 | 1.27±0.74 | 6.75±0.34 | 12.56±0.68 | 7.86±0.47 | 20.43±0.82 | 0.62±0.14 | 1.49±0.38 |
| $T_{19}$ | *BP* | 72.66±2.41 | 72.66±2.41 | 14.91±1.02 | 6.86±0.67 | 12.24±0.47 | 9.33±1.08 | 21.57±1.14 | 0.76±0.1 | 15.83±1.46 |
| $T_{20}$ | *BA* | 28.00±2.00 | 28.00±2.00 | 5.52±0.72 | 7.78±0.42 | 11.44±0.14 | 9.83±0.34 | 21.27±0.31 | 0.85±0.3 | 5.94±0.9 |
| $T_{21}$ | *PF* | 26.00±1.74 | 26.00±1.74 | 6.16±0.66 | 7.74±0.36 | 13.78±0.64 | 8.26±0.44 | 22.05±0.76 | 0.59±0.1 | 5.70±0.74 |
| $T_{22}$ | *BV* | 46.66±2.52 | 46.66±2.52 | 8.88±0.93 | 7.80±0.47 | 11.83±0.61 | 9.50±0.6 | 21.33±0.85 | 0.80±0.1 | 10.03±1.3 |
| $T_{23}$ | Control | 62.66±1.54 | 62.66±1.54 | 18.88±1.07 | 4.68±0.26 | 10.53±0.42 | 6.73±0.59 | 17.26±0.72 | 0.63±0.14 | 10.84±0.84 |
| SEm(±) | | 4.338 | 4.338 | 1.219 | 0.373 | 0.577 | 0.577 | 0.703 | 1.155 | 0.039 |
| C.D. (0.05) | | 12.390 | 12.390 | 3.483 | 1.064 | 1.648 | 1.648 | 2.008 | 3.298 | 0.111 |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; GA- Giberellic acid; IAA- Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; CH-Chitosan; SA-Salicylic acid; , PG- Phloroglucinol; *BP- Bacillus pumilus; Bacillus Amyloliquefaciens; PF- Pseudomonas fluorescens*; *BV-Bacillus velezensis;* Gn- germination; S- Survival; GI- Germination Index; MGT- Mean Germination Time; SL- shoot length; RL- Root length; Sdl L- Seedling Length; SVI- Seedling Vigour Index; AI- Allometric Index; Each figure represents mean (±SD) of three replications

**Table 10. Effect of physical seed treatments on plant height and number of branches in transplanted *O. tenuiflorum***

| T. No. | Physical treatment | Plant height (cm) | | | Number of branches | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | SC | 15.15 ± 0.56 | 33.45 ± 1.02 | 100.3 ± 2.82 | - | 9.99 ± 0.81 | 32.33 ± 1.23 |
| $T_2$ | WS | 15.78 ± 1.20 | 33.62 ± 1.33 | 109.06 ± 1.99 | - | 9.33 ± 0.87 | 43.00 ± 1.45 |
| $T_3$ | HW | 17.17 ± 0.87 | 38.35 ± 1.64 | 106.20 ± 1.47 | - | 9.55 ± 0.97 | 45.33 ± 1.03 |
| $T_4$ | CSA | 11.12 ± 0.76 | 20.75 ± 1.42 | 63.06 ± 2.03 | - | 9.33 ± 0.81 | 24.00 ± 1.51 |
| $T_5$ | Control | 10.53 ± 0.42 | 19.66 ± 0.79 | 85.52 ± 1.31 | - | 4.44 ± 0.76 | 24.33 ± 0.81 |
| SEm(±) | | 0.804 | 1.889 | 4.567 | - | 0.743 | 1.658 |
| C.D. (0.05) | | 2.565 | 6.029 | 14.577 | - | 2.372 | 5.292 |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; DAS- Days after sowing.
Each figure represents mean (±SD) of three replications

**Table 11. Effect of physical seed treatments on basal stem girth and number of nodes in transplanted *O. tenuiflorum***

| T. No. | Physical treatment | Basal stem girth (cm) | | | Number of nodes | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | SC | 0.84 ± 0.1 | 1.48 ± 0.38 | 2.95 ± 0.57 | 12.22 ± 0.76 | 33.55 ± 2.07 | 234.44 ± 2.46 |
| $T_2$ | WS | 0.75 ± 0.14 | 1.11 ± 0.52 | 3.12 ± 0.28 | 11.99 ± 1.29 | 32.66 ± 1.32 | 242.67 ± 2.44 |
| $T_3$ | HW | 0.75 ± 0.14 | 1.51 ± 0.56 | 2.97 ± 0.17 | 12.66 ± 1.17 | 34.22 ± 1.65 | 237.33 ± 2.01 |
| $T_4$ | CSA | 0.73 ± 0.1 | 0.87 ± 0.26 | 2.46 ± 0.50 | 10.44 ± 0.98 | 38.22 ± 1.76 | 228 ± 2.53 |
| $T_5$ | Control | 0.68 ±0.14 | 0.98 ±0.17 | 2.86 ±0.17 | 7.10 ± 0.46 | 26.22 ± 1.08 | 206.6 ± 2.36 |
| SEm(±) | | 0.022 | 0.207 | 0.196 | 1.102 | 2.771 | 5.695 |
| C.D. (0.05) | | 0.069 | NS | NS | 3.517 | NS | 18.176 |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; DAS- Days after sowing.
Each figure represents mean (±SD) of three replications

**Table 12. Effect of hormonal seed priming on plant height and number of branches in transplanted *O. tenuiflorum***

| T. No. | Hormones | Plant height (cm) | | | Number of branches | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | $GA_3$ @ 1500 µM | 19.03 ± 0.74 | 40.21 ± 1.29 | 107.53 ± 1.19 | - | 12.22 ± 0.76 | 43.77 ± 0.46 |
| $T_2$ | $GA_3$ @ 3000 µM | 12.10 ± 0.71 | 20.10 ± 1.33 | 87.43 ± 2.55 | - | 5.99 ± 0.61 | 32.00 ± 1.07 |
| $T_3$ | IAA @ 0.1 µM | 10.53 ± 0.4 | 29.57 ± 0.97 | 93.50 ± 2.43 | - | 16.22 ± 1.88 | 36.66 ± 2.15 |
| $T_4$ | IAA @ 1 µM | 11.23 ± 0.7 | 24.33 ± 2.08 | 75.16 ± 2.01 | - | 6.66 ± 0.61 | 25.33 ± 1.32 |
| $T_5$ | BA @ 100 µM | 13.91 ± 1.06 | 22.17 ± 0.92 | 77.96 ± 2.57 | - | 1.77 ± 0.76 | 45.33 ± 2.09 |
| $T_6$ | BA @ 300 µM | 10.94 ± 0.22 | 19.73 ± 1.28 | 101.60 ± 2.10 | - | 5.10 ± 0.46 | 24.00 ± 1.07 |
| $T_7$ | TDZ @ 200 µM | 10.93 ± 0.67 | 16.60 ± 1.46 | 99.26 ± 2.52 | - | 3.99 ± 0.81 | 26.00 ± 1.74 |
| $T_8$ | TDZ @ 400 µM | 14.30 ± 0.41 | 19.25 ± 1.34 | 108.56 ± 1.89 | - | 3.10 ± 0.66 | 36.66 ± 2.41 |
| $T_9$ | Control | 10.53 ± 0.42 | 19.66 ± 0.79 | 85.52 ± 1.31 | - | 4.44 ± 0.76 | 24.33 ± 0.81 |
| SEm(±) | | 0.507 | 2.003 | 4.910 | - | 1.283 | 3.167 |
| C.D. (0.05) | | 1.518 | 5.997 | 14.702 | - | 3.841 | 9.483 |

T. No. – Treatment Number; GA- Giberellic acid; IAA- Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; DAS- Days after sowing.
Each figure represents mean (±SD) of three replications

**Table 13. Effect of hormonal seed primimg on basal stem girth and number of nodes in transplanted *O. tenuiflorum***

| T. No. | Hormones | Basal stem girth (cm) | | | Number of nodes | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | $GA_3$ @ 1500 µM | 0.80 ± 0.17 | 1.61 ± 0.38 | 2.95 ± 0.3 | 9.55 ± 0.76 | 44.22 ± 1.37 | 244 ± 1.83 |
| $T_2$ | $GA_3$ @ 3000 µM | 0.78 ± 0.17 | 1.01 ± 0.24 | 2.73 ± 0.56 | 10.44 ± 0.76 | 29.11 ± 1.7 | 264.66 ± 2.63 |
| $T_3$ | IAA @ 0.1 µM | 0.72 ± 0.2 | 1.23 ± 0.28 | 2.36 ± 0.45 | 9.33 ± 00 | 42.66 ± 1.29 | 243.33 ± 3.22 |
| $T_4$ | IAA @ 1 µM | 0.79 ± 0.17 | 1.02 ± 0.22 | 2.56 ± 0.55 | 8.66 ± 0.87 | 41.77 ± 1.34 | 245.33 ± 3.43 |
| $T_5$ | BA @ 100 µM | 0.83 ± 0.1 | 0.78 ± 0.2 | 2.43 ± 0.47 | 9.66 ± 0.71 | 24.55 ± 1.54 | 247.33 ± 4.50 |
| $T_6$ | BA @ 300 µM | 0.81 ± 0.22 | 0.65 ± 0.2 | 2.66 ± 0.53 | 9.55 ± 1.10 | 24.99 ± 0.93 | 243.33 ± 3.56 |
| $T_7$ | TDZ @ 200 µM | 0.84 ± 0.26 | 0.74 ± 0.17 | 2.53 ± 0.48 | 8.21 ± 0.66 | 22.44 ± 1.68 | 274.00 ± 2.3 |
| $T_8$ | TDZ @ 400 µM | 0.76 ± 0.22 | 0.78 ± 0.22 | 2.8 ± 0.78 | 8.10 ± 0.78 | 25.22 ± 1.31 | 284.66 ± 1.32 |
| $T_9$ | Control | 0.68 ±0.14 | 0.98 ±0.17 | 2.86 ±0.17 | 7.10 ± 0.46 | 26.22 ± 1.08 | 206.6 ± 2.36 |
| SEm(±) | | 0.046 | 0.074 | 0.305 | 0.642 | 2.039 | 10.248 |
| C.D. (0.05) | | NS | NS | NS | 1.922 | 6.106 | 30.685 |

T. No. – Treatment Number; GA- Giberellic acid; IAA- Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; DAS- Days after sowing.
Each figure represents mean (±SD) of three replications

**Table 14. Effect of biostimulant seed priming on plant height and number of branches in transplanted *O. tenuiflorum***

| T. No. | Biostimulants | Plant height (cm) | | | Number of branches | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | CH @ 5gL$^{-1}$ | 15.00 ± 0.94 | 18.14 ± 0.93 | 89.90 ± 1.64 | - | 7.33 ± 0.61 | 22.66 ± 1.15 |
| $T_2$ | CH @ 10 gL$^{-1}$ | 12.15 ± 0.24 | 25.80 ± 1.61 | 77.33 ± 1.54 | - | 6.66 ± 0.61 | 27.00 ± 1.87 |
| $T_3$ | SA @ 1500µM | 19.46 ± 1.04 | 28.16 ± 1.23 | 86.93 ± 1.92 | - | 12.107 ±0.53 | 28.33 ± 1.68 |
| $T_4$ | SA @ 3000µM | 10.02 ± 0.44 | 20.77 ± 1.88 | 74.40 ± 2.22 | - | 6.66 ± 0.76 | 31.00 ± 1.07 |
| $T_5$ | PG @ 1µM | 11.53 ± 0.37 | 25.88 ± 1.43 | 64.30 ± 1.28 | - | 7.33 ± 0.81 | 23.66 ± 1.52 |
| $T_6$ | PG @ 10µM | 12.56 ± 0.68 | 21.02 ± 1.38 | 59.43 ± 1.26 | - | 10.44 ± 1.08 | 19.33 ± 1.28 |
| $T_7$ | Control | 10.53 ± 0.42 | 19.66 ± 0.79 | 85.52 ± 1.31 | - | 4.44 ± 0.76 | 24.33 ± 0.81 |
| SEm(±) | | 0.574 | 2.105 | 2.927 | - | 0.644 | 2.146 |
| C.D. (0.05) | | 1.558 | 6.447 | 8.964 | - | 1.971 | 6.571 |

T. No. – Treatment Number; CH- Chitosan; SA-Salicylic acid; PG- Phloroglucinol; DAS- Days after sowing. Each figure represents mean (±SD) of three replications

**Table 15. Effect of biostimulants seed primimg on basal stem girth and number of nodes in transplanted *O. tenuiflorum***

| T. No. | Biostimulants | Basal stem girth (cm) | | | Number of nodes | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | CH @ 5gL$^{-1}$ | 0.75 ± 0.24 | 0.88 ± 0.22 | 2.46 ± 0.60 | 9.33 ± 0.61 | 21.33 ± 1.38 | 259.33 ± 3.23 |
| $T_2$ | CH @ 10 gL$^{-1}$ | 0.67 ± 0.1 | 1.49 ± 0.26 | 2.5 ± 0.44 | 9.11 ± 0.94 | 34.66 ± 1.83 | 257.33 ± 2.09 |
| $T_3$ | SA @ 1500µM | 0.76 ± 0.13 | 1.73 ± 0.1 | 2.5 ± 0.56 | 8.88 ± 1.08 | 35.66 ± 1.73 | 256.66 ± 2.72 |
| $T_4$ | SA @ 3000µM | 0.80 ± 0.14 | 1.36 ± 0.36 | 2.9 ± 0.33 | 9.77 ± 0.46 | 31.33 ± 2.09 | 255.33 ± 2.33 |
| $T_5$ | PG @ 1µM | 0.78 ± 0.1 | 1.41 ± 0.17 | 2.2 ± 0.31 | 10.44 ± 0.89 | 38.66 ± 1.54 | 246.00 ± 1.07 |
| $T_6$ | PG @ 10µM | 0.81 ± 0.17 | 1.23 ± 0.26 | 2 ± 0.22 | 10.66 ± 1.00 | 37.77 ± 2.07 | 244.66 ± 2.99 |
| $T_7$ | Control | 0.68 ±0.14 | 0.98 ±0.17 | 2.86 ±0.17 | 7.10 ± 0.46 | 26.22 ± 1.08 | 206.6 ± 2.36 |
| SEm(±) | | 0.032 | 0.072 | 0.211 | 0.766 | 3.141 | 6.833 |
| C.D. (0.05) | | 0.099 | 0.220 | NS | NS | 9.621 | 20.927 |

T. No. – Treatment Number; CH- Chitosan; SA-Salicylic acid; , PG- Phloroglucinol; DAS- Days after sowing. Each figure represents mean (±SD) of three replications

**Table 16. Effect of biopriming of seeds on plant height and number of branches in transplanted *O. tenuiflorum***

| T. No. | Microbes | Plant height (cm) | | | Number of branches | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | *Bacillus pumilus (BP)* | 12.24 ± 0.47 | 24.45 ± 1.38 | 79.00 ± 1.4 | - | 6.44 ± 1.37 | 34.33 ± 2.21 |
| $T_2$ | *Bacillus amyloliquefaciens (BA)* | 11.44 ± 0.14 | 20.98 ± 1.14 | 76.53 ± 1.53 | - | 5.99 ± 0.61 | 29.33 ± 2.52 |
| $T_3$ | *Pseudomonas fluorescens (PF)* | 13.78 ± 0.64 | 22.89 ± 0.97 | 83.76 ± 1.68 | - | 10.22 ± 0.76 | 36.66 ± 2.6 |
| $T_4$ | *Bacillus velezensis (BV)* | 11.83 ± 0.61 | 23.1± 0.9 | 75.93 ± 2.06 | - | 2.21 ± 0.89 | 29.33 ± 2.15 |
| $T_5$ | Control | 10.53 ± 0.42 | 19.66 ± 0.79 | 85.52 ± 1.31 | - | 4.44 ± 0.76 | 24.33 ± 0.81 |
| SEm(±) | | 0.282 | 1.218 | 2.779 | - | 1.009 | 5.149 |
| C.D. (0.05) | | 0.900 | NS | NS | - | 3.220 | NS |

T. No. – Treatment Number; DAS- Days after sowing. Each figure represents mean (±SD) of three replications

**Table 17. Effect of bioprimimg of seeds on basal stem girth and number of nodes in transplanted *O. tenuiflorum***

| T. No. | Biopriming | Basal stem girth (cm) | | | Number of nodes | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | *Bacillus pumilus (BP)* | 0.78 ± 0.17 | 1.22 ± 0.38 | 2.6 ± 0.5 | 10.21 ± 0.89 | 30.88 ± 3.07 | 240 ± 3.64 |
| $T_2$ | *Bacillus amyloliquefaciens (BA)* | 0.89 ± 0.17 | 1.22 ± 0.2 | 2.2 ± 0.33 | 11.33 ± 1.29 | 21.99 ± 1.29 | 246 ± 2.64 |
| $T_3$ | *Pseudomonas fluorescens (PF)* | 0.98 ± 0.1 | 1.22 ± 0.1 | 3.36 ± 0.73 | 12.22 ± 1.33 | 42 ± 1.07 | 260 ± 3.87 |
| $T_4$ | *Bacillus velezensis (BV)* | 0.91 ± 0.1 | 1.15 ± 0.51 | 2.73 ± 0.41 | 11.33 ± 0.61 | 24.88 ± 1.40 | 248 ± 2.88 |
| $T_5$ | Control | 0.68 ±0.14 | 0.98 ±0.17 | 2.86 ±0.17 | 7.10 ± 0.46 | 26.22 ± 1.08 | 206.6 ± 2.36 |
| SEm(±) | | 0.025 | 0.143 | 0.286 | 1.168 | 1.398 | 10.513 |
| C.D. (0.05) | | 0.080 | NS | NS | NS | 4.461 | 33.555 |

T. No. – Treatment Number; DAS- Days after sowing. Each figure represents mean (±SD) of three replications

**Table 18. Effect of various seed pretreatments on plant height and number of branches in transplanted *O. tenuiflorum***

| T. No. | Pretreatment | Plant height (cm) | | | Number of branches | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | SC | 15.15 ± 0.56 | 33.45 ± 1.02 | 100.3 ± 2.82 | - | 9.99 ± 0.81 | 32.33 ± 1.23 |
| $T_2$ | WS | 15.78 ± 1.20 | 33.62 ± 1.33 | 109.06 ± 1.99 | - | 9.33 ± 0.87 | 43.00 ± 1.45 |
| $T_3$ | HW | 17.17 ± 0.87 | 38.35 ± 1.64 | 106.20 ± 1.47 | - | 9.55 ± 0.97 | 45.33 ± 1.03 |
| $T_4$ | CSA | 11.12 ± 0.76 | 20.75 ± 1.42 | 63.06 ± 2.03 | - | 9.33 ± 0.81 | 24.00 ± 1.51 |
| $T_5$ | $GA_3$ @1500 µM | 19.03 ± 0.74 | 40.21 ± 1.29 | 107.53 ± 1.19 | - | 12.22 ± 0.76 | 43.77 ± 0.46 |
| $T_6$ | $GA_3$ @3000µM | 12.1 ± 0.71 | 20.10 ± 1.33 | 87.43 ± 2.55 | - | 5.99 ± 0.61 | 32.00 ± 1.07 |
| $T_7$ | IAA @ 0.1 µM | 10.53 ± 0.4 | 29.57 ± 0.97 | 93.50 ± 2.43 | - | 16.22 ± 1.88 | 36.66 ± 2.15 |
| $T_8$ | IAA @ 1 µM | 11.23 ± 0.7 | 24.33 ± 2.08 | 75.16 ± 2.01 | - | 6.66 ± 0.61 | 25.33 ± 1.32 |
| $T_9$ | BA @ 100 µM | 13.91 ± 1.06 | 22.17 ± 0.92 | 77.96 ± 2.57 | - | 1.77 ± 0.76 | 45.33 ± 2.09 |
| $T_{10}$ | BA @ 300 µM | 10.94 ± 0.22 | 19.73 ± 1.28 | 101.60 ± 2.10 | - | 5.10 ± 0.46 | 24.00 ± 1.07 |
| $T_{11}$ | TDZ @ 200 µM | 10.93 ± 0.67 | 16.60 ± 1.46 | 99.26 ± 2.52 | - | 3.99 ± 0.81 | 26.00 ± 1.74 |
| $T_{12}$ | TDZ @ 400 µM | 14.30 ± 0.41 | 19.25 ± 1.34 | 108.56 ± 1.89 | - | 3.10 ± 0.66 | 36.66 ± 2.41 |
| $T_{13}$ | CH @ $5gL^{-1}$ | 15.00 ± 0.94 | 18.14 ± 0.93 | 89.90 ± 1.64 | - | 7.33 ± 0.61 | 22.66 ± 1.15 |
| $T_{14}$ | CH @ 10 $gL^{-1}$ | 12.15 ± 0.24 | 25.80 ± 1.61 | 77.33 ± 1.54 | - | 6.66 ± 0.61 | 27.00 ± 1.87 |
| $T_{15}$ | SA @ 1500µM | 19.46 ± 1.04 | 28.16 ± 1.23 | 86.93 ± 1.92 | - | 12.107 ±0.53 | 28.33 ± 1.68 |
| $T_{16}$ | SA @ 3000µM | 10.02 ± 0.44 | 20.77 ± 1.88 | 74.40 ± 2.22 | - | 6.66 ± 0.76 | 31.00 ± 1.07 |
| $T_{17}$ | PG @ 1µM | 11.53 ± 0.37 | 25.88 ± 1.43 | 64.30 ± 1.28 | - | 7.33 ± 0.81 | 23.66 ± 1.52 |
| $T_{18}$ | PG @ 10µM | 12.56 ± 0.68 | 21.02 ± 1.38 | 59.43 ± 1.26 | - | 10.44 ± 1.08 | 19.33 ± 1.28 |
| $T_{19}$ | *Bacillus pumilus (BP)* | 12.24 ± 0.47 | 24.45 ± 1.38 | 79.00 ± 1.4 | - | 6.44 ± 1.37 | 34.33 ± 2.21 |
| $T_{20}$ | *Bacillus amyloliquefaciens (BA)* | 11.44 ± 0.14 | 20.98 ± 1.14 | 76.53 ± 1.53 | - | 5.99 ± 0.61 | 29.33 ± 2.52 |
| $T_{21}$ | *Pseudomonas fluorescens (PF)* | 13.78 ± 0.64 | 22.89 ± 0.97 | 83.76 ± 1.68 | - | 10.22 ± 0.76 | 36.66 ± 2.6 |
| $T_{22}$ | *Bacillus velezensis (BV)* | 11.83 ± 0.61 | 23.1± 0.9 | 75.93 ± 2.06 | - | 2.21 ± 0.89 | 29.33 ± 2.15 |
| $T_{23}$ | Control | 10.53 ± 0.42 | 19.66 ± 0.79 | 85.52 ± 1.31 | - | 4.44 ± 0.76 | 24.33 ± 0.81 |
| SEm(±) | | 0.577 | 1.991 | 4.227 | - | 1.033 | 3.739 |
| C.D. (0.05) | | 1.648 | 5.686 | 12.070 | - | 2.949 | 9.739 |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; GA- Giberellic acid; IAA- Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; CH-Chitosan; SA-Salicylic acid; , PG- Phloroglucinol; DAS- Days after sowing; Each figure represents mean (±SD) of three replications

**Table 19. Effect of various of seed treatments on basal stem girth and number of nodes in transplanted *O. tenuiflorum***

| T. No. | Pretreatment | Basal stem girth (cm) | | | Number of nodes | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | SC | 0.84 ± 0.1 | 1.48 ± 0.38 | 2.95 ± 0.57 | 12.22 ± 0.76 | 33.55 ± 2.07 | 234.44 ± 2.46 |
| $T_2$ | WS | 0.75 ± 0.14 | 1.11 ± 0.52 | 3.12 ± 0.28 | 11.99 ± 1.29 | 32.66 ± 1.32 | 242.67 ± 2.44 |
| $T_3$ | HW | 0.75 ± 0.14 | 1.51 ± 0.56 | 2.97 ± 0.17 | 12.66 ± 1.17 | 34.22 ± 1.65 | 237.33 ± 2.01 |
| $T_4$ | CSA | 0.73 ± 0.1 | 0.87 ± 0.26 | 2.46 ± 0.50 | 10.44 ± 0.98 | 38.22 ± 1.76 | 228.00 ± 2.53 |
| $T_5$ | $GA_3$ @1500 µM | 0.80 ± 0.17 | 1.61 ± 0.38 | 2.95 ± 0.3 | 9.55 ± 0.76 | 44.22 ± 1.37 | 244.00 ± 1.83 |
| $T_6$ | $GA_3$ @3000µM | 0.78 ± 0.17 | 1.01 ± 0.24 | 2.73 ± 0.56 | 10.44 ± 0.76 | 29.11 ± 1.7 | 264.66 ± 2.63 |
| $T_7$ | IAA @ 0.1 µM | 0.72 ± 0.2 | 1.23 ± 0.28 | 2.36 ± 0.45 | 9.33 ± 00 | 42.66 ± 1.29 | 243.33 ± 3.22 |
| $T_8$ | IAA @ 1 µM | 0.79 ± 0.17 | 1.02 ± 0.22 | 2.56 ± 0.55 | 8.66 ± 0.87 | 41.77 ± 1.34 | 245.33 ± 3.43 |
| $T_9$ | BA @ 100 µM | 0.83 ± 0.1 | 0.78 ± 0.2 | 2.43 ± 0.47 | 9.66 ± 0.71 | 24.55 ± 1.54 | 247.33 ± 4.50 |
| $T_{10}$ | BA @ 300 µM | 0.81 ± 0.22 | 0.65 ± 0.2 | 2.66 ± 0.53 | 9.55 ± 1.10 | 24.99 ± 0.93 | 243.33 ± 3.56 |
| $T_{11}$ | TDZ @ 200 µM | 0.84 ± 0.26 | 0.74 ± 0.17 | 2.53 ± 0.48 | 8.21 ± 0.66 | 22.44 ± 1.68 | 274.00 ± 2.3 |
| $T_{12}$ | TDZ @ 400 µM | 0.76 ± 0.22 | 0.78 ± 0.22 | 2.8 ± 0.78 | 8.10 ± 0.78 | 25.22 ± 1.31 | 284.66 ± 1.32 |
| $T_{13}$ | CH @ $5gL^{-1}$ | 0.75 ± 0.24 | 0.88 ± 0.22 | 2.46 ± 0.60 | 9.33 ± 0.61 | 21.33 ± 1.38 | 259.33 ± 3.23 |
| $T_{14}$ | CH @ 10 $gL^{-1}$ | 0.67 ± 0.1 | 1.49 ± 0.26 | 2.5 ± 0.44 | 9.11 ± 0.94 | 34.66 ± 1.83 | 257.33 ± 2.09 |
| $T_{15}$ | SA @ 1500µM | 0.76 ± 0.13 | 1.73 ± 0.1 | 2.5 ± 0.56 | 8.88 ± 1.08 | 35.66 ± 1.73 | 256.66 ± 2.72 |
| $T_{16}$ | SA @ 3000µM | 0.80 ± 0.14 | 1.36 ± 0.36 | 2.9 ± 0.33 | 9.77 ± 0.46 | 31.33 ± 2.09 | 255.33 ± 2.33 |
| $T_{17}$ | PG @ 1µM | 0.78 ± 0.1 | 1.41 ± 0.17 | 2.2 ± 0.31 | 10.44 ± 0.89 | 38.66 ± 1.54 | 246.00 ± 1.07 |
| $T_{18}$ | PG @ 10µM | 0.81 ± 0.17 | 1.23 ± 0.26 | 2.0 ± 0.22 | 10.66 ± 1.00 | 37.77 ± 2.07 | 244.66 ± 2.99 |
| $T_{19}$ | *Bacillus pumilus (BP)* | 0.78 ± 0.17 | 1.22 ± 0.38 | 2.6 ± 0.5 | 10.21 ± 0.89 | 30.88 ± 3.07 | 240.00 ± 3.64 |
| $T_{20}$ | *Bacillus amyloliquefaciens (BA)* | 0.89 ± 0.17 | 1.22 ± 0.2 | 2.2 ± 0.33 | 11.33 ± 1.29 | 21.99 ± 1.29 | 246.00 ± 2.64 |
| $T_{21}$ | *Pseudomonas fluorescens (PF)* | 0.98 ± 0.1 | 1.22 ± 0.1 | 3.36 ± 0.73 | 12.22 ± 1.33 | 42.00 ± 1.07 | 260.00 ± 3.87 |
| $T_{22}$ | *Bacillus velezensis (BV)* | 0.91 ± 0.1 | 1.15 ± 0.51 | 2.73 ± 0.41 | 11.33 ± 0.61 | 24.88 ± 1.40 | 248.00 ± 2.88 |
| $T_{23}$ | Control | 0.68 ±0.14 | 0.98 ±0.17 | 2.86 ±0.17 | 7.10 ± 0.46 | 26.22 ± 1.08 | 206.60 ± 2.36 |
| SEm(±) | | 0.036 | 0.131 | 0.276 | 0.945 | 2.55 | 9.072 |
| C.D. (0.05) | | 0.103 | 0.375 | NS | 2.700 | 7.306 | 25.909 |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; GA- Giberellic acid; IAA- Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; CH-Chitosan; SA-Salicylic acid; , PG- Phloroglucinol; DAS- Days after sowing; Each figure represents mean (±SD) of three replications

**Table 20. Effect of physical seed pretreatments on phenological parameters in transplanted *O. tenuiflorum***

| T. No. | Physical treatment | Days to flower initiation (Days) | Days to fruit set (Days) | Days to fruit maturity (Days) |
|---|---|---|---|---|
| $T_1$ | SC | 59.56 ± 0.74 | 2.44 ± 0.33 | 6.22 ± 0.33 |
| $T_2$ | WS | 60.88 ± 1.2 | 2.22 ± 0.46 | 6.33 ± 0.43 |
| $T_3$ | HW | 61.33 ± 1.15 | 2.56 ± 0.46 | 6.56 ± 0.53 |
| $T_4$ | CSA | 62.55 ± 2.10 | 2.44 ± 0.33 | 7.22 ± 0.46 |
| $T_5$ | Control | 67.00 ± 1.31 | 2.33 ± 0.00 | 7.11 ± 0.33 |
| SEm(±) | | 2.324 | 0.157 | 0.302 |
| C.D. (0.05) | | NS | NS | NS |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; Each figure represents mean (±SD) of three replications

**Table 21. Effect of hormonal seed priming on phenological parameters in transplanted *O. tenuiflorum***

| T. No. | Hormones | Days to flower initiation (Days) | Days to fruit set (Days) | Days to fruit maturity (Days) |
|---|---|---|---|---|
| $T_1$ | $GA_3$ @ 1500 µM | 63.55 ± 0.92 | 2.56 ± 0.33 | 7.00 ± 0.61 |
| $T_2$ | $GA_3$ @ 3000 µM | 63.55 ± 1.24 | 2.44 ± 0.53 | 6.78 ± 0.33 |
| $T_3$ | IAA @ 0.1 µM | 59.56 ± 0.74 | 2.33 ± 0.43 | 6.67 ± 0.43 |
| $T_4$ | IAA @ 1 µM | 66.77 ± 1.14 | 2.22 ± 0.33 | 6.89 ± 0.46 |
| $T_5$ | BA @ 100 µM | 63.66 ± 0.87 | 2.44 ± 0.33 | 7.00 ± 0.61 |
| $T_6$ | BA @ 300 µM | 64.55 ± 0.66 | 2.33 ± 0.00 | 6.33 ± 0.43 |
| $T_7$ | TDZ @ 200 µM | 63.77 ± 1.24 | 2.44 ± 0.46 | 6.78 ± 0.69 |
| $T_8$ | TDZ @ 400 µM | 61.22 ± 1.07 | 2.56 ± 0.33 | 7.22 ± 0.46 |
| $T_9$ | Control | 67.00 ± 1.31 | 2.33 ± 0.00 | 7.11 ± 0.33 |
| SEm(±) | | 1.187 | 0.157 | 0.284 |
| C.D. (0.05) | | 3.55 | NS | NS |

T. No. – Treatment Number; GA- Giberellic acid; IAA- Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; Each figure represents mean (±SD) of three replications

**Table 22. Effect of biostimulant seed priming on phenological paramters in transplanted *O. tenuiflorum***

| Treatment | Biostimulants | Days to flower initiation (Days) | Days to fruit set (Days) | Days to fruit maturity (Days) |
|---|---|---|---|---|
| $T_1$ | CH @ $5gL^{-1}$ | 60.66 ± 0.97 | 2.56 ± 0.46 | 7.11 ± 0.69 |
| $T_2$ | CH @ $10gL^{-1}$ | 63.55 ± 1.31 | 2.00 ± 0.00 | 7.22 ± 0.46 |
| $T_3$ | SA @ 1500µM | 65.11 ± 1.34 | 2.44 ± 0.33 | 6.67 ± 0.57 |
| $T_4$ | SA @ 3000µM | 63.67 ± 1.00 | 2.22 ± 0.46 | 6.67 ± 0.57 |
| $T_5$ | PG @ 1µM | 60.89 ± 1.2 | 2.56 ± 0.46 | 7.22 ± 0.46 |
| $T_6$ | PG @ 10µM | 63.78 ± 0.69 | 2.44 ± 0.33 | 6.56 ± 0.53 |
| $T_7$ | Control | 67.00 ± 1.31 | 2.33 ± 0.00 | 7.11 ± 0.33 |
| SEm(±) | | 1.394 | 0.157 | 0.306 |
| C.D. (0.05) | | NS | NS | NS |

T. No. – Treatment Number; CH- Chitosan; SA-Salicylic acid; , PG- Phloroglucinol. Each figure represents mean (±SD) of three replications

**Table 23. Effect of bioprimimg of seeds on phenological parameters in transplanted *O. tenuiflorum***

| T. No. | Microbes | Days to flower initiation (Days) | Days to fruit set (Days) | Days to fruit maturity (Days) |
|---|---|---|---|---|
| $T_1$ | *Bacillus pumilus (BP)* | 65.56 ± 1.26 | 2.00 ± 0.00 | 7.22 ± 0.46 |
| $T_2$ | *Bacillus amyloliquefaciens(BA)* | 59.56 ± 0.74 | 2.44 ± 0.33 | 6.00 ± 0.43 |
| $T_3$ | *Pseudomonas fluorescens (PF)* | 66.44 ± 1.68 | 2.22 ± 0.46 | 7.22 ± 0.46 |
| $T_4$ | *Bacillus velezensis (BV* | 66.00 ± 0.91 | 2.56 ± 0.46 | 5.89 ± 0.53 |
| $T_5$ | Control | 67.00 ± 1.31 | 2.33 ± 0.00 | 7.11 ± 0.33 |
| SEm(±) | | 1.711 | 0.149 | 0.205 |
| C.D. (0.05) | | NS | NS | NS |

Each figure represents mean (±SD) of three replications

**Table 24. Effect of seed pretreatments on phenological parameters in transplanted *O. tenuiflorum***

| Treatment | Pretreatment | Days to flower initiation (Days) | Days to fruit set (Days) | Days to fruit maturity (Days) |
|---|---|---|---|---|
| $T_1$ | Scarification | 59.56 ± 0.74 | 2.44 ± 0.33 | 6.22 ± 0.33 |
| $T_2$ | Water soaking | 60.88 ± 1.2 | 2.22 ± 0.46 | 6.33 ± 0.43 |
| $T_3$ | Hot water | 61.33 ± 1.15 | 2.56 ± 0.46 | 6.56 ± 0.53 |
| $T_4$ | Conc.$H_2SO_4$ | 62.55 ± 2.10 | 2.44 ± 0.33 | 7.22 ± 0.46 |
| $T_5$ | $GA_3$ @ 1500 µM | 63.55 ± 0.92 | 2.56 ± 0.33 | 7.00 ± 0.61 |
| $T_6$ | $GA_3$ @ 3000 µM | 63.55 ± 1.24 | 2.44 ± 0.53 | 6.78 ± 0.33 |
| $T_7$ | IAA @ 0.1 µM | 59.56 ± 0.74 | 2.33 ± 0.43 | 6.67 ± 0.43 |
| $T_8$ | IAA @ 1 µM | 66.77 ± 1.14 | 2.22 ± 0.33 | 6.89 ± 0.46 |
| $T_9$ | BA @ 100 µM | 63.66 ± 0.87 | 2.44 ± 0.33 | 7.00 ± 0.61 |
| $T_{10}$ | BA @ 300 µM | 64.55 ± 0.66 | 2.33 ± 0.00 | 6.33 ± 0.43 |
| $T_{11}$ | TDZ @ 200 µM | 63.77 ± 1.24 | 2.44 ± 0.46 | 6.78 ± 0.69 |
| $T_{12}$ | TDZ @ 400 µM | 61.22 ± 1.07 | 2.56 ± 0.33 | 7.22 ± 0.46 |
| $T_{13}$ | CH @ 5$gL^{-1}$ | 60.66 ± 0.97 | 2.56 ± 0.46 | 7.11 ± 0.69 |
| $T_{14}$ | CH @ 10 $gL^{-1}$ | 63.55 ± 1.31 | 2.00 ± 0.00 | 7.22 ± 0.46 |
| $T_{15}$ | SA @ 1500µM | 65.11 ± 1.34 | 2.44 ± 0.33 | 6.67 ± 0.57 |
| $T_{16}$ | SA @ 3000µM | 63.67 ± 1.00 | 2.22 ± 0.46 | 6.67 ± 0.57 |
| $T_{17}$ | PG @ 1µM | 60.89 ± 1.2 | 2.56 ± 0.46 | 7.22 ± 0.46 |
| $T_{18}$ | PG @ 10µM | 63.78 ± 0.69 | 2.44 ± 0.33 | 6.56 ± 0.53 |
| $T_{19}$ | *Bacillus pumilus (BP)* | 65.56 ± 1.26 | 2.00 ± 0.00 | 7.22 ± 0.46 |
| $T_{20}$ | *Bacillus amyloliquefaciens(BA)* | 59.56 ± 0.74 | 2.44 ± 0.33 | 6.00 ± 0.43 |
| $T_{21}$ | *Pseudomonas fluorescens (PF)* | 66.44 ± 1.68 | 2.22 ± 0.46 | 7.22 ± 0.46 |
| $T_{22}$ | *Bacillus velezensis(BV)* | 66.00 ± 0.91 | 2.56 ± 0.46 | 5.89 ± 0.53 |
| $T_{23}$ | Control | 67.00 ± 1.31 | 2.33 ± 0.00 | 7.11 ± 0.33 |
| SEm(±) | | 1.600 | 0.165 | 0.296 |
| C.D. (0.05) | | 4.570 | NS | NS |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; GA- Giberellic acid; IAA- Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; CH-Chitosan*;* SA-Salicylic acid; , PG- Phloroglucinol; DAS- Days after sowing; Each figure represents mean (±SD) of three replications

**Table 25. Effect of physical seed pretreatments on yield parameters in transplanted *O. tenuiflorum* at 90 DAS**

| T. No. | Physical treatment | Total leaf biomass (g plant$^{-1}$) | | Total stem biomass (g plant$^{-1}$) | | Total shoot biomass (g plant$^{-1}$) | | Harvest Index |
|---|---|---|---|---|---|---|---|---|
| | | Fresh weight | Dry weight | Fresh weight | Dry weight | Fresh weight | Dry weight | |
| $T_1$ | SC | 64.00 ± 3.10 | 12.31 ± 1.26 | 46.76 ± 2.49 | 13.42 ± 1.41 | 110.76 ± 1.86 | 25.73 ± 0.62 | 0.90 ± 0.00 |
| $T_2$ | WS | 66.93 ± 2.98 | 13.06 ± 1.43 | 59.66 ± 2.79 | 17.10 ± 1.56 | 126.6 ± 6.06 | 30.16 ± 2.10 | 0.92 ± 0.00 |
| $T_3$ | HW | 65.10 ± 2.64 | 12.66 ± 1.23 | 65.00 ± 1.76 | 18.56 ± 0.83 | 130.1 ± 3.14 | 31.22 ± 1.49 | 0.91 ± 0.1 |
| $T_4$ | CSA | 34.07 ± 2.41 | 6.54 ± 1.00 | 59.7 ± 1.71 | 17.03 ± 0.74 | 93.76 ± 2.93 | 23.58 ± 1.24 | 0.83 ± 0.1 |
| $T_5$ | Control | 43.96 ± 1.93 | 8.49 ± 0.76 | 35 ± 1.34 | 10.02 ± 0.81 | 78.96 ± 1.96 | 18.52 ± 1.00 | 0.89 ± 0.1 |
| SEm(±) | | 23.488 | 1.459 | 4.921 | 1.500 | 9.727 | 2.381 | 0.009 |
| C.D. (0.05) | | 7.359 | 4.655 | 6.959 | 2.122 | 31.045 | 7.599 | 0.029 |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; Each figure represents mean (±SD) of three replications

**Table 26. Effect of hormonal seed priming on yield parameters in transplanted *O. tenuiflorum* at 90 DAS**

| T. No. | Hormones | Total leaf biomass (g plant$^{-1}$) | | Total stem biomass (g plant$^{-1}$) | | Total shoot biomass (g plant$^{-1}$) | | Harvest Index |
|---|---|---|---|---|---|---|---|---|
| | | Fresh weight | Dry weight | Fresh weight | Dry weight | Fresh weight | Dry weight | |
| $T_1$ | $GA_3$@1500µM | 99.1 ± 2.29 | 19.15 ± 0.69 | 94.4 ± 1.12 | 26.98 ± 0.64 | 193.50 ± 2.17 | 46.13 ± 0.37 | 0.92 ± 0.14 |
| $T_2$ | $GA_3$@3000µM | 42.46 ± 1.11 | 8.22 ± 0.5 | 81.33 ± 2.39 | 23.22 ± 1.21 | 123.80 ± 2.12 | 31.45 ± 1.17 | 0.86 ± 0.1 |
| $T_3$ | IAA@0.1µM | 67.7 ± 2.92 | 13.08 ± 1.22 | 74.73 ± 2.76 | 21.39 ± 1.52 | 142.43 ± 4.02 | 34.48 ± 1.96 | 0.87 ± 0.1 |
| $T_4$ | IAA@1µM | 50.2 ± 2.59 | 9.72 ± 1.13 | 81.8 ± 2.10 | 23.37 ± 1.10 | 132.00 ± 3.22 | 33.09 ± 1.50 | 0.85 ± 0.1 |
| $T_5$ | BA@100µM | 71.5 ± 2.16 | 13.89 ± 1.1 | 116.5 ± 2.93 | 33.34 ± 1.65 | 188.00 ± 3.14 | 47.23 ± 1.84 | 0.88 ± 0.14 |
| $T_6$ | BA@300µM | 73.63 ± 1.17 | 14.27 ± 0.74 | 61.13 ± 2.18 | 17.50 ± 1.22 | 134.76 ± 2.43 | 31.77 ± 1.32 | 0.92 ± 0.00 |
| $T_7$ | TDZ@200µM | 47.53 ± 1.98 | 9.24 ± 0.98 | 92.63 ± 3.10 | 26.56 ± 1.81 | 140.16 ± 3.73 | 35.81 ± 2.03 | 0.83 ± 0.14 |
| $T_8$ | TDZ@400 µM | 84.81 ± 2.53 | 16.51 ± 1.31 | 104.83 ± 2.19 | 29.99 ± 1.33 | 189.65 ± 2.43 | 46.50 ± 1.47 | 0.87 ± 0.1 |
| $T_9$ | Control | 43.96 ± 1.93 | 8.49 ± 0.76 | 35±1.34 | 10.02 ± 0.81 | 78.96±1.96 | 18.52±1.00 | 0.89±0.1 |
| SEm(±) | | 5.193 | 1.071 | 6.205 | 1.934 | 9.611 | 2.577 | 0.016 |
| C.D. (0.05) | | 15.550 | 3.206 | 18.579 | 5.791 | 28.777 | 7.717 | 0.049 |

T. No. – Treatment Number; GA- Gibberellic acid; IAA- Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; Each figure represents mean (±SD) of three replications

**Table 27. Effect of biostimulant seed priming on yield parameters in transplanted *O. tenuiflorum* at 90 DAS**

| T. No. | Biostimulants | Total leaf biomass (g plant$^{-1}$) | | Total stem biomass (g plant$^{-1}$) | | Total shoot biomass (g plant$^{-1}$) | | Harvest Index |
|---|---|---|---|---|---|---|---|---|
| | | Fresh weight | Dry weight | Fresh weight | Dry weight | Fresh weight | Dry weight | |
| $T_1$ | CH @ 5gL$^{-1}$ | 95.93 ± 1.00 | 18.60 ± 0.78 | 102.76 ± 1.37 | 29.36 ± 0.63 | 198.7 ± 1.38 | 47.96 ± 0.60 | 0.90 ± 0.1 |
| $T_2$ | CH @ 10gL$^{-1}$ | 70.10 ± 1.55 | 13.57 ± 0.61 | 74.13 ± 2.65 | 21.15 ± 1.37 | 144.23 ± 2.92 | 34.73 ± 1.31 | 0.91 ± 0.00 |
| $T_3$ | SA @ 1500µM | 87.80 ± 1.03 | 17.02 ± 0.71 | 129.70 ± 0.98 | 37.08 ± 0.93 | 217.50 ± 1.41 | 54.10 ± 1.15 | 0.89 ± 0.00 |
| $T_4$ | SA @ 3000µM | 65.93 ± 2.29 | 12.83 ± 1.17 | 87.56 ± 2.85 | 25.07 ± 1.61 | 153.5 ± 3.66 | 37.91 ± 2.00 | 0.88 ± 0.1 |
| $T_5$ | PG @ 1µM | 79.4 ± 2.71 | 15.34 ± 1.10 | 73.2 ± 1.60 | 20.93 ± 0.97 | 152.6 ± 2.55 | 36.27 ± 1.03 | 0.89 ± 0.1 |
| $T_6$ | PG @ 10µM | 75.43 ± 2.61 | 14.54 ± 0.95 | 60.53 ± 2.10 | 17.32 ± 1.18 | 135.96 ± 3.16 | 31.87 ± 1.40 | 0.88 ± 0.14 |
| $T_7$ | Control | 43.96 ± 1.93 | 8.49 ± 0.76 | 35 ± 1.34 | 10.02 ± 0.81 | 78.96 ± 1.96 | 18.52 ± 1.00 | 0.89 ± 0.1 |
| SEm(±) | | 4.645 | 0.883 | 4.642 | 1.452 | 7.735 | 1.968 | 0.013 |
| C.D. (0.05) | | 14.226 | 2.703 | 14.217 | 4.448 | 23.688 | 6.027 | 0.020 |

T. No. – Treatment Number; CH- Chitosan; SA-Salicylic acid; , PG- Phloroglucinol. Each figure represents mean (±SD) of three replications

**Table 28. Effect of seed biopriming on yield parameters in transplanted *O. tenuiflorum* at 90 DAS**

| T. No. | Microbes | Total leaf biomass (g plant$^{-1}$) | | Total stem biomass (g plant$^{-1}$) | | Total shoot biomass (g plant$^{-1}$) | | Harvest Index |
|---|---|---|---|---|---|---|---|---|
| | | Fresh weight | Dry weight | Fresh weight | Dry weight | Fresh weight | Dry weight | |
| $T_1$ | *BP* | 50.33 ± 1.18 | 9.76 ± 0.70 | 84.03 ± 3.03 | 23.97 ± 1.57 | 134.36 ± 2.92 | 33.30 ± 1.30 | 0.84 ± 0.14 |
| $T_2$ | *BA* | 69.83± 2.28 | 13.57 ± 1.14 | 81.5 ± 2.16 | 23.25 ± 0.97 | 151.33 ± 0.73 | 36.82 ± 0.66 | 0.87 ± 0.1 |
| $T_3$ | *PF* | 31.8 ± 0.63 | 6.16 ± 0.47 | 114.4 ± 3.38 | 32.67 ± 1.20 | 146.2 ± 2.34 | 38.84 ± 1.13 | 0.86 ± 0.17 |
| $T_4$ | *BV* | 61.33 ± 2.49 | 11.91 ± 1.15 | 76.36 ± 1.85 | 21.83 ± 1.02 | 137.7 ± 3.06 | 33.74 ± 1.50 | 0.86 ± 0.1 |
| $T_5$ | Control | 43.96 ± 1.93 | 8.49 ± 0.76 | 35.00 ± 1.34 | 10.02 ± 0.81 | 78.96 ± 1.96 | 18.52 ± 1.00 | 0.89 ± 0.1 |
| SEm(±) | | 4.049 | 0.917 | 5.557 | 1.467 | 6.450 | 1.484 | 0.019 |
| C.D. (0.05) | | 12.925 | 2.926 | 17.736 | 4.681 | 20.586 | 4.737 | NS |

T. No. – Treatment Number; *BP- Bacillus pumilus; BA - Bacillus amyloliquefaciens; PF- Pseudomonas fluorescens*; *BV-Bacillus velezensis;*
Each figure represents mean (±SD) of three replications

**Table 29. Effect of seed pretreatments on yield parameters in transplanted *O. tenuiflorum* at 90 DAS**

| T. No. | Pretreatment | Total leaf biomass (g plant$^{-1}$) | | Total stem biomass (g plant$^{-1}$) | | Total shoot biomass (g plant$^{-1}$) | | Harvest Index |
|---|---|---|---|---|---|---|---|---|
| | | Fresh weight | Dry weight | Fresh weight | Dry weight | Fresh weight | Dry weight | |
| $T_1$ | SC | 64.00 ± 3.10 | 12.31 ± 1.26 | 46.76 ± 2.49 | 13.42 ± 1.41 | 110.76 ± 1.86 | 25.73 ± 0.62 | 0.90 ± 0.00 |
| $T_2$ | WS | 66.93 ± 2.98 | 13.06 ± 1.43 | 59.66 ± 2.79 | 17.10 ± 1.56 | 126.6 ± 6.06 | 30.16 ± 2.10 | 0.92 ± 0.00 |
| $T_3$ | HW | 65.10 ± 2.64 | 12.66 ± 1.23 | 65.00 ± 1.76 | 18.56 ± 0.83 | 130.1 ± 3.14 | 31.22 ± 1.49 | 0.91 ± 0.1 |
| $T_4$ | CSA | 34.07 ± 2.41 | 6.54 ± 1.00 | 59.7 ± 1.71 | 17.03 ± 0.74 | 93.76 ± 2.93 | 23.58 ± 1.24 | 0.83 ± 0.1 |
| $T_5$ | $GA_3$ @1500 µM | 99.1 ± 2.29 | 19.15 ± 0.69 | 94.4 ± 1.12 | 26.98 ± 0.64 | 193.5 ± 2.17 | 46.13 ± 0.37 | 0.92 ± 0.14 |
| $T_6$ | $GA_3$ @3000µM | 42.46 ± 1.11 | 8.22 ± 0.5 | 81.33 ± 2.39 | 23.22 ± 1.21 | 123.8 ± 2.12 | 31.45 ± 1.17 | 0.86 ± 0.1 |
| $T_7$ | IAA @ 0.1 µM | 67.7 ± 2.92 | 13.08 ± 1.22 | 74.73 ± 2.76 | 21.39 ± 1.52 | 142.43 ± 4.02 | 34.48 ± 1.96 | 0.87 ± 0.1 |
| $T_8$ | IAA @ 1 µM | 50.2 ± 2.59 | 9.72 ± 1.13 | 81.8 ± 2.10 | 23.37 ± 1.10 | 132.0 ± 3.22 | 33.09 ± 1.50 | 0.85 ± 0.1 |
| $T_9$ | BA @ 100 µM | 71.5 ± 2.16 | 13.89 ± 1.1 | 116.5 ± 2.93 | 33.34 ± 1.65 | 188.0 ± 3.14 | 47.23 ± 1.84 | 0.88 ± 0.14 |
| $T_{10}$ | BA @ 300 µM | 73.63 ± 1.17 | 14.27 ± 0.74 | 61.13 ± 2.18 | 17.50 ± 1.22 | 134.76 ± 2.43 | 31.77 ± 1.32 | 0.92 ± 0.00 |
| $T_{11}$ | TDZ @ 200 µM | 47.53 ± 1.98 | 9.24± 0.98 | 92.63 ± 3.10 | 26.56 ± 1.81 | 140.16 ± 3.73 | 35.81 ± 2.03 | 0.83 ± 0.14 |
| $T_{12}$ | TDZ @ 400 µM | 84.81 ± 2.53 | 16.51 ± 1.31 | 104.83± 2.19 | 29.99 ± 1.33 | 189.65 ± 2.43 | 46.50 ± 1.47 | 0.87 ± 0.1 |
| $T_{13}$ | CH @ 5gL$^{-1}$ | 95.93 ± 1.00 | 18.60 ± 0.78 | 102.76± 1.37 | 29.36 ± 0.63 | 198.7 ± 1.38 | 47.96 ± 0.60 | 0.90 ± 0.1 |
| $T_{14}$ | CH @ 10 gL$^{-1}$ | 70.10 ± 1.55 | 13.57 ± 0.61 | 74.13 ± 2.65 | 21.15 ± 1.37 | 144.23 ± 2.92 | 34.73 ± 1.31 | 0.91 ± 0.00 |
| $T_{15}$ | SA @ 1500µM | 87.80 ± 1.03 | 17.02 ± 0.71 | 129.7 ± 0.98 | 37.08 ± 0.93 | 217.50 ± 1.41 | 54.10 ± 1.15 | 0.89 ± 0.00 |
| $T_{16}$ | SA @ 3000µM | 65.93 ± 2.29 | 12.83 ± 1.17 | 87.56 ± 2.85 | 25.07 ± 1.61 | 153.5 ± 3.66 | 37.91 ± 2.00 | 0.88 ± 0.1 |
| $T_{17}$ | PG @ 1µM | 79.4 ± 2.71 | 15.34 ± 1.10 | 73.2 ± 1.60 | 20.93 ± 0.97 | 152.6 ± 2.55 | 36.27 ± 1.03 | 0.89 ± 0.1 |
| $T_{18}$ | PG @ 10µM | 75.43 ± 2.61 | 14.54 ± 0.95 | 60.53 ± 2.10 | 17.32 ± 1.18 | 135.96 ± 3.16 | 31.87 ± 1.40 | 0.88 ± 0.14 |
| $T_{19}$ | *BP* | 50.33 ± 1.18 | 9.76 ± 0.70 | 84.03 ± 3.03 | 23.97 ± 1.57 | 134.36 ± 2.92 | 33.30 ± 1.30 | 0.84 ± 0.14 |
| $T_{20}$ | *BA* | 69.83 ± 2.28 | 13.57 ± 1.14 | 81.5 ± 2.16 | 23.25 ± 0.97 | 151.33 ± 0.73 | 36.82 ± 0.66 | 0.87 ± 0.1 |
| $T_{21}$ | *PF* | 31.8 ± 0.63 | 6.16 ± 0.47 | 114.4 ± 3.38 | 32.67 ± 1.20 | 146.2 ± 2.34 | 38.84 ± 1.13 | 0.86 ± 0.17 |
| $T_{22}$ | *BV* | 61.33 ± 2.49 | 11.91 ± 1.15 | 76.36 ± 1.85 | 21.83 ± 1.02 | 137.7 ± 3.06 | 33.74 ± 1.50 | 0.86 ± 0.1 |
| $T_{23}$ | Control | 43.96 ± 1.93 | 8.49 ± 0.76 | 35 ± 1.34 | 10.02 ± 0.81 | 78.96 ± 1.96 | 18.52 ± 1.00 | 0.89 ± 0.1 |
| SEm(±) | | 5.536 | 1.133 | 5.760 | 1.733 | 9.056 | 2.314 | 0.015 |
| C.D. (0.05) | | 15.809 | 3.236 | 16.450 | 4.949 | 25.862 | 6.608 | 0.044 |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; GA- Gibberellic acid; IAA- Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; CH-Chitosan; SA-Salicylic acid; , PG- Phloroglucinol; *BP- Bacillus pumilus; Bacillus amyloliquefaciens; PF- Pseudomonas fluorescens*; *BV-Bacillus velezensis.* Each figure represents mean (±SD) of three replications

**Table 30. Effect of physical treatments on seed germination and growth parameters of seedling of *Ocimum basilicum***

| T. No. | Physical treatment | Gn (%) | S (%) | GI | MGT (Days) | SL (cm) | RL (cm) | Sdl L (cm) | AI | SVI |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | SC | 49.33±2.19 | 49.33±2.19 | 10.93±0.95 | 6.50±0.67 | 17.83±0.26 | 13.77±0.67 | 31.60±0.63 | 0.77±0.17 | 15.57±1.18 |
| $T_2$ | WS | 55.33±3.11 | 55.33±3.11 | 16.13±1.72 | 4.73±0.38 | 19.23±1.08 | 14.60±1.41 | 33.83±1.77 | 0.75±0.24 | 18.27±1.61 |
| $T_3$ | HW | 52.67±2.09 | 52.67±2.09 | 12.47±0.96 | 5.10±0.00 | 18.50±0.61 | 15.47±0.64 | 33.96±0.88 | 0.84±0.1 | 17.95±1.36 |
| $T_4$ | CSA | 32.00±2.03 | 32.00±2.03 | 4.67±0.76 | 6.03±0.17 | 17.60±0.44 | 15.30±0.44 | 32.90±0.63 | 0.86±0.1 | 10.53±1.19 |
| $T_5$ | Control | 58.67±2.16 | 58.67±2.16 | 16.00±1.20 | 5.20±0.31 | 15.27± 0.50 | 13.03±0.58 | 28.30±0.74 | 0.85±0.14 | 16.56±1.03 |
| SEm(±) | | 5.918 | 5.918 | 1.606 | 0.222 | 0.574 | 0.945 | 1.497 | 0.003 | 1.425 |
| C.D. (0.05) | | NS | NS | 5.126 | 0.707 | 1.882 | NS | NS | NS | 4.718 |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; Gn- germination; S- Survival; GI- Germination Index; MGT- Mean Germination Time; SL- shoot length; RL- Root length; Sdl L- Seedling Length; SVI- Seedling Vigour Index; AI- Allometric Index; Each figure represents mean (±SD) of three replications

**Table 31. Effect of hormonal priming on seed germination and growth parameters of seedling of *Ocimum basilicum***

| T. No. | Hormones | Gn (%) | S (%) | GI | MGT (Days) | SL (cm) | RL (cm) | Sdl L (cm) | AI | SVI |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | $GA_3$ @ 1500 µM | 34.00±1.07 | 34.00±1.07 | 8.17±0.57 | 5.10±0.31 | 17.40±0.80 | 12.87±0.61 | 30.26±0.53 | 0.74±0.22 | 10.28±0.5 |
| $T_2$ | $GA_3$ @ 3000 µM | 39.33±1.46 | 39.33±1.46 | 9.20±0.91 | 5.20±0.31 | 22.10±0.47 | 16.93±0.70 | 39.03±0.85 | 0.77±0.14 | 15.36±0.99 |
| $T_3$ | IAA @ 0.1 µM | 32.00±2.84 | 32.00±2.84 | 7.13±1.28 | 5.23±0.26 | 18.33±0.62 | 14.70±0.98 | 33.03±1.13 | 0.80±0.2 | 10.44±1.52 |
| $T_4$ | IAA @ 1 µM | 35.33±1.70 | 35.33±1.70 | 8.27±0.76 | 5.17±0.17 | 19.03±0.93 | 15.57±0.62 | 34.60±1.11 | 0.88±0.14 | 12.19±0.93 |
| $T_5$ | BA @ 100 µM | 37.33±1.92 | 37.33±1.92 | 8.97±0.94 | 5.10±0.00 | 20.00±0.84 | 14.23±0.86 | 34.23±1.18 | 0.71±0.14 | 12.68±0.92 |
| $T_6$ | BA @ 300 µM | 80.67±1.82 | 80.67±1.82 | 29.33±1.36 | 4.10±0.24 | 17.50±0.74 | 14.37±0.74 | 31.86±0.98 | 0.82±0.17 | 25.75±1.28 |
| $T_7$ | TDZ @ 200 µM | 40.67±1.32 | 40.67±1.32 | 12.87±1.00 | 4.50±0.34 | 17.40±1.00 | 13.83±0.81 | 31.23±1.24 | 0.80±0.17 | 12.72±0.98 |
| $T_8$ | TDZ @ 400 µM | 35.33±2.09 | 35.33±2.09 | 7.83±1.22 | 5.33±0.42 | 17.17±0.53 | 12.57±0.76 | 29.73±0.83 | 0.73±0.17 | 10.56±1.25 |
| $T_9$ | Control | 58.67±2.16 | 58.67±2.16 | 16.00±1.20 | 5.20±0.31 | 15.27±0.50 | 13.03±0.58 | 28.30±0.74 | 0.85±0.14 | 16.56±1.03 |
| SEm(±) | | 4.079 | 4.079 | 1.224 | 0.090 | 0.611 | 0.602 | 1.055 | 0.030 | 1.299 |
| C.D. (0.05) | | 12.215 | 12.215 | 3.664 | 0.270 | 1.831 | 1.803 | 3.160 | NS | 3.888 |

T. No. – Treatment Number; GA- Giberellic acid; IAA- Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; Gn- germination; S- Survival; GI- Germination Index; MGT- Mean Germination Time; SL- shoot length; RL- Root length; Sdl L- Seedling Length; SVI- Seedling Vigour Index; AI- Allometric Index; Each figure represents mean (±SD) of three replications

**Table 32. Effect of biostimulant priming on seed germination and growth parameters of seedling of *Ocimum basilicum***

| T. No. | Biostimulant | Gn (%) | S (%) | GI | MGT (Days) | SL (cm) | RL (cm) | Sdl L (cm) | AI | SVI |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | CH@5gL$^{-1}$ | 62.00±2.24 | 62.00±2.24 | 21.17±1.28 | 4.43±0.36 | 19.60±0.62 | 14.73±0.46 | 34.33±0.74 | 0.75±0.10 | 21.31±1.36 |
| $T_2$ | CH@10 gL$^{-1}$ | 52.00±2.14 | 52.00±2.14 | 17.87±1.56 | 4.50±0.44 | 18.36±0.28 | 16.43±0.41 | 34.80±0.38 | 0.89±0.10 | 18.08±1.23 |
| $T_3$ | SA@1500µM | 75.33±1.15 | 75.33±1.15 | 27.53±1.02 | 4.10±0.31 | 20.37±0.70 | 14.83±0.36 | 35.20±0.70 | 0.73±0.14 | 27.92±0.93 |
| $T_4$ | SA@3000µM | 79.33±1.54 | 79.33±1.54 | 27.43±1.12 | 4.27±0.26 | 18.60±0.41 | 17.07±0.43 | 35.66±0.57 | 0.92±0.10 | 26.86±0.46 |
| $T_5$ | PG@1µM | 73.66±1.28 | 73.66±1.28 | 39.63±2.05 | 3.23±0.34 | 17.43±0.74 | 14.67±0.48 | 32.10±0.84 | 0.84±0.14 | 24.89±1.49 |
| $T_6$ | PG@10µM | 59.33±1.32 | 59.33±1.32 | 28.30±1.11 | 3.47±0.30 | 19.93±0.30 | 15.00±1.60 | 34.93±1.60 | 0.75±0.36 | 20.81±1.45 |
| $T_7$ | Control | 58.67±2.16 | 58.67±2.16 | 16.00±1.20 | 5.20±0.31 | 15.27±0.50 | 13.03±0.58 | 28.30±0.74 | 0.85±0.14 | 16.56±1.03 |
| SEm(±) | | 3.420 | 3.420 | 2.165 | 0.122 | 0.346 | 1.000 | 1.083 | 0.051 | 1.380 |
| C.D. (0.05) | | 10.475 | 10.475 | 6.630 | 0.374 | 1.058 | NS | 3.318 | NS | 4.227 |

T. No. – Treatment Number; CH- Chitosan; SA-Salicylic acid; , PG- Phloroglucinol; Gn- germination; S- Survival; GI- Germination Index; MGT- Mean Germination Time; SL- shoot length; RL- Root length; Sdl L- Seedling Length; SVI- Seedling Vigour Index; AI- Allometric Index; Each figure represents mean (±SD) of three replications

**Table 33. Effect of biopriming on seed germination and growth parameters of seedling of *Ocimum basilicum***

| T. No. | Microbes | Gn (%) | S (%) | GI | MGT (Days) | SL (cm) | RL (cm) | Sdl L (cm) | AI | SVI |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | *BP* | 58.00±3.14 | 58.00±3.14 | 19.80±1.83 | 4.30±0.00 | 18.13±0.76 | 14.33±0.88 | 32.46±1.14 | 0.79±0.17 | 18.76±1.72 |
| $T_2$ | *BA* | 80.67±1.87 | 80.67±1.87 | 40.20±1.37 | 3.57±0.47 | 19.80±0.54 | 18.83±0.51 | 38.63±0.7 | 0.95±0.10 | 31.15±1.14 |
| $T_3$ | *PF* | 76.67±2.60 | 76.67±2.60 | 32.40±2.34 | 3.90±0.56 | 20.70±0.74 | 18.27±0.30 | 38.96±0.78 | 0.88±0.14 | 29.84±1.56 |
| $T_4$ | *BV* | 82.00±2.24 | 82.00±2.24 | 42.60±1.79 | 3.50±0.51 | 19.67±0.67 | 17.83±0.62 | 37.50±0.58 | 0.91±0.20 | 30.72±1.27 |
| $T_5$ | Control | 58.67±2.16 | 58.67±2.16 | 16.00±1.20 | 5.20±0.31 | 15.27±0.50 | 13.03±0.58 | 28.30±0.74 | 0.8±0.14 | 16.56±1.03 |
| SEm(±) | | 6.367 | 6.367 | 3.406 | 0.218 | 0.451 | 0.439 | 0.745 | 0.025 | 2.021 |
| C.D. (0.05) | | 20.321 | 20.321 | 10.870 | 0.696 | 1.439 | 1.400 | 2.377 | 0.079 | 6.451 |

T. No. – Treatment Number; *BP- Bacillus pumilus; BA - Bacillus Amyloliquefaciens; PF- Pseudomonas fluorescens*; *BV-Bacillus velezensis;* SA- Salicylic acid; , PG- Phloroglucinol; Gn- germination; S- Survival; GI- Germination Index; MGT- Mean Germination Time; SL- shoot length; RL- Root length; Sdl L- Seedling Length; SVI- Seedling Vigour Index; AI- Allometric Index; Each figure represents mean (±SD) of three replications

**Table 34. Effect of various pretreatments on seed germination and growth parameters of seedling of *Ocimum basilicum***

| T. No. | Pretreatment | Gn (%) | S (%) | GI | MGT (Days) | SL (cm) | RL (cm) | Sdl L (cm) | AI | SVI |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | SC | 49.33±2.19 | 49.33 ± 2.19 | 10.93±0.95 | 6.50±0.67 | 17.83±0.26 | 13.77±0.67 | 31.60±0.63 | 0.77±0.17 | 15.57±1.18 |
| $T_2$ | WS | 55.33±3.11 | 55.33 ± 3.11 | 16.13±1.72 | 4.73± 0.38 | 19.23±1.08 | 14.60±1.41 | 33.83±1.77 | 0.75±0.24 | 18.27±1.61 |
| $T_3$ | HW | 52.67±2.09 | 52.67 ± 2.09 | 12.47±0.96 | 5.10± 0.00 | 18.50±0.61 | 15.47±0.64 | 33.96±0.88 | 0.84±0.10 | 17.95±1.36 |
| $T_4$ | CSA | 32.00±2.03 | 32.00 ± 2.03 | 4.67 ± 0.76 | 6.03± 0.17 | 17.60±0.44 | 15.30±0.44 | 32.90±0.63 | 0.86±0.10 | 10.53±1.19 |
| $T_5$ | $GA_3$ @1500 µM | 34.00±1.07 | 34.00 ± 1.07 | 8.17 ± 0.57 | 5.10± 0.31 | 17.40±0.80 | 12.87±0.61 | 30.26±0.53 | 0.74±0.22 | 10.28±0.50 |
| $T_6$ | $GA_3$ @3000µM | 39.33±1.46 | 39.33 ± 1.46 | 9.20 ± 0.91 | 5.20± 0.31 | 22.10±0.47 | 16.93±0.70 | 39.03±0.85 | 0.77±0.14 | 15.36±0.99 |
| $T_7$ | IAA @ 0.1 µM | 32.00±2.84 | 32.00 ± 2.84 | 7.13 ± 1.28 | 5.23± 0.26 | 18.33±0.62 | 14.70±0.98 | 33.03±1.13 | 0.80±0.20 | 10.44±1.52 |
| $T_8$ | IAA @ 1 µM | 35.33±1.70 | 35.33 ± 1.70 | 8.27 ± 0.76 | 5.17± 0.17 | 19.03±0.93 | 15.57±0.62 | 34.60±1.11 | 0.88 ±0.14 | 12.19±0.93 |
| $T_9$ | BA @ 100 µM | 37.33±1.92 | 37.33 ± 1.92 | 8.97 ± 0.94 | 5.10± 0.00 | 20.00±0.84 | 14.23±0.86 | 34.23±1.18 | 0.71±0.14 | 12.68±0.92 |
| $T_{10}$ | BA @ 300 µM | 80.67±1.82 | 80.67 ± 1.82 | 29.33±1.36 | 4.10± 0.24 | 17.50±0.74 | 14.37±0.74 | 31.86±0.98 | 0.82±0.17 | 25.75±1.28 |
| $T_{11}$ | TDZ @ 200 µM | 40.67±1.32 | 40.67 ± 1.32 | 12.87±1.00 | 4.50± 0.34 | 17.40±1.00 | 13.83±0.81 | 31.23±1.24 | 0.80±0.17 | 12.72±0.98 |
| $T_{12}$ | TDZ @ 400 µM | 35.33±2.09 | 35.33 ± 2.09 | 7.83±1.22 | 5.33± 0.42 | 17.17±0.53 | 12.57±0.76 | 29.73±0.83 | 0.73±0.17 | 10.56±1.25 |
| $T_{13}$ | CH @ $5gL^{-1}$ | 62.00±2.24 | 62.00 ± 2,24 | 21.17±1.28 | 4.43± 0.36 | 19.60±0.62 | 14.73±0.46 | 34.33±0.74 | 0.75±0.10 | 21.31±1.36 |
| $T_{14}$ | CH @ 10 $gL^{-1}$ | 52.00±2.14 | 52.00 ± 2.14 | 17.87±1.56 | 4.50± 0.44 | 18.36±0.28 | 16.43±0.41 | 34.80±0.38 | 0.89±0.10 | 18.08±1.23 |
| $T_{15}$ | SA @ 1500µM | 75.33±1.15 | 75.33 ± 1.15 | 27.53±1.02 | 4.10± 0.31 | 20.37±0.70 | 14.83±0.36 | 35.20±0.7 | 0.73±0.14 | 27.92±0.93 |
| $T_{16}$ | SA @ 3000µM | 79.33±1.54 | 79.33 ± 1.54 | 27.43±1.12 | 4.27± 0.26 | 18.60±0.41 | 17.07±0.43 | 35.66±0.57 | 0.92±0.10 | 26.86±0.46 |
| $T_{17}$ | PG @ 1µM | 73.66±1.28 | 73.66 ± 1.28 | 39.63±2.05 | 3.23± 0.34 | 17.43±0.74 | 14.67±0.48 | 32.10±0.84 | 0.84±0.14 | 24.89±1.49 |
| $T_{18}$ | PG @ 10µM | 59.33±1.32 | 59.33 ± 1.32 | 28.30±1.11 | 3.47± 0.30 | 19.93±0.3 | 15.00±1.60 | 34.93±1.60 | 0.75±0.36 | 20.81±1.45 |
| $T_{19}$ | *BP* | 58.00±3.14 | 58.00 ± 3.14 | 19.80±1.83 | 4.30± 0.00 | 18.13±0.76 | 14.33±0.88 | 32.46±1.14 | 0.79±0.17 | 18.76±1.72 |
| $T_{20}$ | *BA* | 80.67±1.87 | 80.67 ± 1.87 | 40.20±1.37 | 3.57± 0.47 | 19.80±0.54 | 18.83±0.51 | 38.63±0.7 | 0.95±0.10 | 31.15±1.14 |
| $T_{21}$ | *PF* | 76.67±2.60 | 76.67 ± 2.60 | 32.40±2.34 | 3.90± 0.56 | 20.70±0.74 | 18.27±0.3 | 38.96±0.78 | 0.88±0.14 | 29.84±1.56 |
| $T_{22}$ | *BV* | 82.00±2.24 | 82.00 ± 2.24 | 42.60±1.79 | 3.50± 0.51 | 19.67±0.67 | 17.83±0.62 | 37.50±0.58 | 0.91±0.20 | 30.72±1.27 |
| $T_{23}$ | Control | 58.67±2.16 | 58.67 ± 2.16 | 16.00±1.20 | 5.20± 0.31 | 15.27±0.50 | 13.03±0.58 | 28.30±0.74 | 0.85±0.14 | 16.56±1.03 |
| SEm(±) | | 4.864 | 4.864 | 2.196 | 0.166 | 0.538 | 0.817 | 1.166 | 0.038 | 1.627 |
| C.D. (0.05) | | 13.890 | 13.890 | 6.271 | 0.473 | 1.537 | 2.332 | 3.331 | 0.110 | 4.664 |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; GA- Giberellic acid; IAA- Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; CH-Chitosan; SA-Salicylic acid; , PG- Phloroglucinol; *BP- Bacillus pumilus; Bacillus Amyloliquefaciens; PF- Pseudomonas fluorescens*; *BV-Bacillus velezensi;* Gn- germination; S- Survival; GI- Germination Index; MGT- Mean Germination Time; SL- shoot length; RL- Root length; Sdl L- Seedling Length; SVI- Seedling Vigour Index; AI- Allometric Index; Each figure represents mean (±SD) of three replications

**Table 35. Effect of physical seed treatments on plant height and number of branches in transplanted *O. basilicum***

| T. No. | Physical treatment | Plant height (cm) | | | Number of branches | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | SC | 17.83 ± 0.26 | 25.77 ± 0.26 | 60.10 ± 1.63 | - | 13.77 ± 1.16 | 14.67 ± 1.54 |
| $T_2$ | WS | 19.23 ± 1.08 | 24.20 ± 0.8 | 57.27 ± 1.17 | - | 13.33 ± 0.81 | 15.33 ± 1.32 |
| $T_3$ | HW | 18.50 ± 0.61 | 24.90 ± 0.51 | 56.83 ± 1.45 | - | 13.53 ± 0.88 | 13.33 ± 1.54 |
| $T_4$ | CSA | 17.60 ± 0.44 | 26.97 ± 1.17 | 57.83 ± 1.86 | - | 12.87 ± 0.65 | 16.00 ± 1.07 |
| $T_5$ | Control | 15.27 ± 0.50 | 27.50 ± 0.56 | 52.40 ± 1. 22 | - | 12.20 ± 0.64 | 12.63 ± 1.23 |
| SEm(±) | | 0.574 | 0.707 | 2.356 | - | 0.810 | 1.915 |
| C.D. (0.05) | | 1.882 | 2.258 | NS | - | NS | NS |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; DAS- Days after sowing.
Each figure represents mean (±SD) of three replications

**Table 36. Effect of physical seed treatments on basal stem girth and number of nodes in transplanted *O. basilicum***

| T. No. | Physical treatment | Basal stem girth (cm) | | | Number of nodes | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | SC | 0.80 ± 0.24 | 1.40 ± 0.24 | 3.10 ± 0.38 | 14.00 ± 1.07 | 51.30 ± 1.07 | 174.00 ± 2.82 |
| $T_2$ | WS | 0.77 ± 0.17 | 1.27 ± 0.3 | 3.10 ± 0.41 | 11.33 ± 1.15 | 45.60 ± 1.44 | 160.00 ± 2.03 |
| $T_3$ | HW | 0.73 ± 0.17 | 1.43 ± 0.26 | 4.00 ± 0.51 | 11.33 ± 1.15 | 49.07 ± 1.25 | 168.67 ± 2.74 |
| $T_4$ | CSA | 0.73 ± 0.17 | 1.23 ± 0.17 | 3.23 ± 0.44 | 10.00 ± 1.41 | 46.40 ± 1.15 | 158.00 ± 1.51 |
| $T_5$ | Control | 0.80 ± 0.24 | 1.47 ± 0.26 | 2.60 ± 0.38 | 7.33 ± 0.81 | 53.67 ± 1.09 | 173.97 ± 3.11 |
| SEm(±) | | 0.045 | 0.065 | 0.194 | 1.366 | 1.508 | 6.906 |
| C.D. (0.05) | | NS | NS | 0.619 | NS | NS | NS |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; DAS- Days after sowing.
Each figure represents mean (±SD) of three replications

**Table 37. Effect of hormonal seed priming on plant height and number of branches in transplanted *O. basilicum***

| T. No. | Hormones | Plant height (cm) | | | Number of branches | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | $GA_3$ @ 1500 µM | 17.40 ± 0.80 | 26.40 ± 1.03 | 59.33 ± 1.19 | - | 13.10 ± 0.76 | 16.33 ± 0.93 |
| $T_2$ | $GA_3$ @ 3000 µM | 22.10 ± 0.47 | 28.27 ± 0.81 | 57.20 ± 1.52 | - | 13.77 ± 0.97 | 18.00 ± 1.07 |
| $T_3$ | IAA @ 0.1 µM | 18.33 ± 0.62 | 30.20 ± 0.38 | 58.73 ± 1.81 | - | 14.10 ± 0.63 | 16.00 ± 1.07 |
| $T_4$ | IAA @ 1 µM | 19.03 ± 0.93 | 29.20 ± 0.72 | 61.43 ± 1.31 | - | 14.17 ± 0.9 | 13.33 ± 1.54 |
| $T_5$ | BA @ 100 µM | 20.00 ± 0.84 | 31.93 ± 0.88 | 61.77 ± 1.5 | - | 14.07 ± 0.88 | 12.67 ± 1.32 |
| $T_6$ | BA @ 300 µM | 17.50 ± 0.74 | 30.47 ± 0.87 | 55.03 ± 2.33 | - | 13.10 ± 0.76 | 16.67 ± 1.32 |
| $T_7$ | TDZ @ 200 µM | 17.40 ± 1.00 | 26.07 ± 0.57 | 56.67 ± 1.58 | - | 10.17 ± 1.17 | 16.00 ± 1.86 |
| $T_8$ | TDZ @ 400 µM | 17.17 ± 0.53 | 29.00 ± 0.77 | 60.10 ± 1.14 | - | 13.10 ± 0.76 | 14.67 ± 1.32 |
| $T_9$ | Control | 15.27 ± 0.50 | 27.50 ± 0.56 | 52.40 ± 1. 22 | - | 12.20 ± 0.64 | 12.63 ± 1.23 |
| SEm(±) | | 0.611 | 0.639 | 2.716 | - | 0.778 | 1.912 |
| C.D. (0.05) | | 1.831 | 1.912 | NS | - | 2.330 | NS |

T. No. – Treatment Number; GA- Giberellic acid; IAA- Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; DAS- Days after sowing.
Each figure represents mean (±SD) of three replications

**Table 38. Effect of hormonal seed primimg on basal stem girth and number of nodes in transplanted *O. basilicum***

| T. No. | Hormones | Basal stem girth (cm) | | | Number of nodes | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | $GA_3$ @ 1500 µM | 0.90 ± 0.24 | 1.20 ± 0.31 | 3.17 ± 0.34 | 8.00 ± 1.07 | 46.07 ± 1.66 | 159.33 ± 1.32 |
| $T_2$ | $GA_3$ @ 3000 µM | 0.90 ± 0.38 | 1.43 ± 0.3 | 3.80 ± 0.34 | 8.00 ± 1.07 | 54.63 ± 1.58 | 159.33 ± 2.16 |
| $T_3$ | IAA @ 0.1 µM | 0.67 ± 0.24 | 1.43 ± 0.17 | 2.90 ± 0.34 | 6.67 ± 0.81 | 55.07 ± 1.37 | 160.00 ± 1.51 |
| $T_4$ | IAA @ 1 µM | 0.73 ± 0.17 | 1.43 ± 0.17 | 3.30 ± 0.38 | 7.33 ± 0.81 | 56.40 ± 1.08 | 161.33 ± 2.19 |
| $T_5$ | BA @ 100 µM | 0.90 ± 0.00 | 1.50 ± 0.34 | 3.97 ± 0.3 | 7.67 ± 0.93 | 49.73 ± 1.65 | 160.67 ± 1.54 |
| $T_6$ | BA @ 300 µM | 0.90 ± 0.24 | 1.57 ± 0.3 | 3.70 ± 0.53 | 9.33 ± 1.15 | 48.20 ± 1.99 | 155.33 ± 2.33 |
| $T_7$ | TDZ @ 200 µM | 0.77 ± 0.34 | 1.37 ± 0.34 | 2.73 ± 0.51 | 8.00 ± 1.07 | 44.63 ± 2.21 | 162.67 ± 1.70 |
| $T_8$ | TDZ @ 400 µM | 0.93 ± 0.17 | 1.53 ± 0.26 | 4.03 ± 0.47 | 10.00 ± 1,07 | 54.87 ± 1.06 | 158.67 ± 1.54 |
| $T_9$ | Control | 0.80 ± 0.24 | 1.47 ± 0.26 | 2.60 ± 0.38 | 7.33 ± 0.81 | 53.67 ± 1.09 | 173.97 ± 3.11 |
| SEm(±) | | 0.085 | 0.085 | 0.185 | 1.012 | 2.769 | 4.680 |
| C.D. (0.05) | | NS | NS | 0.554 | NS | NS | NS |

T. No. – Treatment Number; GA- Giberellic acid; IAA- Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; DAS- Days after sowing.
Each figure represents mean (±SD) of three replications

**Table 39. Effect of biostimulant seed priming on plant height and number of branches in transplanted *O. basilicum***

| T. No. | Biostimulants | Plant height (cm) | | | Number of branches | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | CH @ 5gL$^{-1}$ | 19.60 ± 0.62 | 29.60 ± 0.72 | 61.67 ± 1.68 | - | 14.20 ± 0.99 | 16.00 ± 1.07 |
| $T_2$ | CH @ 10 gL$^{-1}$ | 18.36 ± 0.28 | 30.40 ± 0.6 | 60.46 ± 1.21 | - | 13.33 ± 1.32 | 19.33 ± 1.32 |
| $T_3$ | SA @ 1500µM | 20.37 ± 0.70 | 27.90 ± 0.67 | 57.90 ± 1.37 | - | 12.10 ± 0.31 | 15.33 ± 1.32 |
| $T_4$ | SA @ 3000µM | 18.60 ± 0.41 | 29.33 ± 1.13 | 54.63 ± 1.56 | - | 13.20 ± 0.81 | 18.87 ± 1.12 |
| $T_5$ | PG @ 1µM | 17.43 ± 0.74 | 36.03 ± 0.64 | 58.33 ± 1.53 | - | 15.63 ± 0.7 | 17.33 ± 1.54 |
| $T_6$ | PG @ 10µM | 19.93 ± 0.3 | 31.53 ± 1.05 | 59.00 ± 1.79 | - | 13.73 ± 0.76 | 18.67 ± 1.70 |
| $T_7$ | Control | 15.27 ± 0.50 | 27.50 ± 0.56 | 52.40 ± 1. 22 | - | 12.20 ± 0.64 | 12.63 ± 1.23 |
| SEm(±) | | 0.346 | 0.736 | 2.323 | - | 0.870 | 1.917 |
| C.D. (0.05) | | 1.058 | 2.255 | NS | - | NS | NS |

T. No. – Treatment Number; CH- Chitosan; SA-Salicylic acid; , PG- Phloroglucinol; DAS- Days after sowing. Each figure represents mean (±SD) of three replications

**Table 40. Effect of biostimulants priming seed primimg on basal stem girth and number of nodes in transplanted *O. basilicum***

| T. No. | Biostimulants | Basal stem girth (cm) | | | Number of nodes | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | CH @ 5gL$^{-1}$ | 0.83 ± 0.36 | 1.67 ± 0.26 | 4.37 ± 0.61 | 10.67 ± 1.15 | 48.40 ± 2.42 | 165.33 ± 2.41 |
| $T_2$ | CH @ 10 gL$^{-1}$ | 0.73 ± 0.17 | 1.40 ± 0.24 | 4.73 ± 0.44 | 10.67 ± 1.15 | 48.73 ± 1.03 | 162.67 ± 2.09 |
| $T_3$ | SA @ 1500µM | 0.73 ± 0.3 | 1.40 ± 0.24 | 3.03 ± 0.38 | 10.00 ± 1.51 | 52.20 ± 0.76 | 154.67 ± 1.92 |
| $T_4$ | SA @ 3000µM | 1.23 ± 0.34 | 1.47 ± 0.26 | 2.43 ± 0.3 | 10.67 ± 0.81 | 46.17 ± 1.10 | 189.73 ± 3.26 |
| $T_5$ | PG @ 1µM | 0.80 ± 0.00 | 1.63 ± 0.36 | 3.17 ± 0.42 | 10.00 ± 1.07 | 53.97 ± 1.29 | 160.00 ± 2.03 |
| $T_6$ | PG @ 10µM | 0.87 ± 0.17 | 1.43 ± 0.17 | 2.93 ± 0.38 | 8.67 ± 1.32 | 50.20 ± 1.57 | 166.00 ± 2.53 |
| $T_7$ | Control | 0.80 ± 0.24 | 1.47 ± 0.26 | 2.60 ± 0.38 | 7.33 ± 0.81 | 53.67 ± 1.09 | 173.97 ± 3.11 |
| SEm(±) | | 0.081 | 0.075 | 0.205 | 1.425 | 2.625 | 6.897 |
| C.D. (0.05) | | 0.247 | 0.21 | 0.627 | NS | NS | NS |

T. No. – Treatment Number; CH- Chitosan; SA-Salicylic acid; , PG- Phloroglucinol; DAS- Days after sowing. Each figure represents mean (±SD) of three replications

**Table 41. Effect of biopriming of seeds on plant height and number of branches in transplanted *O. basilicum***

| T. No. | Microbes | Plant height (cm) | | | Number of branches | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | *Bacillus pumilus (BP)* | 18.13 ± 0.76 | 26.40 ± 0.64 | 56.70 ± 1.77 | - | 12.43 ± 0.98 | 12.00 ± 1.07 |
| $T_2$ | *Bacillus amyloliquefaciens (BA)* | 19.80 ± 0.54 | 28.43 ± 0.72 | 54.37 ± 1.42 | - | 11.63 ± 0.7 | 19.20 ± 0.78 |
| $T_3$ | *Pseudomonas fluorescens (PF)* | 20.70 ± 0.74 | 29.47 ± 1.03 | 56.13 ± 1.17 | - | 12.30 ± 0.76 | 20.40 ± 0.7 |
| $T_4$ | *Bacillus velezensis (BV)* | 19.67 ± 0.67 | 27.80 ± 0.64 | 57.13 ± 1.55 | - | 10.73 ± 0.83 | 18.87 ± 1.27 |
| $T_5$ | Control | 15.27 ± 0.50 | 27.50 ± 0.56 | 52.40 ± 1. 22 | - | 12.20 ± 0.64 | 12.63 ± 1.23 |
| SEm(±) | | 0.451 | 0.609 | 2.191 | - | 0.661 | 1.175 |
| C.D. (0.05) | | 1.439 | 1.943 | NS | - | NS | 3.752 |

T. No. – Treatment Number; DAS- Days after sowing. Each figure represents mean (±SD) of three replications

**Table 42. Effect of bioprimimg of seeds on basal stem girth and number of nodes in transplanted *O. basilicum***

| T. No. | Biopriming | Basal stem girth (cm) | | | Number of nodes | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | *Bacillus pumilus (BP)* | 0.93 ± 0.3 | 1.40 ± 0.24 | 2.93 ± 0.3 | 9.33 ± 1.32 | 60.87 ± 1.67 | 149.33 ± 3.15 |
| $T_2$ | *Bacillus amyloliquefaciens (BA)* | 0.93 ± 0.26 | 1.53 ± 0.26 | 2.70 ± 0.24 | 12.67 ± 1.32 | 48.87 ± 1.39 | 197.30 ± 1.91 |
| $T_3$ | *Pseudomonas fluorescens (PF)* | 1.03 ± 0.26 | 1.37 ± 0.17 | 2.67 ± 0.34 | 13.33 ± 0.81 | 52.87 ± 0.9 | 205.30 ± 2.13 |
| $T_4$ | *Bacillus velezensis (BV)* | 0.93 ± 0.3 | 1.50 ± 0.31 | 3.00 ± 0.47 | 12.00 ± 1.07 | 57.10 ± 1.04 | 197.87 ± 2.89 |
| $T_5$ | Control | 0.80 ± 0.24 | 1.47 ± 0.26 | 2.60 ± 0.38 | 7.33 ± 0.81 | 53.67 ± 1.09 | 173.97 ± 3.11 |
| SEm(±) | | 0.075 | 0.068 | 0.143 | 1.300 | 1.725 | 7.717 |
| C.D. (0.05) | | NS | NS | NS | 4.148 | 5.507 | 24.630 |

T. No. – Treatment Number; DAS- Days after sowing. Each figure represents mean (±SD) of three replications

**Table 43. Effect of various seed pretreatments on plant height and number of branches in transplanted *O. basilicum***

| T. No. | Pretreatment | Plant height (cm) | | | Number of branches | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | SC | 17.83 ± 0.26 | 25.77 ± 0.26 | 60.10 ± 1.63 | - | 13.77 ± 1.16 | 14.67 ± 1.54 |
| $T_2$ | WS | 19.23 ± 1.08 | 24.20 ± 0.8 | 57.27 ± 1.17 | - | 13.33 ± 0.81 | 15.33 ± 1.32 |
| $T_3$ | HW | 18.50 ± 0.61 | 24.90 ± 0.51 | 56.83 ± 1.45 | - | 13.53 ± 0.88 | 13.33 ± 1.54 |
| $T_4$ | CSA | 17.60 ± 0.44 | 26.97 ± 1.17 | 57.83 ± 1.86 | - | 12.87 ± 0.65 | 16.00 ± 1.07 |
| $T_5$ | $GA_3$ @1500 µM | 17.40 ± 0.80 | 26.40 ± 1.03 | 59.33 ± 1.19 | - | 13.10 ± 0.76 | 16.33 ± 0.93 |
| $T_6$ | $GA_3$ @3000µM | 22.10 ± 0.47 | 28.27 ± 0.81 | 57.20 ± 1.52 | - | 13.77 ± 0.97 | 18.00 ± 1.07 |
| $T_7$ | IAA @ 0.1 µM | 18.33 ± 0.62 | 30.20 ± 0.38 | 58.73 ± 1.81 | - | 14.10 ± 0.63 | 16.00 ± 1.07 |
| $T_8$ | IAA @ 1 µM | 19.03 ± 0.93 | 29.20 ± 0.72 | 61.43 ± 1.31 | - | 14.17 ± 0.9 | 13.33 ± 1.54 |
| $T_9$ | BA @ 100 µM | 20.00 ± 0.84 | 31.93 ± 0.88 | 61.77 ± 1.5 | - | 14.07 ± 0.88 | 12.67 ± 1.32 |
| $T_{10}$ | BA @ 300 µM | 17.50 ± 0.74 | 30.47 ± 0.87 | 55.03 ± 2.33 | - | 13.10 ± 0.76 | 16.67 ± 1.32 |
| $T_{11}$ | TDZ @ 200 µM | 17.40 ± 1.00 | 26.07 ± 0.57 | 56.67 ± 1.58 | - | 10.17 ± 1.17 | 16.00 ± 1.86 |
| $T_{12}$ | TDZ @ 400 µM | 17.17 ± 0.53 | 29.00 ± 0.77 | 60.10 ± 1.14 | - | 13.10 ± 0.76 | 14.67 ± 1.32 |
| $T_{13}$ | CH @ $5gL^{-1}$ | 19.60 ± 0.62 | 29.60 ± 0.72 | 61.67 ± 1.68 | - | 14.20 ± 0.99 | 16.00 ± 1.07 |
| $T_{14}$ | CH @ 10 $gL^{-1}$ | 18.36 ± 0.28 | 30.40 ± 0.6 | 60.46 ± 1.21 | - | 13.33 ± 1.32 | 19.33 ± 1.32 |
| $T_{15}$ | SA @ 1500µM | 20.37 ± 0.70 | 27.90 ± 0.67 | 57.90 ± 1.37 | - | 12.10 ± 0.31 | 15.33 ± 1.32 |
| $T_{16}$ | SA @ 3000µM | 18.60 ± 0.41 | 29.33 ± 1.13 | 54.63 ± 1.56 | - | 13.20 ± 0.81 | 18.87 ± 1.12 |
| $T_{17}$ | PG @ 1µM | 17.43 ± 0.74 | 36.03 ± 0.64 | 58.33 ± 1.53 | - | 15.63 ± 0.7 | 17.33 ± 1.54 |
| $T_{18}$ | PG @ 10µM | 19.93 ± 0.3 | 31.53 ± 1.05 | 59.00 ± 1.79 | - | 13.73 ± 0.76 | 18.67 ± 1.70 |
| $T_{19}$ | *Bacillus pumilus (BP)* | 18.13 ± 0.76 | 26.40 ± 0.64 | 56.70 ± 1.77 | - | 12.43 ± 0.98 | 12.00 ± 1.07 |
| $T_{20}$ | *Bacillus amyloliquefaciens (BA)* | 19.80 ± 0.54 | 28.43 ± 0.72 | 54.37 ± 1.42 | - | 11.63 ± 0.7 | 19.20 ± 0.78 |
| $T_{21}$ | *Pseudomonas fluorescens (PF)* | 20.70 ± 0.74 | 29.47 ± 1.03 | 56.13 ± 1.17 | - | 12.30 ± 0.76 | 20.40 ± 0.7 |
| $T_{22}$ | *Bacillus velezensis (BV)* | 19.67 ± 0.67 | 27.80 ± 0.64 | 57.13 ± 1.55 | - | 10.73 ± 0.83 | 18.87 ± 1.27 |
| $T_{23}$ | Control | 15.27 ± 0.50 | 27.50 ± 0.56 | 52.40 ± 1. 22 | - | 12.20 ± 0.64 | 12.63 ± 1.23 |
| SEm(±) | | 0.538 | 0.71 | 2.547 | - | 0.83 | 1.83 |
| C.D. (0.05) | | 1.537 | 2.02 | NS | - | 2.36 | NS |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; GA- Giberellic acid; IAA-Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; CH-Chitosan; SA-Salicylic acid; , PG- Phloroglucinol; DAS- Days after sowing; Each figure represents mean (±SD) of three replications

**Table 44. Effect of various of seed treatments on basal stem girth and number of nodes in transplanted *O. basilicum***

| T. No. | Pretreatment | Basal stem girth (cm) | | | Number of nodes | | |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | SC | 0.80 ± 0.24 | 1.40 ± 0.24 | 3.10 ± 0.38 | 14.00 ± 1.07 | 51.30 ± 1.07 | 174.00 ± 2.82 |
| $T_2$ | WS | 0.77 ± 0.17 | 1.27 ± 0.3 | 3.10 ± 0.41 | 11.33 ± 1.15 | 45.60 ± 1.44 | 160.00 ± 2.03 |
| $T_3$ | HW | 0.73 ± 0.17 | 1.43 ± 0.26 | 4.00 ± 0.51 | 11.33 ± 1.15 | 49.07 ± 1.25 | 168.67 ± 2.74 |
| $T_4$ | CSA | 0.73 ± 0.17 | 1.23 ± 0.17 | 3.23 ± 0.44 | 10.00 ± 1.41 | 46.40 ± 1.15 | 158.00 ± 1.51 |
| $T_5$ | $GA_3$ @1500 µM | 0.90 ± 0.24 | 1.20 ± 0.31 | 3.17 ± 0.34 | 8.00 ± 1.07 | 46.07 ± 1.66 | 159.33± 1.32 |
| $T_6$ | $GA_3$ @3000µM | 0.90 ± 0.38 | 1.43 ± 0.3 | 3.80 ± 0.34 | 8.00 ± 1.07 | 54.63 ± 1.58 | 159.33 ± 2.16 |
| $T_7$ | IAA @ 0.1 µM | 0.67 ± 0.24 | 1.43 ± 0.17 | 2.90 ± 0.34 | 6.67 ± 0.81 | 55.07 ± 1.37 | 160.00 ± 1.51 |
| $T_8$ | IAA @ 1 µM | 0.73 ± 0.17 | 1.43 ± 0.17 | 3.30 ± 0.38 | 7.33 ± 0.81 | 56.40 ± 1.08 | 161.33 ± 2.19 |
| $T_9$ | BA @ 100 µM | 0.90 ± 0.00 | 1.50 ± 0.34 | 3.97 ± 0.3 | 7.67 ± 0.93 | 49.73 ± 1.65 | 160.67 ± 1.54 |
| $T_{10}$ | BA @ 300 µM | 0.90 ± 0.24 | 1.57 ± 0.3 | 3.70 ± 0.53 | 9.33 ± 1.15 | 48.20 ± 1.99 | 155.33 ± 2.33 |
| $T_{11}$ | TDZ @ 200 µM | 0.77 ± 0.34 | 1.37 ± 0.34 | 2.73 ± 0.51 | 8.00 ± 1.07 | 44.63 ± 2.21 | 162.67 ± 1.70 |
| $T_{12}$ | TDZ @ 400 µM | 0.93 ± 0.17 | 1.53 ± 0.26 | 4.03 ± 0.47 | 10.00 ± 1,07 | 54.87 ± 1.06 | 158.67 ± 1.54 |
| $T_{13}$ | CH @ $5gL^{-1}$ | 0.83 ± 0.36 | 1.67 ± 0.26 | 4.37 ± 0.61 | 10.67 ± 1.15 | 48.40 ± 2.42 | 165.33 ± 2.41 |
| $T_{14}$ | CH @ 10 $gL^{-1}$ | 0.73 ± 0.17 | 1.40 ± 0.24 | 4.73 ± 0.44 | 10.67 ± 1.15 | 48.73 ± 1.03 | 162.67 ± 2.09 |
| $T_{15}$ | SA @ 1500µM | 0.73 ± 0.3 | 1.40 ± 0.24 | 3.03 ± 0.38 | 10.00 ± 1.51 | 52.20 ± 0.76 | 154.67 ± 1.92 |
| $T_{16}$ | SA @ 3000µM | 1.23 ± 0.34 | 1.47 ± 0.26 | 2.43 ± 0.3 | 10.67 ± 0.81 | 46.17 ± 1.10 | 189.73 ± 3.26 |
| $T_{17}$ | PG @ 1µM | 0.80 ± 0.00 | 1.63 ± 0.36 | 3.17 ± 0.42 | 10.00 ± 1.07 | 53.97 ± 1.29 | 160.00 ± 2.03 |
| $T_{18}$ | PG @ 10µM | 0.87 ± 0.17 | 1.43 ± 0.17 | 2.93 ± 0.38 | 8.67 ± 1.32 | 50.20 ± 1.57 | 166.00 ± 2.53 |
| $T_{19}$ | *Bacillus pumilus (BP)* | 0.93 ± 0.3 | 1.40 ± 0.24 | 2.93 ± 0.3 | 9.33 ± 1.32 | 60.87 ± 1.67 | 149.33 ± 3.15 |
| $T_{20}$ | *Bacillus amyloliquefaciens (BA)* | 0.93 ± 0.26 | 1.53 ± 0.26 | 2.70 ± 0.24 | 12.67 ± 1.32 | 48.87 ± 1.39 | 197.30 ± 1.91 |
| $T_{21}$ | *Pseudomonas fluorescens (PF)* | 1.03 ± 0.26 | 1.37 ± 0.17 | 2.67 ± 0.34 | 13.33 ± 0.81 | 52.87 ± 0.9 | 205.30 ± 2.13 |
| $T_{22}$ | *Bacillus velezensis (BV)* | 0.93 ± 0.3 | 1.50 ± 0.31 | 3.00 ± 0.47 | 12.00 ± 1.07 | 57.10 ± 1.04 | 197.87 ± 2.89 |
| $T_{23}$ | Control | 0.80 ± 0.24 | 1.47 ± 0.26 | 2.60 ± 0.38 | 7.33 ± 0.81 | 53.67 ± 1.09 | 173.97 ± 3.11 |
| SEm(±) | | 0.08 | 0.08 | 0.19 | 1.317 | 2.46 | 5.840 |
| C.D. (0.05) | | 0.22 | 0.22 | 0.54 | 3.761 | 7.03 | 16.677 |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; GA- Giberellic acid; IAA-Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; CH-Chitosan; SA-Salicylic acid; , PG- Phloroglucinol; DAS- Days after sowing; Each figure represents mean (±SD) of three replications

**Table 45. Effect of physical seed pretreatments on phenological parameters in transplanted *O. basilicum***

| T. No. | Physical treatment | Days to flower initiation (Days) | Days to fruit set (Days) | Days to fruit maturity (Days) |
|---|---|---|---|---|
| $T_1$ | SC | 58.00 ± 1.31 | 1.33 ± 0.57 | 8.00 ± 0.76 |
| $T_2$ | WS | 65.00 ± 1.7 | 1.33 ± 0.57 | 9.33 ± 0.57 |
| $T_3$ | HW | 63.33 ± 1.65 | 1.00 ± 0.00 | 8.00 ± 0.76 |
| $T_4$ | CSA | 73.00 ± 2.00 | 1.33 ± 0.57 | 8.33 ± 0.57 |
| $T_5$ | Control | 67.67 ± 1.61 | 1.67 ± 0.57 | 9.33 ± 1.09 |
| SEm(±) | | 2.894 | 0.298 | 0.683 |
| C.D. (0.05) | | 9.238 | NS | NS |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; Each figure represents mean (±SD) of three replications

**Table 46. Effect of hormonal seed priming on phenological parameters in transplanted *O. basilicum***

| T. No. | Hormones | Days to flower initiation (Days) | Days to fruit set (Days) | Days to fruit maturity (Days) |
|---|---|---|---|---|
| $T_1$ | $GA_3$ @ 1500 µM | 63.00 ± 2.36 | 1.33 ± 0.57 | 8.67 ± 1.09 |
| $T_2$ | $GA_3$ @ 3000 µM | 66.33 ± 1.36 | 1.33 ± 0.57 | 9.67 ± 0.93 |
| $T_3$ | IAA @ 0.1 µM | 64.33 ± 2.40 | 1.33 ± 0.57 | 8.00 ± 0.76 |
| $T_4$ | IAA @ 1 µM | 57.33 ± 2.01 | 1.33 ± 0.57 | 8.33 ± 0.57 |
| $T_5$ | BA @ 100 µM | 62.67 ± 1.65 | 2.00 ± 0.00 | 8.33 ± 0.81 |
| $T_6$ | BA @ 300 µM | 62.33 ± 2.09 | 1.00 ± 0.00 | 9.33 ± 0.57 |
| $T_7$ | TDZ @ 200 µM | 69.67 ± 1.65 | 1.67 ± 0.57 | 8.67 ± 1.09 |
| $T_8$ | TDZ @ 400 µM | 56.33 ± 1.93 | 1.00 ± 0.00 | 8.33 ± 0.81 |
| $T_9$ | Control | 67.67 ± 1.61 | 1.67 ± 0.57 | 9.33 ± 1.09 |
| SEm(±) | | 3.933 | 0.272 | 0.853 |
| C.D. (0.05) | | NS | NS | NS |

T. No. – Treatment Number; GA- Giberellic acid; IAA- Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; Each figure represents mean (±SD) of three replications

**Table 47. Effect of biostimulant seed priming on phenological paramters in transplanted *O. basilicum***

| Treatment | Biostimulants | Days to flower initiation (Days) | Days to fruit set (Days) | Days to fruit maturity (Days) |
|---|---|---|---|---|
| $T_1$ | CH @ 5gL$^{-1}$ | 65.33 ± 2.34 | 2.00 ± 0.00 | 7.67 ± 0.57 |
| $T_2$ | CH @ 10gL$^{-1}$ | 52.00 ± 1.62 | 1.33 ± 0.57 | 7.67 ± 0.57 |
| $T_3$ | SA @ 1500µM | 63.67 ± 1.42 | 1.67 ± 0.57 | 8.00 ± 0.76 |
| $T_4$ | SA @ 3000µM | 55.67 ± 1.36 | 1.33 ± 0.57 | 7.67 ± 0.57 |
| $T_5$ | PG @ 1µM | 61.67 ± 1.78 | 1.67 ± 0.57 | 8.00 ± 0.76 |
| $T_6$ | PG @ 10µM | 68.67 ± 1.52 | 1.00 ± 0.00 | 8.67 ± 0.81 |
| $T_7$ | Control | 67.67 ± 1.61 | 1.67 ± 0.57 | 9.33 ± 1.09 |
| SEm(±) | | 3.094 | 0.282 | 0.642 |
| C.D. (0.05) | | 9.475 | NS | NS |

T. No. – Treatment Number; CH- Chitosan; SA-Salicylic acid; , PG- Phloroglucinol. Each figure represents mean (±SD) of three replications

**Table 48. Effect of bioprimimg of seeds on phenological parameters in transplanted *O. basilicum***

| T. No. | Microbes | Days to flower initiation (Days) | Days to fruit set (Days) | Days to fruit maturity (Days) |
|---|---|---|---|---|
| $T_1$ | *Bacillus pumilus (BP)* | 58.67 ± 1.81 | 1.33 ± 0.57 | 8.33 ± 0.81 |
| $T_2$ | *Bacillus amyloliquefaciens(BA)* | 48.33 ± 1.32 | 1.00 ± 0.00 | 8.67 ± 0.81 |
| $T_3$ | *Pseudomonas fluorescens (PF)* | 53.00 ± 1.62 | 1.33 ± 0.57 | 8.67 ± 0.93 |
| $T_4$ | *Bacillus velezensis (BV* | 48.00 ± 1.07 | 1.00 ± 0.00 | 8.33 ± 0.81 |
| $T_5$ | Control | 67.67 ± 1.61 | 1.67 ± 0.57 | 9.33 ± 1.09 |
| SEm(±) | | 2.408 | 0.258 | 0.843 |
| C.D. (0.05) | | 7.687 | NS | NS |

Each figure represents mean (±SD) of three replications

**Table 49. Effect of seed pretreatments on phenological parameters in transplanted *O. basilicum***

| Treatment | Pretreatment | Days to flower initiation (Days) | Days to fruit set (Days) | Days to fruit maturity (Days) |
|---|---|---|---|---|
| $T_1$ | Scarification | 58.00 ± 1.31 | 1.33 ± 0.57 | 8.00 ± 0.76 |
| $T_2$ | Water soaking | 65.00 ± 1.7 | 1.33 ± 0.57 | 9.33 ± 0.57 |
| $T_3$ | Hot water | 63.33 ± 1.65 | 1.00 ± 0.00 | 8.00 ± 0.76 |
| $T_4$ | Conc.$H_2SO_4$ | 73.00 ± 2.00 | 1.33 ± 0.57 | 8.33 ± 0.57 |
| $T_5$ | $GA_3$ @ 1500 µM | 63.00 ± 2.36 | 1.33 ± 0.57 | 8.67 ± 1.09 |
| $T_6$ | $GA_3$ @ 3000 µM | 66.33 ± 1.36 | 1.33 ± 0.57 | 9.67 ± 0.93 |
| $T_7$ | IAA @ 0.1 µM | 64.33 ± 2.40 | 1.33 ± 0.57 | 8.00 ± 0.76 |
| $T_8$ | IAA @ 1 µM | 57.33 ± 2.01 | 1.33 ± 0.57 | 8.33 ± 0.57 |
| $T_9$ | BA @ 100 µM | 62.67 ± 1.65 | 2.00 ± 0.00 | 8.33 ± 0.81 |
| $T_{10}$ | BA @ 300 µM | 62.33 ± 2.09 | 1.00 ± 0.00 | 9.33 ± 0.57 |
| $T_{11}$ | TDZ @ 200 µM | 69.67 ± 1.65 | 1.67 ± 0.57 | 8.67 ± 1.09 |
| $T_{12}$ | TDZ @ 400 µM | 56.33 ± 1.93 | 1.00 ± 0.00 | 8.33 ± 0.81 |
| $T_{13}$ | CH @ 5g$L^{-1}$ | 65.33 ± 2.34 | 2.00 ± 0.00 | 7.67 ± 0.57 |
| $T_{14}$ | CH @ 10 g$L^{-1}$ | 52.00 ± 1.62 | 1.33 ± 0.57 | 7.67 ± 0.57 |
| $T_{15}$ | SA @ 1500µM | 63.67 ± 1.42 | 1.67 ± 0.57 | 8.00 ± 0.76 |
| $T_{16}$ | SA @ 3000µM | 55.67 ± 1.36 | 1.33 ± 0.57 | 7.67 ± 0.57 |
| $T_{17}$ | PG @ 1µM | 61.67 ± 1.78 | 1.67 ± 0.57 | 8.00 ± 0.76 |
| $T_{18}$ | PG @ 10µM | 68.67 ± 1.52 | 1.00 ± 0.00 | 8.67 ± 0.81 |
| $T_{19}$ | *Bacillus pumilus (BP)* | 58.67 ± 1.81 | 1.33 ± 0.57 | 8.33 ± 0.81 |
| $T_{20}$ | *Bacillus amyloliquefaciens(BA)* | 48.33 ± 1.32 | 1.00 ± 0.00 | 8.67 ± 0.81 |
| $T_{21}$ | *Pseudomonas fluorescens (PF)* | 53.00 ± 1.62 | 1.33 ± 0.57 | 8.67 ± 0.93 |
| $T_{22}$ | *Bacillus velezensis(BV)* | 48.00 ± 1.07 | 1.00 ± 0.00 | 8.33 ± 0.81 |
| $T_{23}$ | Control | 67.67 ± 1.61 | 1.67 ± 0.57 | 9.33 ± 1.09 |
| SEm(±) | | 3.34 | 0.27 | 0.69 |
| C.D. (0.05) | | 9.54 | NS | NS |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; GA- Giberellic acid; IAA- Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; CH-Chitosan; SA-Salicylic acid; , PG- Phloroglucinol; DAS- Days after sowing; Each figure represents mean (±SD) of three replications

**Table 50. Effect of physical seed pretreatments on yield parameters in transplanted *O. basilicum* at 90 DAS**

| T. No. | Physical treatment | Total leaf biomass (g plant$^{-1}$) | | Total stem biomass (g plant$^{-1}$) | | Total shoot biomass (g plant$^{-1}$) | | Harvest Index |
|---|---|---|---|---|---|---|---|---|
| | | Fresh weight | Dry weight | Fresh weight | Dry weight | Fresh weight | Dry weight | |
| $T_1$ | SC | 58.97 ± 1.60 | 6.25 ± 0.57 | 28.63 ± 1.96 | 3.86 ± 0.74 | 87.60 ± 2.39 | 10.11 ± 0.89 | 0.90 ± 0.00 |
| $T_2$ | WS | 55.07 ± 1.63 | 5.84 ± 0.56 | 26.13 ± 1.77 | 3.51 ± 0.64 | 81.20 ± 2.21 | 9.35 ± 0.78 | 0.93 ± 0.10 |
| $T_3$ | HW | 50.60 ± 3.09 | 5.37 ± 1.01 | 44.63 ± 2.50 | 5.98 ± 0.87 | 95.23 ± 2.88 | 11.35 ± 0.94 | 0.91 ± 0.17 |
| $T_4$ | CSA | 59.40 ± 2.72 | 6.29 ± 0.88 | 39.70 ± 3.33 | 5.35± 1.23 | 99.10 ± 4.21 | 11.65 ± 1.48 | 0.90 ± 0.10 |
| $T_5$ | Control | 54.17 ± 1.67 | 5.742 ± 0.54 | 24.7 ± 0.74 | 3.32 ± 0.26 | 78.86 ± 1.51 | 9.06 ± 0.47 | 0.92 ± 0.10 |
| SEm(±) | | 5.794 | 0.630 | 6.150 | 0.823 | 9.459 | 1.170 | 0.017 |
| C.D. (0.05) | | NS | NS | NS | NS | NS | NS | NS |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; Each figure represents mean (±SD) of three replications

**Table 51. Effect of hormonal seed priming on yield parameters in transplanted *O. basilicum* at 90 DAS**

| T. No. | Hormones | Total leaf biomass (g plant$^{-1}$) | | Total stem biomass (g plant$^{-1}$) | | Total shoot biomass (g plant$^{-1}$) | | Harvest Index |
|---|---|---|---|---|---|---|---|---|
| | | Fresh weight | Dry weight | Fresh weight | Dry weight | Fresh weight | Dry weight | |
| $T_1$ | $GA_3$@1500µM | 81.27 ± 2.96 | 8.61 ± 0.97 | 25.70 ± 1.37 | 3.45 ± 0.50 | 106.96 ± 2.65 | 12.07 ± 0.86 | 0.89 ± 0.1 |
| $T_2$ | $GA_3$@3000µM | 78.6 ± 2.27 | 8.32 ± 0.70 | 67.40 ± 1.53 | 9.06 ± 0.53 | 146.00 ± 2.68 | 17.39 ± 0.84 | 0.92 ± 0.1 |
| $T_3$ | IAA@0.1µM | 87.23 ± 2.22 | 9.24 ± 0.69 | 28.80 ± 1.25 | 3.87 ± 0.44 | 116.03 ± 2.55 | 13.11 ± 0.84 | 0.90 ± 0.1 |
| $T_4$ | IAA@1µM | 72.80 ± 1.95 | 7.71 ± 0.59 | 48.40 ± 2.3 | 6.49 ± 0.79 | 121.20 ± 2.99 | 14.21 ± 0.98 | 0.90 ± 0.1 |
| $T_5$ | BA@100µM | 67.23 ± 1.94 | 7.13 ± 0.66 | 30.96 ± 1.36 | 4.16 ± 0.44 | 98.20 ± 1.84 | 11.29 ± 0.61 | 0.86 ± 0.1 |
| $T_6$ | BA@300µM | 54.73 ± 1.25 | 5.80 ± 0.43 | 38.73 ± 2.37 | 5.19 ± 0.83 | 93.46 ± 2.30 | 10.99 ± 0.77 | 0.90 ± 0.1 |
| $T_7$ | TDZ@200µM | 61.93 ± 2.40 | 6.57 ± 0.81 | 35.43 ± 2.42 | 4.78 ± 0.91 | 97.36 ± 3.41 | 11.35 ± 1.22 | 0.90 ± 0.1 |
| $T_8$ | TDZ@400 µM | 40.90 ± 1.81 | 4.33 ± 0.54 | 45.36 ± 1.75 | 6.11 ± 0.67 | 86.26 ± 1.60 | 10.44 ± 0.56 | 0.88 ± 0.1 |
| $T_9$ | Control | 54.17 ± 1.67 | 5.74 ± 0.54 | 24.7 ± 0.74 | 3.32 ± 0.26 | 78.86 ± 1.51 | 9.06 ± 0.47 | 0.92 ± 0.1 |
| SEm(±) | | 4.854 | 0.516 | 3.643 | 0.479 | 6.774 | 0.779 | 0.012 |
| C.D. (0.05) | | 14.535 | 1.544 | 10.908 | 1.434 | 20.283 | 2.334 | 0.024 |

T. No. – Treatment Number; GA- Gibberellic acid; IAA- Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; Each figure represents mean (±SD) of three replications

**Table 52. Effect of biostimulant seed priming on yield parameters in transplanted *O. basilicum* at 90 DAS**

| T. No. | Biostimulants | Total leaf biomass (g plant$^{-1}$) | | Total stem biomass (g plant$^{-1}$) | | Total shoot biomass (g plant$^{-1}$) | | Harvest Index |
|---|---|---|---|---|---|---|---|---|
| | | Fresh weight | Dry weight | Fresh weight | Dry weight | Fresh weight | Dry weight | |
| $T_1$ | CH @ 5gL$^{-1}$ | 59.50 ± 1.67 | 6.31 ± 0.56 | 55.60 ± 1.53 | 7.47 ± 0.47 | 115.10 ± 1.61 | 13.78 ± 0.47 | 0.90 ± 0.10 |
| $T_2$ | CH @ 10gL$^{-1}$ | 73.33 ± 1.23 | 7.77 ± 0.34 | 26.83 ± 1.63 | 3.61 ± 0.62 | 100.16 ± 1.73 | 11.39 ± 0.67 | 0.89 ± 0.14 |
| $T_3$ | SA @ 1500µM | 79.40 ± 2.26 | 8.41 ± 0.70 | 42.10 ± 1.11 | 5.66 ± 0.43 | 121.50 ± 2.00 | 14.07 ± 0.53 | 0.91 ± 0.14 |
| $T_4$ | SA @ 3000µM | 74.40 ± 1.36 | 7.88 ±0.34 | 59.76 ± 2.89 | 8.06 ± 1.09 | 134.17 ± 2.57 | 15.95 ± 1.04 | 0.96 ± 0.10 |
| $T_5$ | PG @ 1µM | 62.66 ± 1.95 | 6.63 ± 0.59 | 40.30 ± 1.12 | 5.42 ± 0.46 | 102.96 ± 1.90 | 12.06 ± 0.59 | 0.90 ± 0.00 |
| $T_6$ | PG @ 10µM | 59.07 ± 2.27 | 6.25 ± 0.72 | 43.20 ± 1.74 | 5.80 ± 0.61 | 102.26 ± 2.86 | 12.06 ± 0.95 | 0.89 ± 0.10 |
| $T_7$ | Control | 54.17 ± 1.67 | 5.74 ± 0.54 | 24.7 ± 0.74 | 3.32 ± 0.26 | 78.86 ± 1.51 | 9.06 ± 0.47 | 0.92 ± 0.10 |
| SEm(±) | | 3.574 | 0.356 | 3.700 | 0.523 | 4.810 | 0.606 | 0.012 |
| C.D. (0.05) | | 10.946 | 1.089 | 11.331 | 1.603 | 14.730 | 1.885 | 0.038 |

T. No. – Treatment Number; CH- Chitosan; SA-Salicylic acid; , PG- Phloroglucinol. Each figure represents mean (±SD) of three replications

**Table 53. Effect of seed biopriming on yield parameters in transplanted *O. basilicum* at 90 DAS**

| T. No. | Microbes | Total leaf biomass (g plant$^{-1}$) | | Total stem biomass (g plant$^{-1}$) | | Total shoot biomass (g plant$^{-1}$) | | Harvest Index |
|---|---|---|---|---|---|---|---|---|
| | | Fresh weight | Dry weight | Fresh weight | Dry weight | Fresh weight | Dry weight | |
| $T_1$ | *BP* | 63.10 ± 1.00 | 6.68 ± 0.31 | 39.63 ± 1.58 | 5.32 ± 0.52 | 102.73 ± 2.58 | 12.01 ± 0.45 | 0.90 ± 0.1 |
| $T_2$ | *BA* | 74.93 ± 2.23 | 7.94 ± 0.75 | 58.83 ± 1.71 | 7.92 ± 0.67 | 133.76 ± 2.81 | 15.87 ± 1.00 | 0.87 ± 0.1 |
| $T_3$ | *PF* | 75.47 ± 1.85 | 8.00 ± 0.64 | 72.26 ± 1.92 | 9.73 ± 0.75 | 147.73 ± 2.67 | 17.73 ± 0.99 | 0.90 ± 0.1 |
| $T_4$ | *BV* | 99.60 ± 2.27 | 10.55± 0.67 | 53.43 ± 2.20 | 7.17 ± 0.76 | 153.03 ± 3.04 | 17.73 ± 0.95 | 0.92 ± 0.1 |
| $T_5$ | Control | 54.17 ± 1.67 | 5.74 ± 0.54 | 24.7 ± 0.74 | 3.32 ± 0.26 | 78.86 ± 1.51 | 9.06 ± 0.47 | 0.92 ± 0.1 |
| SEm(±) | | 3.806 | 0.403 | 3.257 | 0.438 | 7.407 | 1.280 | 0.104 |
| C.D. (0.05) | | 12.149 | 1.285 | 10.395 | 1.397 | 23.643 | 4.085 | 0.032 |

T. No. – Treatment Number; *BP- Bacillus pumilus; BA - Bacillus amyloliquefaciens; PF- Pseudomonas fluorescens*; *BV-Bacillus velezensis;*
Each figure represents mean (±SD) of three replications

**Table 54. Effect of seed pretreatments on yield parameters in transplanted *O. basilicum* at 90 DAS**

| T. No. | Microbes | Total leaf biomass (g plant$^{-1}$) | | Total stem biomass (g plant$^{-1}$) | | Total shoot biomass (g plant$^{-1}$) | | Harvest Index |
|---|---|---|---|---|---|---|---|---|
| | | Fresh weight | Dry weight | Fresh weight | Dry weight | Fresh weight | Dry weight | |
| $T_1$ | SC | 58.97 ± 1.60 | 6.25 ± 0.57 | 28.63 ± 1.96 | 3.86 ± 0.74 | 87.60 ± 2.39 | 10.11 ± 0.89 | 0.90 ± 0.00 |
| $T_2$ | WS | 55.07 ± 1.63 | 5.84 ± 0.56 | 26.13 ± 1.77 | 3.51 ± 0.64 | 81.20 ± 2.21 | 9.35 ± 0.78 | 0.93 ± 0.10 |
| $T_3$ | HW | 50.60 ± 3.09 | 5.37 ± 1.01 | 44.63 ± 2.50 | 5.98 ± 0.87 | 95.23 ± 2.88 | 11.35 ± 0.94 | 0.91 ± 0.17 |
| $T_4$ | CSA | 59.40 ± 2.72 | 6.29 ± 0.88 | 39.70 ± 3.33 | 5.35± 1.23 | 99.10 ± 4.21 | 11.65 ± 1.48 | 0.90 ± 0.10 |
| $T_5$ | $GA_3$ @1500 µM | 81.27 ± 2.96 | 8.61 ± 0.97 | 25.70 ± 1.37 | 3.45 ± 0.50 | 106.96 ± 2.65 | 12.07 ± 0.86 | 0.89 ± 0.10 |
| $T_6$ | $GA_3$ @3000µM | 78.6 ± 2.27 | 8.32 ± 0.70 | 67.40 ± 1.53 | 9.06 ± 0.53 | 146.00 ± 2.68 | 17.39 ± 0.84 | 0.92 ± 0.10 |
| $T_7$ | IAA @ 0.1 µM | 87.23 ± 2.22 | 9.24 ± 0.69 | 28.80 ± 1.25 | 3.87 ± 0.44 | 116.03 ± 2.55 | 13.11 ± 0.84 | 0.90 ± 0.10 |
| $T_8$ | IAA @ 1 µM | 72.80 ± 1.95 | 7.71 ± 0.59 | 48.40 ± 2.3 | 6.49 ± 0.79 | 121.20 ± 2.99 | 14.21 ± 0.98 | 0.90 ± 0.10 |
| $T_9$ | BA @ 100 µM | 67.23 ± 1.94 | 7.13 ± 0.66 | 30.96 ± 1.36 | 4.16 ± 0.44 | 98.20 ± 1.84 | 11.29 ± 0.61 | 0.86 ± 0.10 |
| $T_{10}$ | BA @ 300 µM | 54.73 ± 1.25 | 5.80 ± 0.43 | 38.73 ± 2.37 | 5.19 ± 0.83 | 93.46 ± 2.30 | 10.99 ± 0.77 | 0.90 ± 0.10 |
| $T_{11}$ | TDZ @ 200 µM | 61.93 ± 2.40 | 6.57 ± 0.81 | 35.43 ± 2.42 | 4.78 ± 0.91 | 97.36 ± 3.41 | 11.35 ± 1.22 | 0.90 ± 0.10 |
| $T_{12}$ | TDZ @ 400 µM | 40.90 ± 1.81 | 4.33 ± 0.54 | 45.36 ± 1.75 | 6.11 ± 0.67 | 86.26 ± 1.60 | 10.44 ± 0.56 | 0.88 ± 0.10 |
| $T_{13}$ | CH @ 5gL$^{-1}$ | 59.50 ± 1.67 | 6.31 ± 0.56 | 55.60 ± 1.53 | 7.47 ± 0.47 | 115.10 ± 1.61 | 13.78 ± 0.47 | 0.90 ± 0.10 |
| $T_{14}$ | CH @ 10 gL$^{-1}$ | 73.33 ± 1.23 | 7.77 ± 0.34 | 26.83 ± 1.63 | 3.61 ± 0.62 | 100.16 ± 1.73 | 11.39 ± 0.67 | 0.89 ± 0.14 |
| $T_{15}$ | SA @ 1500µM | 79.4 ± 2.26 | 8.41 ± 0.7 | 42.10 ± 1.11 | 5.66 ± 0.43 | 121.50 ± 2.00 | 14.07 ± 0.53 | 0.91 ± 0.14 |
| $T_{16}$ | SA @ 3000µM | 74.40 ± 1.36 | 7.88 ± 0.34 | 59.76 ± 2.89 | 8.06 ± 1.09 | 134.17 ± 2.57 | 15.95 ± 1.04 | 0.96 ± 0.10 |
| $T_{17}$ | PG @ 1µM | 62.66 ± 1.95 | 6.63 ± 0.59 | 40.30 ± 1.12 | 5.42 ± 0.46 | 102.96 ± 1.90 | 12.06 ± 0.59 | 0.90 ± 0.00 |
| $T_{18}$ | PG @ 10µM | 59.07 ± 2.27 | 6.25 ± 0.72 | 43.20 ± 1.74 | 5.80 ± 0.61 | 102.26 ± 2.86 | 12.06 ± 0.95 | 0.89 ± 0.10 |
| $T_{19}$ | *BP* | 63.10 ± 1.00 | 6.68 ± 0.31 | 39.63 ± 1.58 | 5.32 ± 0.52 | 102.73 ± 2.58 | 12.01 ± 0.45 | 0.90 ± 0.10 |
| $T_{20}$ | *BA* | 74.93 ± 2.23 | 7.94 ± 0.75 | 58.83 ± 1.71 | 7.92 ± 0.67 | 133.76 ± 2.81 | 15.87 ± 1.00 | 0.87 ± 0.10 |
| $T_{21}$ | *PF* | 75.47 ± 1.85 | 8.00 ± 0.64 | 72.26 ± 1.92 | 9.73 ± 0.75 | 147.73 ± 2.67 | 17.73 ± 0.99 | 0.90 ± 0.10 |
| $T_{22}$ | *BV* | 99.60 ± 2.27 | 10.55±0.67 | 53.43 ± 2.20 | 7.17 ± 0.76 | 153.03 ± 3.04 | 17.72 ± 0.95 | 0.92 ± 0.10 |
| $T_{23}$ | Control | 54.17 ± 1.67 | 5.74± 0.54 | 24.7 ± 0.74 | 3.32 ± 0.26 | 78.86 ± 1.51 | 9.06 ± 0.47 | 0.92 ± 0.10 |
| SEm(±) | | 4.746 | 0.502 | 4.455 | 0.601 | 7.280 | 0.878 | 0.013 |
| C.D. (0.05) | | 13.554 | 1.435 | 12.723 | 1.717 | 20.789 | 2.506 | 0.037 |

T. No. – Treatment Number; SC-Scarification; WS-Water soaking; HW-Hot water; CSA-Concentrated Sulphuric Acid; GA- Gibberellic acid; IAA- Indole Acetic Acid; BA-Benzyl Adenine; TDZ-Thidiazuron; CH-Chitosan; SA-Salicylic acid; , PG- Phloroglucinol; *BP- Bacillus pumilus; Bacillus amyloliquefaciens; PF-Pseudomonas fluorescens*; *BV-Bacillus velezensis.* Each figure represents mean (±SD) of three replications


Plate 1. Effect of physical pretreatments on *Ocimum tenuiflorum* seeds at 30 DAS: (A) Scarification (using sand paper), (B) Watersoaking (overnight), (C) Hotwater treatment (65$^{o}$C for 10 min), (D) Concentrated sulphuric acid (1 min), (E) Control


Plate 2. Effect of hormonal priming on *Ocimum tenuiflorum* seeds at 30 DAS: (A) $GA_3$ @ 1500 µM, (B) $GA_3$ @ 3000 µM, (C) IAA @ 0.1 µM, (D) IAA @ 1 µM, (E) BA @ 100 µM, (F) BA @ 300 µM, (G) TDZ @ 200 µM, (H) TDZ @ 400 µM, (I) Control


Plate 3. Effect of biostimulants priming on *Ocimum tenuiflorum* seeds at 30 DAS: (A) Chitosan @ 5g $L^{-1}$, (B) Chitosan @ 10 $gL^{-1}$, (C) Salicylic acid @ 1500 µM, (D) Salicylic acid @ 3000 µM, (E) Phloroglucinol @ 1 µM, (F) Phloroglucinol @ 10 µM, (G) Control


Plate 4. Effect of biopriming on *Ocimum tenuiflorum* seeds at 30 DAS: (A) *Bacillus pumilus*VLY17, (B) *Bacillus amyloliquefaciens*VLY24, (C) *Pseudomonas fluorescens*PN026R, (D) *Bacillus velezensis* PCSE10, (E) Control


Plate 5. Effect of physical treatment on *Ocimum tenuiflorum* at 90 DAS: (A) Scarification (using sand paper), (B) Water soaking (overnight), (C) Hotwater treatment (65$^{o}$C for 10 min), (D) Concentrated sulphuric acid (1 min), (E) Control

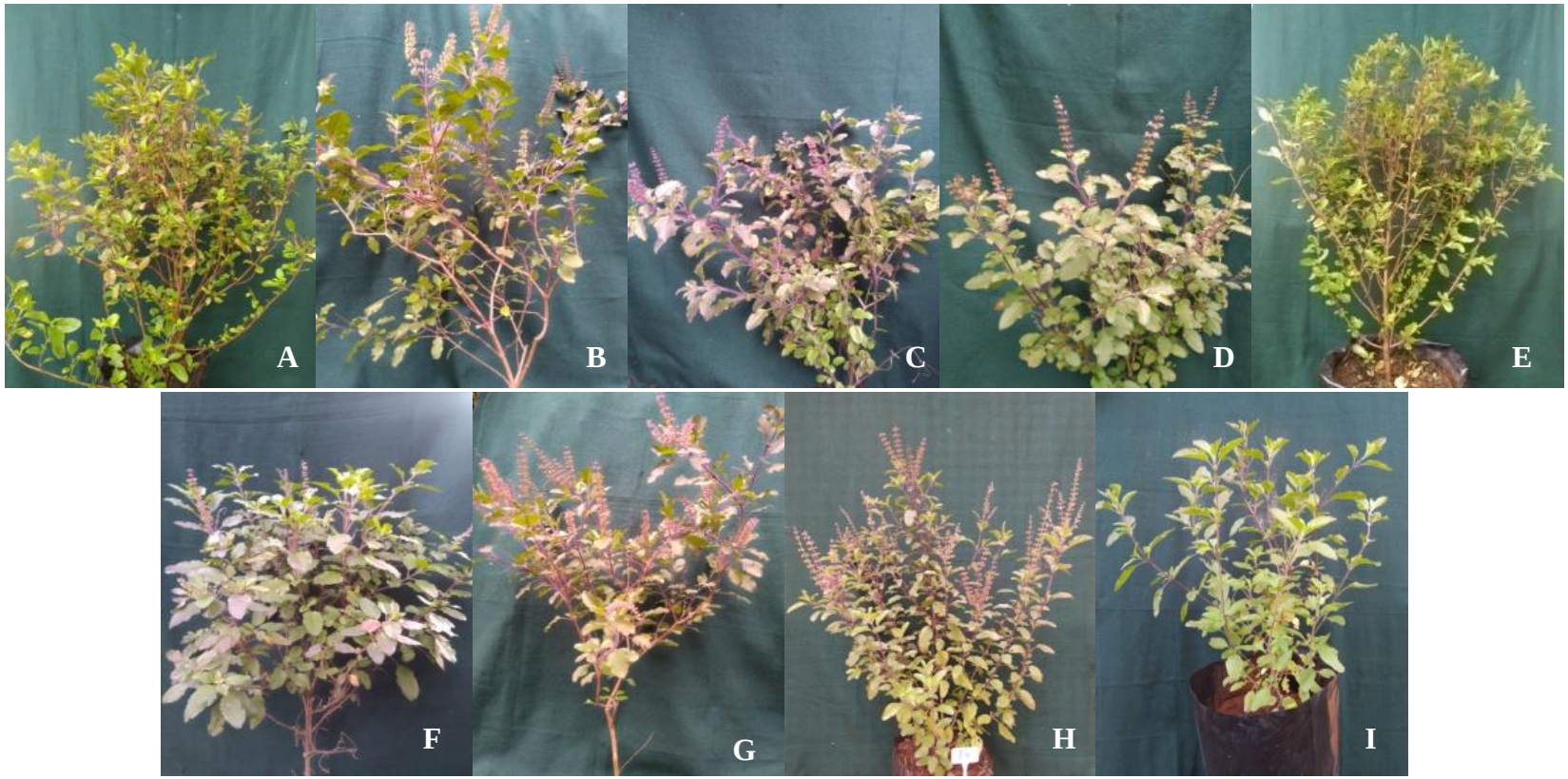


Plate 6. Effect of hormonal treatment on *Ocimum tenuiflorum at* 90 DAS: (A) $GA_3$ @ 1500 µM, (B) $GA_3$ @ 3000 µM, (C) IAA @ 0.1 µM, (D) IAA @ 1 µM, (E) BA @ 100 µM, (F) BA @ 300 µM, (G) TDZ @ 200 µM, (H) TDZ @ 400 µM, (I) Control

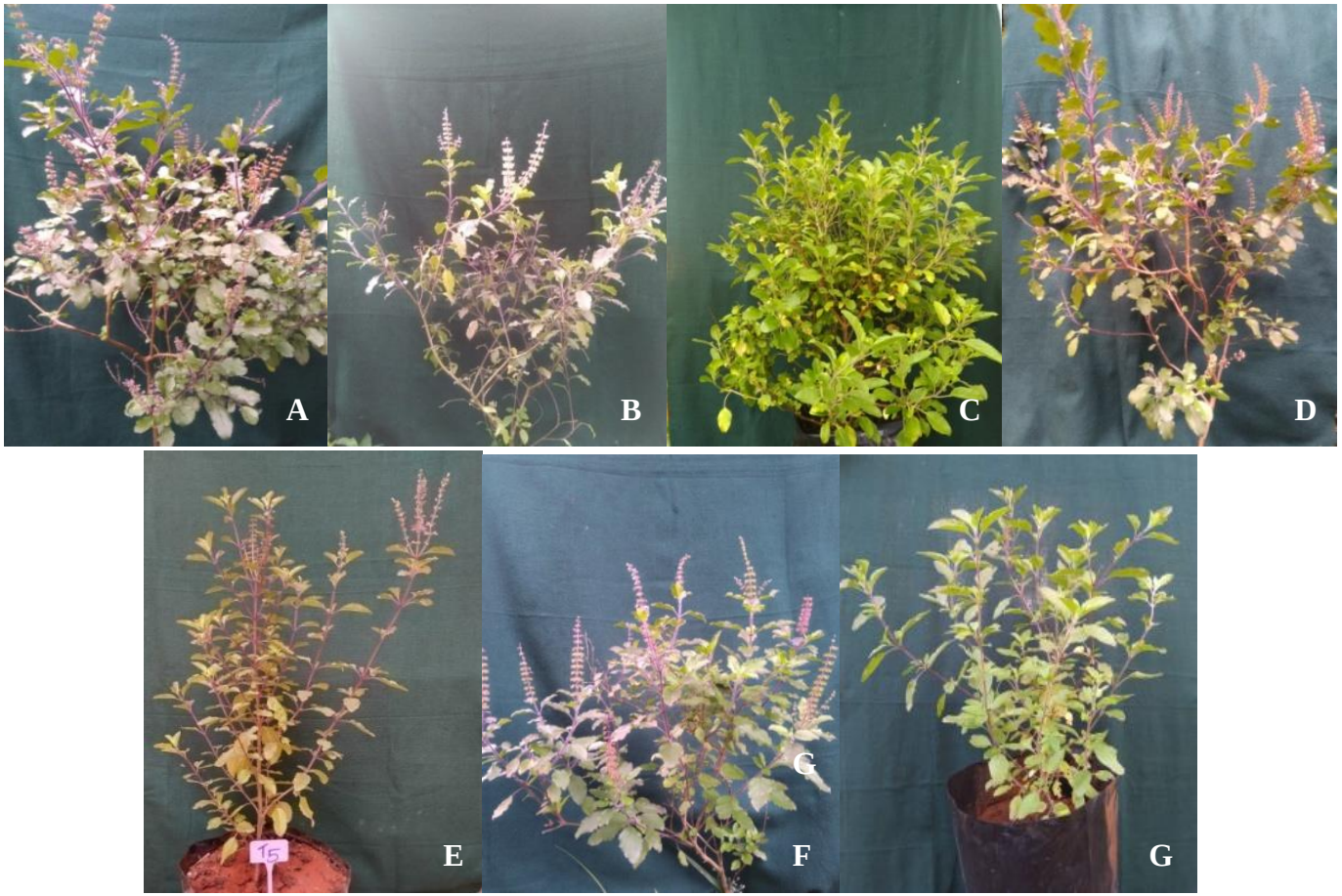


Plate 7. Effect of biostimulant priming on *Ocimum tenuiflorum* at 90 DAS: (A) Chitosan @ 5g $L^{-1}$, (B) Chitosan @ 10 $gL^{-1}$, (C) Salicylic acid @ 1500 µM, (D) Salicylic acid @ 3000 µM, (E) Phloroglucinol @ 1 µM, (F) Phloroglucinol @ 10 µM, (G) Control


Plate 8. Effect of biopriming on *Ocimum tenuiflorum* at 90 DAS: (A) *Bacillus pumilus*VLY17, (B) *Bacillus amyloliquefaciens*VLY24, (C) *Pseudomonas fluorescens*PN026R, (D) *Bacillus velezensis*PCSE10, (E) Control


Plate 9. Effect of physical treatments on *O. basilicum* seeds at 30 DAS: (A) Scarification (using sand paper), (B) Water soaking (overnight), (C) Hotwater treatment (65$^{o}$C for 10 min), (D) Concentrated sulphuric acid (1 min), (E) Control


Plate 10. Effect of hormonal priming on *O. basilicum* seeds 30 at DAS: (A) $GA_3$ @ 1500 µM, (B) $GA_3$ @ 3000 µM, (C) IAA @ 0.1 µM, (D) IAA @ 1 µM, (E) BA @ 100 µM, (F) BA @ 300 µM, (G) TDZ @ 200 µM, (H) TDZ @ 400 µM, (I) Control


Plate 11. Effect of biostimulant priming on *O. basilicum* seeds at 30 DAS: (A) Chitosan @ 5g $L^{-1}$, (B) Chitosan @ 10 $gL^{-1}$, (C) Salicylic acid @ 1500 µM, (D) Salicylic acid @ 3000 µM, (E) Phloroglucinol @ 1 µM, (F) Phloroglucinol @ 10 µM, (G) Control


Plate 12. Effect of biopriming on *O. basilicum* seeds at 30 DAS: (A) *Bacillus pumilus*VLY17, (B) *Bacillus amyloliquefaciens*VLY24, (C) *Pseudomonas fluorescens*PN026R, (D) *Bacillus velezensis* PCSE10, (E) Control


Plate 13. Effect of physical seed pretreatments of *O. basilicum* at 90 DAS: (A) Scarification (using sand paper), (B) Water soaking (overnight), (C) Hotwater treatment (65$^{o}$C for 10 min), (D) Concentrated sulphuric acid (1 min), (E) Control


Plate 14. Effect of hormonal priming of *Ocimum basilicum* seeds at 90 DAS: (A) $GA_3$ @ 1500 µM, (B) $GA_3$ @ 3000 µM, (C) IAA @ 0.1 µM, (D) IAA @ 1 µM, (E) BA @ 100 µM, (F) BA @ 300 µM, (G) TDZ @ 200 µM, (H) TDZ @ 400 µM, (I) Control


Plate 15. Effect of biostimulant priming of *Ocimum basilicum* seeds at 90 DAS: (A) Chitosan @ 5g $L^{-1}$, (B) Chitosan @ 10 $gL^{-1}$, (C) Salicylic acid @ 1500 µM, (D) Salicylic acid @ 3000 µM, (E) Phloroglucinol @ 1 µM, (F) Phloroglucinol @ 10 µM, (G) Control


Plate 16. Effect of biopriming on *Ocimum basilicum* seeds at 90 DAS: (A) *Bacillus pumilus* VLY17, (B) *Bacillus amyloliquefaciens* VLY24, (C) *Pseudomonas fluorescens*PN026R, (D) *Bacillus velezensis*PCSE10, (E) Control


Plate 17. Pests observed during the study in O*cimum* spp. (A) Leaf roller in *O. tenuiflorum*, (B) Leaf roller in *O. basilicum* (C) Lace bug in *O. tenuiflorum* (D) Lace bug in *O. basilicum*

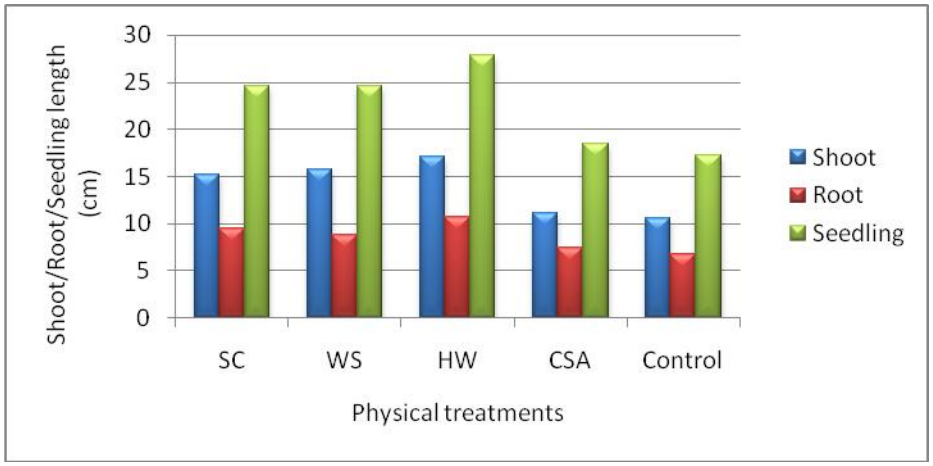


**Fig 1.Effect of physical treatments on shoot, root and seedling length in *O. tenuiflorum***

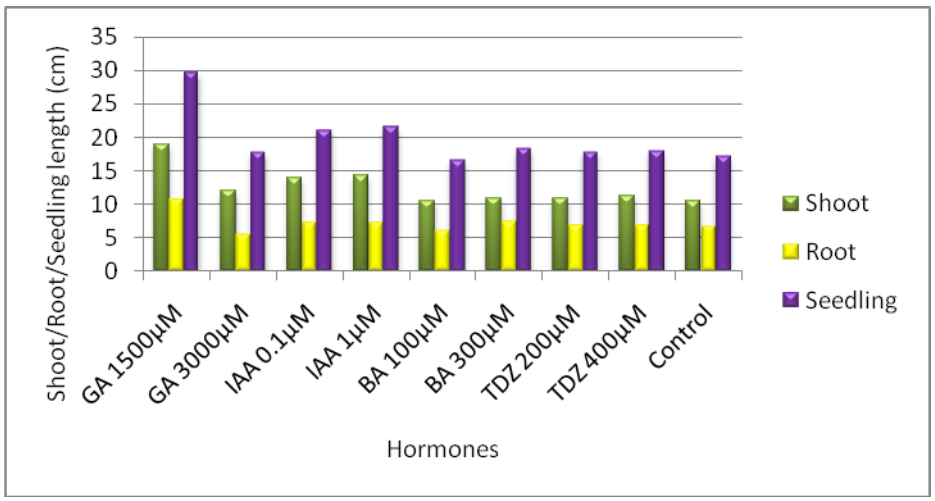


**Fig 2. Effect of hormonal priming on shoot, root and seedling length in *O. tenuiflorum***

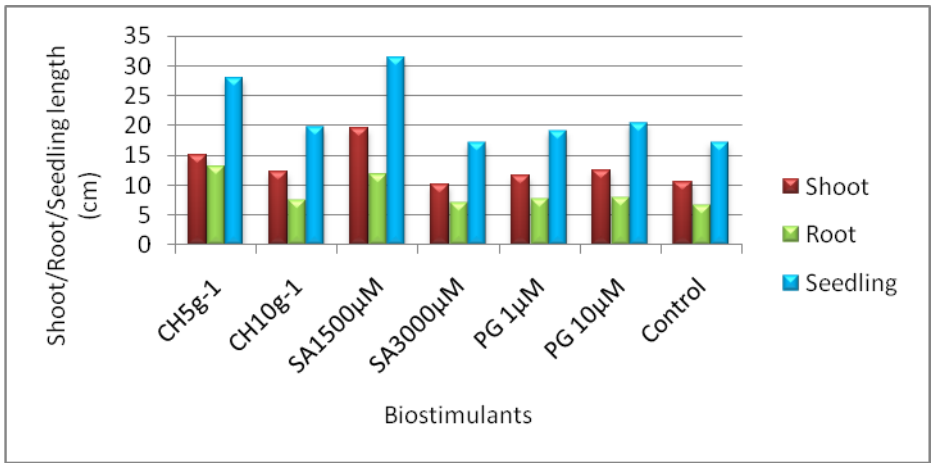


**Fig 3. Effect of biostimulant on shoot, root and seedling length in *O. tenuiflorum***

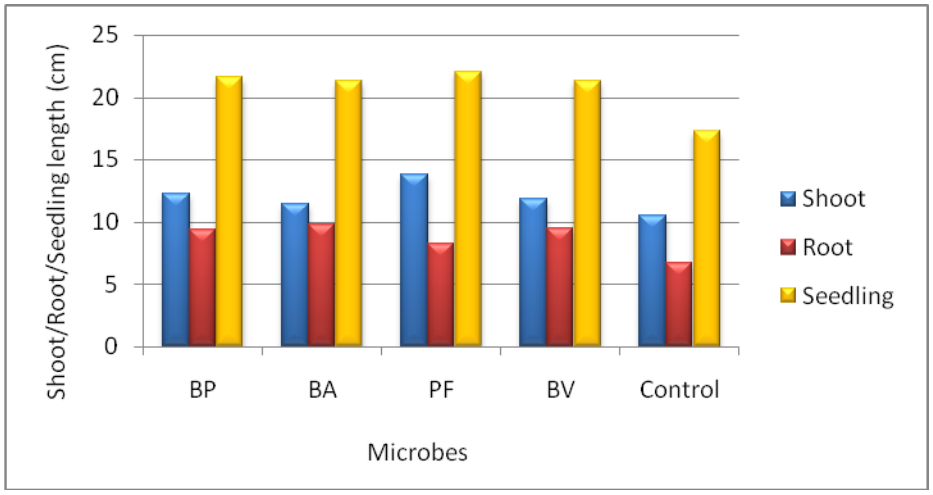


**Fig 4. Effect of boipriming on shoot, root and seedling length in *O. tenuiflorum***

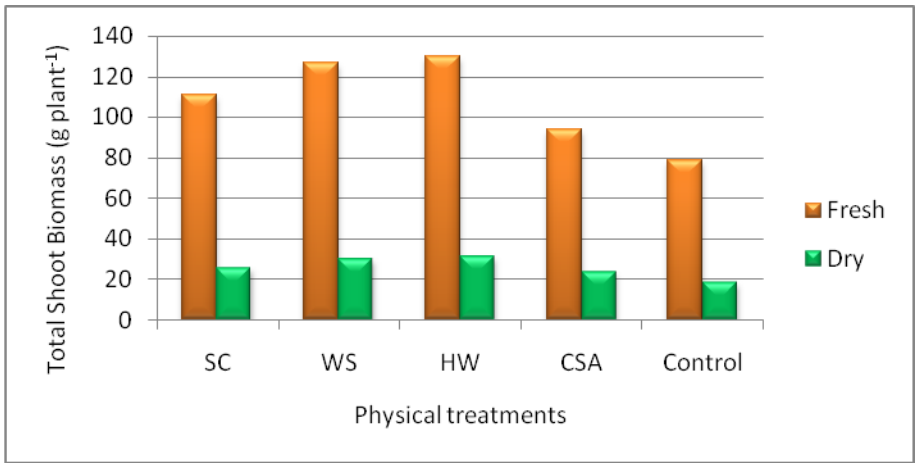


**Fig 5. Effect of physical treatments of total shoot biomass in *O. tenuiflorum***

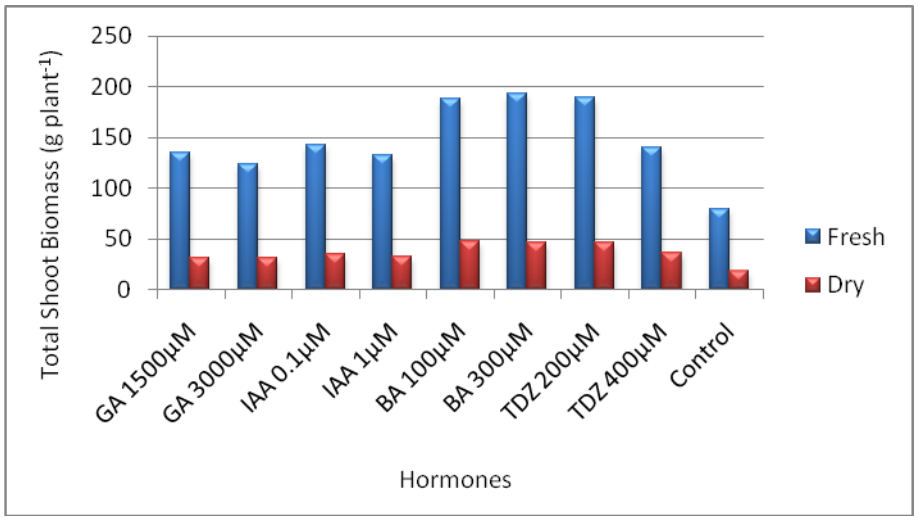


**Fig 6. Effect of hormonal priming of total shoot biomass in *O. tenuiflorum***

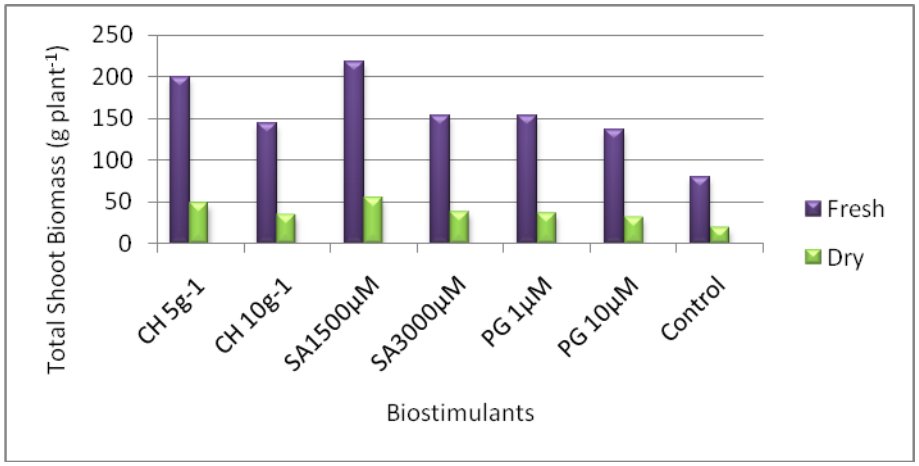


**Fig 7. Effect of biostimulant priming of total shoot biomass in *O. tenuiflorum***

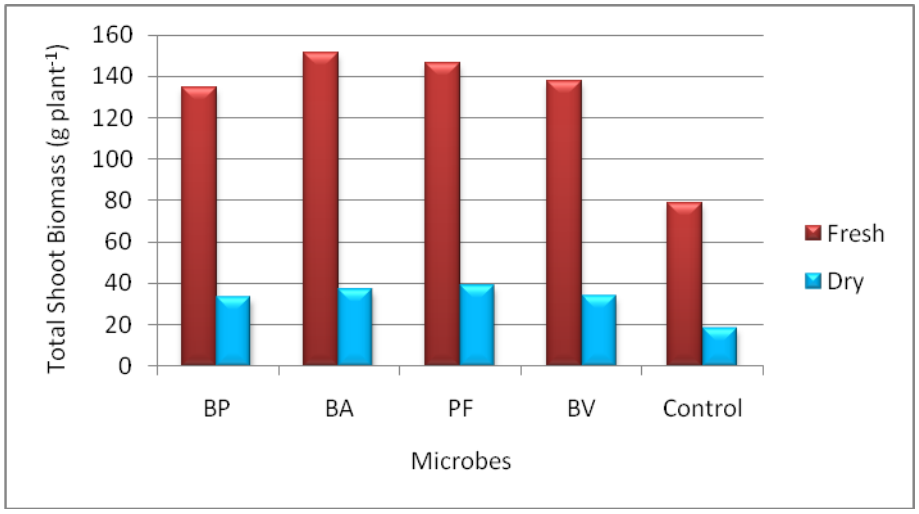


**Fig 8. Effect of biopriming of total shoot biomass in *O. tenuiflorum***

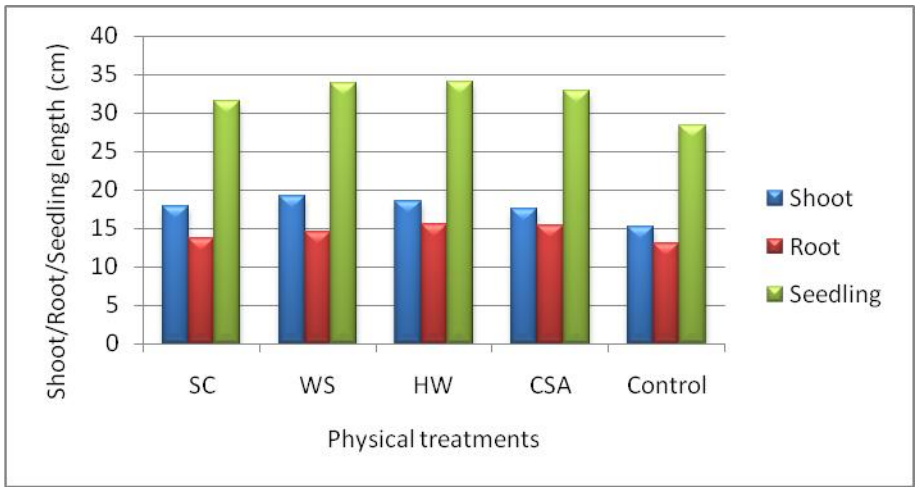


**Fig 9. Effect of physical treatments on shoot, root and seedling length in *O. basilicum***

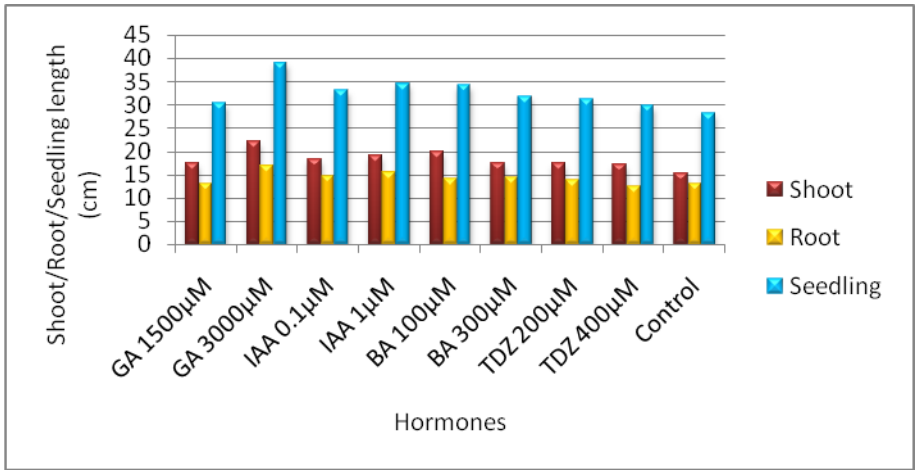


**Fig 10. Effect of hormonal priming on shoot, root and seedling length in *O. basilicum***

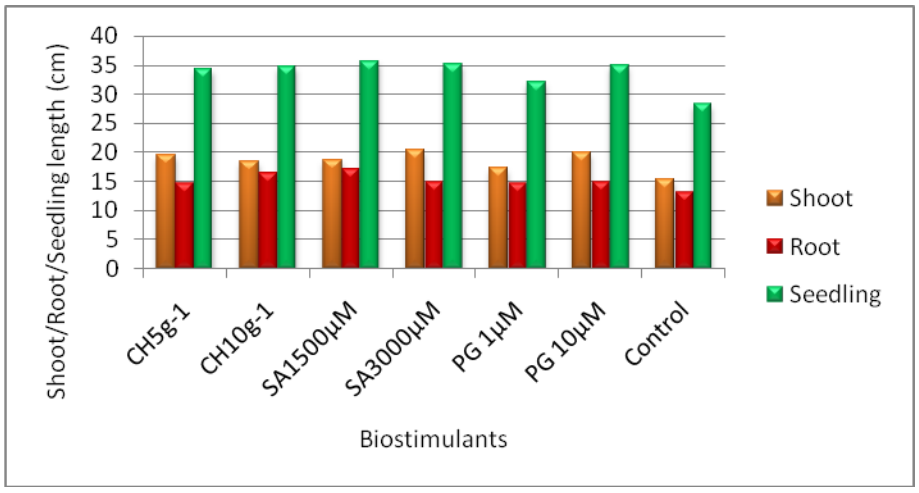


**Fig 11.Effect of biostimulant priming on shoot, root and seedling length in *O. basilicum***

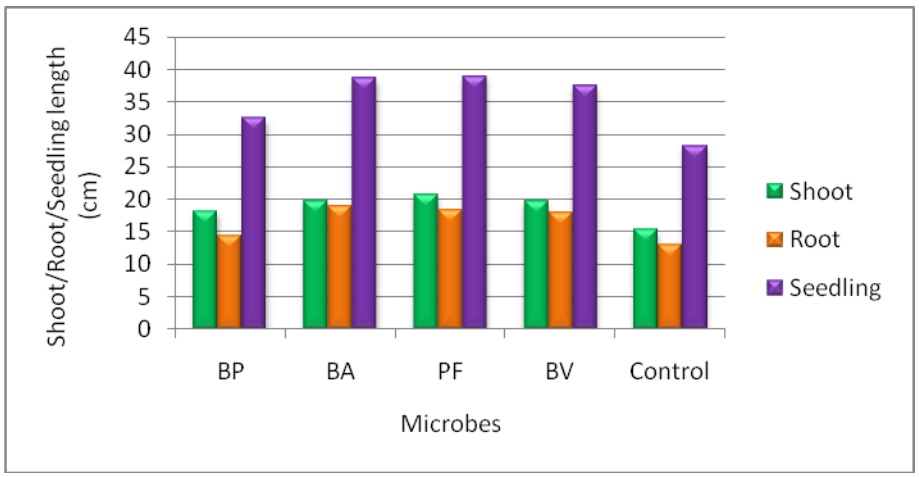


**Fig 12. Effect of biopriming on shoot, root and seedling length in *O. basilicum***

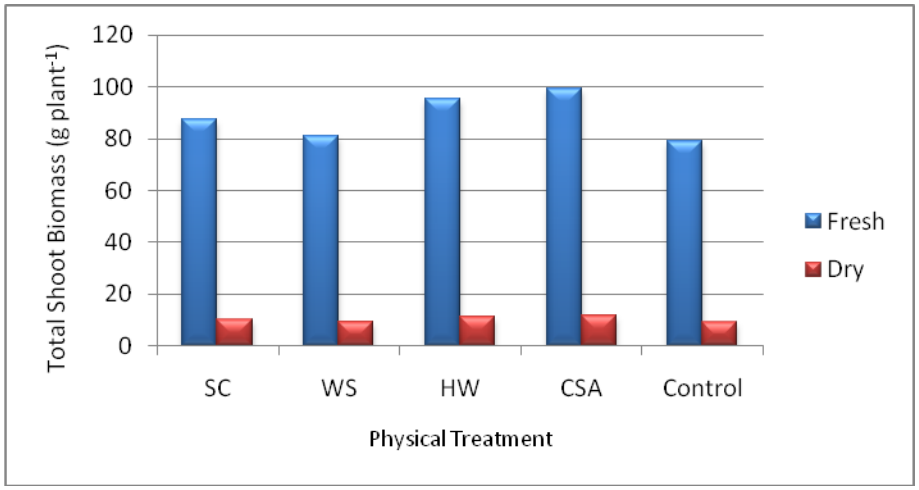


**Fig 13. Effect of physical treatments of total shoot biomass in *O. basilicum***

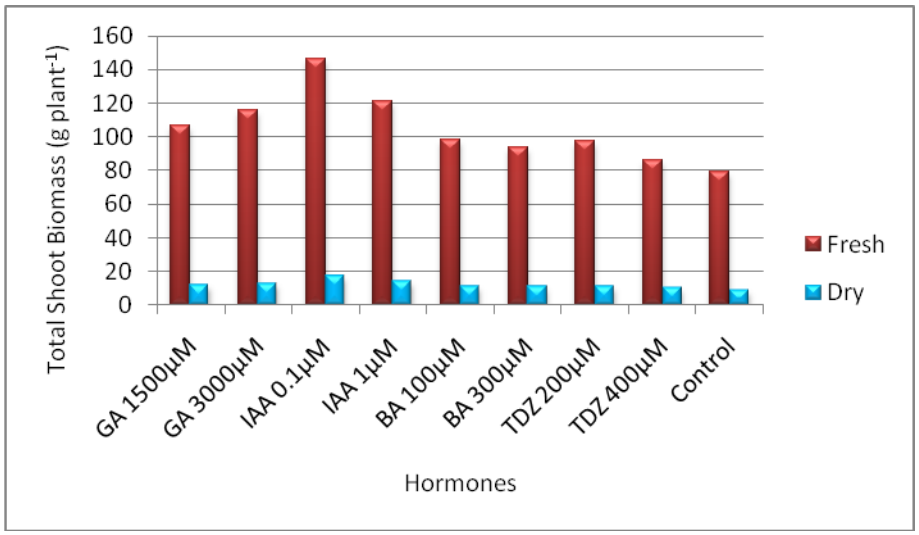


**Fig 14. Effect of hormonal priming of total shoot biomass in *O. basilicum***

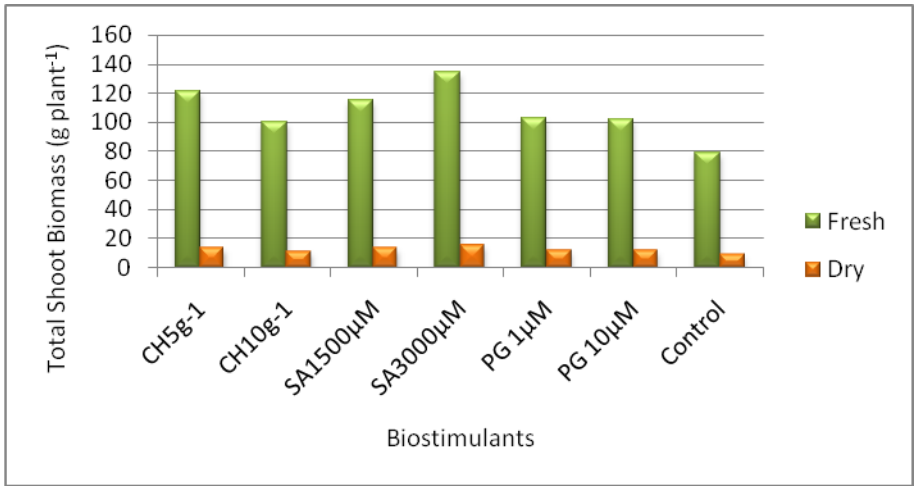


**Fig 15. Effect of biostimulants priming of total shoot biomass in *O. basilicum***

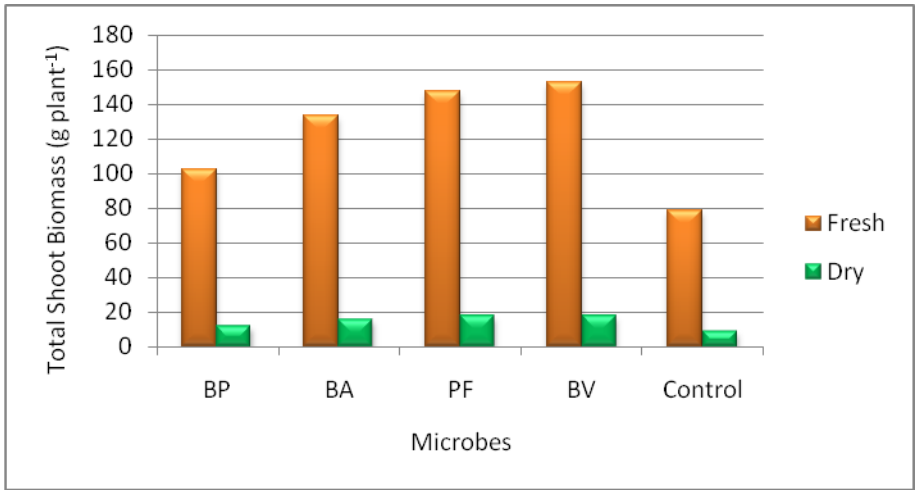


**Fig 16. Effect of biopriming of total shoot biomass in *O. basilicum***

# DISCUSSION

# 5. DISCUSSION

The present study entitled “Germination and plant growth responses in *Ocimum* spp. to seed pretreatments” was carried out during 2018-2020 at the Department of Plantation Crops and Spices, College of Agriculture, Vellayani. The results of study are discussed in this chapter.

The seeds of the two *Ocimum* species were subjected to different pretreatments, to study their effect on germination and seedling parameters; further transplanted to grow bags after 30 DAS and maintained upto harvest (90 DAS), to study their effect on plant growth. The responses of the two species towards various pretreatments are discussed here.

## 5.1 Effect of physical pretreatments of seeds on enhancing germination and plant growth in *Ocimum* spp.

The seeds of the two species when subjected to different physical pretreatments, *O. tenuiflorum* seeds exposed to concentrated sulphuric acid for 1min recorded maximum germination and survival of 85.33 per cent. In consensus with our study, Imani *et al.* (2014) demonstrated a higher germination of 95 per cent, on treating the seeds of *Canna indica* with concentrated $H_2SO_4$ for three and four hours. However, in the present study, *O. basilicum* seeds treated with $H_2SO_4$ were observed to give the lowest germination of 32 per cent. Aduradola and Adejomo (2005) reported that seeds of *Erythronphleum suaveolens* soaked in concentrated $H_2SO_4$ inhibited germination and reduced germination per cent which could be due to probable damage of the embryo by the acid. Differential response of the two species to sulfuric acid treatments might be attributed to the structural or biochemical variation in the seed, which needs to be further elucidated.

*O. tenuiflorum* seeds treated with hot water recorded the highest seedling vigour index (19.67) and seedling length (27.83 cm). Among the treatments, higher plant height and shoot biomass (fresh and dry weight) at harvest stage (90 DAS), were also observed in this treatment.

However, in *O.basilicum*, overnight water soaking treatment recorded maximum germination index of 16.13 and seedling vigor index of 18.27. In consensus with our finding, Farahani and Maroufi (2011) reported higher seedling vigour index in the seeds of *O. basilicum* and *Helianthus annus*, seeds exposed to hydropriming for 12 h.

In *O. basilicum*, though water soaking treatment recorded higher seedling vigour index, this did not reflect in the seedling length. No significant variation was observed in seedling length among the various physical treatments tried. Similar effect was observed in shoot biomass also.

The phenological parameters did not show any variation among the physical treatment in *O. tenuiflorum*. In *O. basilicum*, scarfication recorded the least number of days to flowering which was found on par with hot water and water soaking treatments. However, no variation was observed with respect to days to fruit set and fruit maturity in *O. basilicum.*

### *5.1* Effect of hormonal priming of seeds on enhancing germination and plant growth in *Ocimum spp*

In the study, it was demonstrated that *O. tenuiflorum* seed priming using $GA_3$ @ 1500 µM recorded maximum germination of 96 per cent, seedling length of 29.63 cm and maximum seedling vigour index of 28.42. Similar effects of $GA_3$ was observed in seeds of *Atropa belladonna* (Genova *et al.,* 1997), *Cucumis melo* (Emem *et al.,* 2017), *Rauvolfia serpentina (*Phatak *et al.,* 2018) and *Pimpinella anisum* (Shahrajabian *et al.,* 2019).

In the study, it was observed that priming of *O. basilicum* seeds with higher concentration of $GA_3$ @ 3000 µM, recorded higher seedling length. However, higher germination and seedling vigour index were observed in seeds primed with BA @ 300 µM. Singh (2004) and Gamery and Mousa (2017) demonstrated the enhanced germination per cent in the seeds of *Zinnia elengans and Nigella sativa,* due to priming with BA.

It was observed in our study that the control treatment gave significantly higher germination per cent, survival per cent, germination index and lower mean germination time than the seeds pretreated with IAA, BA and TDZ in *O. tenuiflorum*. Leadem (1987) opined that IAA has little or no effect on seed germination under normal situation except under stress situation, where improvement in germination had been observed. Inhibitory effect of IAA on seed germination has been reported in soybean seeds by Shuai *et al.* (2017). The inhibitory effect of TDZ has been reported in *Arachis hypogea* (Singh *et al*., 2008). However, *O. basilicum* seeds primed with BA @ 300 µM recorded the lowest mean germination time and the highest germination per cent, germination index and seedling vigour index. In line with this finding, positive effect of seed priming with BA has been reported in *Allium cepa* and *Nigella sativa* by Gamery and Mousa (2017).

When transplanted, plants raised from *O. tenuiflorum* seeds primed with $GA_3$ @ 1500 µM, attained significantly higher plant height and shoot biomass, while in case of *O. basilicum,* plants raised from $GA_3$ @ 3000 µM primed seeds recorded significantly higher shoot biomass. No significant variation was observed in plant height at harvest stage in *O. basilicum.* It was observed that in spite of higher seedling vigour index, the *O. basilicum* plants raised from BA @ 300 µM primed seeds recorded significantly lower seedling length and shoot biomass, which was on par with the control that recorded the lowest value. In accordance with this finding, Silva *et al.* (2019) explained that application of BA in seed treatment reduced shoot mass and yield in bean crop.

With respect to phenological parameters, days to flowering showed significant variation with the minimum number of days being recorded in IAA 0.1 µM, which was on par with TDZ @ 400 µM in *O. tenuiflorum,* while days to fruit set and fruit maturity did not show any variation among the hormonal treatments tried. In contrast to this, Singh *et al.* (2008) reported that seed priming with TDZ delayed flowering in *Arachis hypogea,* However, no significant effect was observed in any of the phenological parameters in *O. basilicum*.

## 5.3 Effect of biostimulant priming of seeds for enhancing germination and plant growth in *Ocimum spp*

In *O. tenuiflorum,* the control (non-pretreated seeds) recorded maximum germination of 62.66 per cent and higher germination index (18.88) over the various biostimulant treatments tried. Though only a lower germination of 36 per cent was recorded in salicylic acid (SA) @ 1500 µM primed seeds, it recorded significantly higher seedling vigour index and seedling length. The higher seedling vigour index observed in this treatment was due to the enhanced length of the seedlings. However, seeds primed with SA @ 3000 µM recorded the lowest seedling length and seedling vigour index. This could be attributed to inhibitory effect of higher concentration of SA. The control treatment also recorded significantly higher seedling vigour index, in spite of the lowest seedling length, which was due to higher germination percent. Also, it was observed that seeds primed with chitosan @ 5 $gL^{-1}$, that gave a lower germination of 12.67 per cent recorded a higher seedling length, which was significantly on par with the seedlings raised from SA @ 1500 µM primed seeds. Samarah *et al.* (2016) opined that chitosan seed priming enhanced seed germination and seedling growth in many plant species. The lower germination per cent observed in the study could be attributed to higher concentration of chitosan used in the study. Seed priming using a lower concentration 2 g $L^{-1}$ has been reported to give better germination and seedling length compared to 5 g $L^{-1}$ in *Plantago ovata* seeds (Mahdavi, 2013).

*O. basilicum* seeds pretreated with SA @ 1500 µM and 3000 µM exhibited significantly higher germination per cent, seedling length and seedling vigor index. In line with this result, Maia *et al.* (2000) demonstrated that SA increased the germination per cent in soybean seedlings, besides stimulating the length of roots and increasing the green biomass. Moghaddam *et al.* (2018) also confirmed the positive effect of SA on germination per cent and seedling length in *Trigonella foenumgraecum.* Shatpathy *et al.* (2018) observed significantly higher seedling length in SA-primed seeds than non-primed seeds. Alamri *et al.* (2018) also is of the view that salicylic acid treatment increased germination, seedling height and vigor index in wheat seedlings. It was also observed that seeds primed using phloroglucinol @ 1µM was significantly on par with SA primed seeds with respect to germination per cent. The same treatment exhibited the highest germination index and the lowest mean germination time. It was observed in our study that these germination parameters declined at higher concentration of phloroglucinol. Masando *et al.* (2018) reported the positive effect of seed priming with phloroglucinol on germination, survival and seedling height in *Ceratotheca triloba.*

In contrast to this, it was observed in the study that phloroglucinol primed seeds recorded very low germination per cent, germination index and higher mean germination time in *O. tenuiflorum.*

When transplanted, *O. tenuiflorum* plants raised from SA @ 1500 µM and chitosan @ 5g $L^{-1}$ primed seeds, gave significantly higher plant height and shoot biomass at harvest. These plants exhibited significantly higher seedling length at 30 DAS. Though the control recorded a higher seedling vigour index, it did not reflect in the shoot biomass. However, with *O. basilicum*, SA @1500 µM and 3000 µM, which recorded higher seedling vigour index and seedling height gave higher shoot biomass. A higher seedling length was observed in chitosan and phloroglucinol primed seeds, in which the shoot biomass was found to be significantly higher than the control treatments.

In *O. tenuiflorum,* phenological parameters did not show any significant effect among the biostimulant priming treatments. Chitosan 10 $gL^{-1}$ recorded the least number of days to flowering in *O. basilicum* and was found to be on par with SA @ 3000 µM. In confirmation to this, Ohta *et al.* (1999) reported that chitosan seed treatment had a positive influence on plant growth and reduced the time taken for flowering in *Eustoma grandiflorum*. Paulín *et al.* (2013) also confirmed an enhanced seedling length, plant growth, shoot biomass and reduced flowering time in maize due to chitosan treatment. However, days to fruit set and fruit maturity did not show any variation among the treatments in *O. basilicum* also.

**5.4 Effect of biopriming of seeds for enhancing germination and plant growth in *Ocimum spp.***

Among the biopriming treatments tried with various microbial cultures, *O. tenuiflorum* seeds bioprimed with *Bacillus pumilus* recorded significantly higher germination, seedling length and maximum seedling vigour index. In agreement with this result, Bashan *et al.* (2010) confirmed the enhancement in germination, seedling length and other morphological parameters on priming *Atriplex lentiformis* seeds with *B. pumilus*. In our study, it was also observed that the higher value of seedling length was on par with all other microbial treatments tried. However, the highest root length and allometric index was recorded in seedlings derived from the treatment involving *B. amyloliquefaciens.* Talboys *et al.* (2014) demonstrated that seed priming with *B. amyloliquefaciens* stimulated root production in *Triticum aestivum,* due to auxin secretion by the organism.

In the study, it was demonstrated that seed priming with *B. velezensis* recorded higher germination per cent, seedling length and seedling vigour index in *O. basilicum*. *B. amyloliquefaciens* and *Pseudomonas fluorescens* also recorded on par values with respect to these parameters. The enhancement in germination parameters and morphological parameters of the seedlings was reported by Moeinzadeh *et al.* (2010) in *Helianthus annus* and Rodriguez *et al.* (2015) in *Abies hickelii* on seed priming with *P. fluorescens*. Gowtham *et al.* (2018) also

confirmed the positive effect of priming of chilli seeds with *B. amyloliquefaciens* on seed germination, seedling vigour index and vegetative growth parameters. However, it was observed in our study that seed priming with *B. amyloliquefaciens* and *P. fluorescens* in *O. tenuiflorum* in spite of showing higher seedling length, recorded a lower germination of 28 and 26 per cent, respectively. Also, it was noticed that though seed priming with *B. pumilus* gave the highest germination per cent, seedling length and seedling vigour index in *O. tenuiflorum*, this treatment recorded the lowest values with respect to these parameters, in *O. basilicum*.

When transplanted, the plants derived from biopriming with various microbes did not show any variation with respect to plant height at 60 DAS and at harvest in both the species. The number of branches and stem girth did not show any variation among the treatments in *O. tenuflorum.* But the shoot biomass was higher for all the biopriming treatments over the control. The leaf biomass was found to be significantly higher in plants derived from seed primed with *Bacillus* spp. while *P. fluorescens* recorded a lower value. However, the stem biomass was observed to be the highest in plants derived from the treatment involving *P. fluorescens* followed by *Bacillus* spp. The plants that recorded higher seedling length, when transplanted corresponded to higher shoot biomass at harvest.

In case of *O. basilicum*, plant height and stem girth did not show any significant variation among the treatments. However, this species showed significantly higher values with respect to number of branches in plants derived from seeds primed with *B.amyloliquefaciens, P. fluorescens* and *B. velezensis.* The same treatments recorded significantly higher shoot biomass at harvest. Plant-growth-promoting activity of *B. amyloliquefaciens* is well documented in various studies (Bochow *et al.,* 2001; Grosch *et al.,* 1999; Idriss *et al.,* 2002; Schmiedeknecht *et al.,* 1998; Yao *et al.,* 2006). *B. velezensis* was reported to benefit plant growth by nutrient uptake and secreting secondary metabolites such as indole-3-acetic acid that promote root development (Kim *et al.,* 2017). Raj *et*

*al.* (2004) and Sharma *et al.* (2013) confirmed that biopriming of seeds with *P. fluorescens* improved plant growth in pearl millet and soyabean, respectively.

The results of the study confirmed the opinion of Moeinzadeh *et al*. (2010) that biopriming treatment would potentially promote quick and even germination as well as better plant growth.

The phenological parameters did not show any significant effect among the bioprimimg treatments in *O.tenuiflorum*. In O. *bsailicum*, *B. velezensis* recorded the least number of days to flowering which was found to be on par with *B. amyloliquefaciens* and *P. fluorescens*. Sharma *et al.* (2018) also demonstrated earliness in flowering in soybean on bioprimimg with *P. fluorescens.* The parameters, days to fruit set and fruit maturity did not show any significant effect in O. *basilicum.*

## 5.5 Effect of various pretreatment of seeds for enhancing germination in *Ocimum* spp.

In *O. tenuiflorum*, among the various pretreatments tried, higher germination per cent was recorded by the seeds primed with $GA_3$ @ 1500 µM followed by $GA_3$ @ 3000 µM and concentrated $H_2SO_4$. The mean germination time recorded lower values for all physical pretreatments and $GA_3$ pretreatments. These were found to be on par with the control. The result indicated that none of the pretreatments gave quicker germination compared to the control, though various pretreatments gave better performance with respect to other germination parameters. SA @ 1500 µM recorded the highest seedling length, which was on par with $GA_3$ @ 1500 µM and chitosan 5g $L^{-1}$. $GA_3$ @ 1500 µM recorded significantly higher seedling vigour index. Lecat *et al*. (1992) opined that $GA_3$ induced enhancement of germination is brought about by the hydrolysis of storage nutrients in the seeds and have a direct effect on embryo growth. According to Halter *et al.* (2005) gibberellins (GAs) play a major role in the termination of seed dormancy.

In *O. basilicum*, a higher germination per cent was observed in seeds primed with microbes (*B. amyloliquefaciens, P. fluorescens* and *B. velezensis*), SA @ 1500 µM and 3000 µM, BA @ 300 µM and PG @ 1 µM. Mean germination time was the least for PG pretreatments, *B. amyloliquefaciens*, and *B. velezensis*, which indicated that these treatments gave quicker germination over the control treatment. A higher seedling length was observed in seeds primed with $GA_3$ @ 3000 µM and with microbes (*B. amyloliquefaciens, P. fluorescens* and *B. velezensis*). A higher seedling vigour index was observed on biopriming with microbes (*B. amyloliquefaciens, P. fluorescens* and *B. velezensis*) and SA pretreatments.

It can be inferred from the study that those treatments which gave better germination in *O. tenuiflorum*, gave very low germination in *O. basilicum*, much lower than the control treatments. Also, these treatments recorded lower seedling length (except for $GA_3$ @ 3000 µM, which recorded the highest seedling length) and seedling vigour index. The highest seedling length recorded in seeds primed with $GA_3$ @ 3000 µM was found to be on par with those of bioprimed seeds with *B. amyloliquefaciens, P. fluorescens* and *B. velezensis*. Similarly, those treatments which gave better performance with respect to germination and seedling growth parameters in *O. basilicum*, gave a lower performance in *O. tenuiflorum*. This indicates that each growth promoting agent/ pretreatment agent acts differentially, even at the species level.

When transplanted, plants derived from SA @ 1500 µM primed *O. tenuiflorum* seeds, recorded the highest shoot biomass. This was found to be on par with $GA_3$ @ 1500 µM and chitosan @ 5 g $L^{-1}$. These three treatments showed on par values with respect to seedling length, but seedling vigour index was significantly higher with respect to $GA_3$ @ 1500 µM only. The seedling vigour index as being estimated based on the two parameters, germination per cent and seedling length, the lower seedling vigour index recorded by chitosan @ 5 g $L^{-1}$ and SA @ 1500 µM was due to low germination per cent (12.66 and 36.00, respectively) attained in the seeds primed using these biostimulants.

In case of *O. basilicum,* when transplanted, seeds primed using $GA_3$ @ 3000 µM, SA @ 3000 µM and microbes, *B. amyloliquefaciens, P. fluorescens* and *B. velezensis* gave higher shoot biomass. The same treatments recorded higher seedling length. The plants derived from these microbial priming treatments recorded significantly higher seedling vigour index also. However, $GA_3$ @ 3000 µM gave a very low seedling vigour index of 15.36 against 31.15 recorded by *B. amyloliquefaciens*. This could be attributed to the low germination per cent (39.33) recorded in $GA_3$ @ 3000 µM primed seeds.

With respect to phenological parameters, only days to flowering showed significant variation among the seed pretreatments in both the species. In *O. tenuiflorum*, scarification, IAA 0.1 µM and *B. amyloliquefaciens* recorded the minimum number of days to flowering and in O. *basilicum*, *B. velezensis* recorded the least number of days to flowering.

In the study, $GA_3$ @ 1500 µM recorded maximum germination per cent (96.00), seedling length (29.63 cm), seedling vigour index (28.42) and yield (shoot biomass (Fresh weight -193.50 g; dry weight- 46.13 g) in *O. tenuiflorum.* In case of *O. basilicum*, biopriming using *B. velezensis* recorded maximum germination per cent (82.00), seedling length (37.50 cm), seedling vigour index (30.72) and shoot biomass (fresh weight-153.03 g; dry weight-17.72 g), whose values were found to be on par with *B. amyloliquefaciens* and *P. fluorescens*.

In this study, it was observed the final shoot biomass at harvest, which is indicative of yield is a reflection of seedling length rather than seedling vigour index, in both the species. The seedling vigour index tends to be low in those plants derived from primed seeds, which gave better performance in terms of yield, shoot biomass. This was due to low germination per cent recorded in such treatments. As both these *Ocimum* species being transplanted crops, low germination per cent could be compensated by a slight increase in the seed rate and selection of vigorous seedlings. Also, it was observed the plants exposed to different pretreatments responded differentially in terms of germination, seedling

growth and plant growth parameters in the two *Ocimum* spp., *O. tenuiflorum and O. basilicum*. This could be attributed to structural and biochemical variation within the seed and/or plant. The interaction of various growth promoting agents used in seed priming with the endogenous growth regulators has to be further investigated to understand the factors underlying these differential responses in the two species. Seed and plant metabolomics studies of the *Ocimum* spp. on exposure to various pretreatments might elucidate the reason for differential responses in these species.

**Future line of work**

- The seed priming experiments have to be carried out at field level to confirm its efficiency at field level.
- Effect of each of these components in improving the crop quality in terms of essential oil and secondary metabolite production has to be studied.
- The effect of different modes of application *viz.,* foliar spray, combined application of seed priming and foliar spray have to be studied.
- Seed and plant metabolomics studies with respect to various seed priming agents have to be carried out to elucidate the differential responses obtained in the two *Ocimum* spp., *O. tenuiflorum* and O. *basilicum.*

# SUMMARY

# 6. SUMMARY

The present investigation entitled "Germination and plant growth responses in *Ocimum* spp. to seed pretreatments" was conducted in the Department of Plantation Crops and Spices, College of Agriculture, Vellayani during 2018-2020 with the objective to standardize pretreatment of seeds for enhanced germination and plant growth in *Ocimum tenuiflorum* L. and *Ocimum basilicum* L.

The seeds of *Ocimum tenuiflorum* and *Ocimum basilicum* used for the study were sourced from Indian Institute of Horticultural Research, Bengaluru.

The study was carried out in two phases, 1) Pretreatment of seeds for enhanced germination; 2) Evaluation of transplanted seedlings derived from pretreated seeds for enhanced plant growth. The seeds of both the species of *Ocimum* were subjected to various treatments *viz.*, physical treatments, hormonal priming, biostimulant priming and biopriming (using microbes), prior to sowing. The seeds subjected to germination without any pretreatment were taken as the control.

In the first phase of the study, *O. tenuiflorum* seeds when exposed to physical treatments, pretreatment using concentrated sulphuric acid for 1min recorded maximum germination (85.33 per cent). Germination index, mean germination time and allometric index did not show any significant variation among the physical treatments. Hot water treatment recorded the highest shoot length (17.17 cm), root length (10.66 cm), seedling length (27.83 cm) and seedling vigour index (19.67) at 30 days after sowing.

Among the hormonal priming treatments, seeds primed with $GA_3$ @1500 µM recorded the highest germination (96 per cent), germination index (26.03), shoot length (19.03 cm), root length (10.60 cm), seedling length (29.63 cm) and

seedling vigour index (28.42). $GA_3$ @ 3000 µM recorded the lowest mean germination time of 4.55 days and BA @ 300 µM recorded the highest allometric index (0.66).

In biostimulant seed priming, the control treatment recorded the highest germination (62.66 per cent) and higher germination index (18.88). The mean germination time did not show any significant variation. Salicylic acid @ 1500 µM was observed to give the significantly higher shoot length (19.46 cm), seedling length (31.29 cm) and seedling vigour index (11.46). Chitosan @ $5gL^{-1}$ recorded the highest root length (13.00 cm) and maximum allometric index (0.86).

The seeds when subjected to biopriming with microbes, seeds primed with *Bacillus pumilus* VLY17 recorded the highest germination (72.66 per cent) and the maximum seedling vigour index (15.83). The control treatment exhibited maximum germination index (18.88) and least value (4.68 days) of mean germination time. *Pseudomonas fluorescens*PN026 recorded the highest shoot length (13.78 cm) and the highest seedling length (22.05) cm. *Bacillus amyloliquefaciens*VLY24 observed the highest root length (9.83 cm) and the maximum (0.85) allometric index.

Among all the pretreatments tried, $GA_3$ @ 1500 µM recorded maximum germination and seedling vigour index. $GA_3$ @ 3000 µM recorded the highest germination index. Water soaking recorded the least number of days to mean germination time. Salicylic acid @ 1500 µM recorded the highest shoot length and seedling length. Chitosan @ 5g $L^{-1}$ was observed to give the highest root length and maximum allometric index.

When transplanted, *O. tenuiflorum* plants exhibited significantly higher plant height (109.06 cm) in water soaking treatment among the physical treatments at 90 DAS (harvest). Hot water treatment showed higher number of branches (45.33). The physical treatments did not show any significant influence on phenological parameters *viz.*, days to flower initiation, days to fruit set and

days to maturity. The hot water treatment recorded the highest total fresh (130.10 g) and dry (31.22 g) shoot biomass and harvest index (0.91).

When the plants obtained from the hormonal seed priming were transplanted, those from TDZ @ 400 µM primed seeds, recorded the highest plant height (108.56 cm) at 90 DAS. The higher number of branches (45.33) was observed in $T_5$ (BA @ 100 µM). IAA @ 0.1 µM recorded minimum (59.55 days) number of days to flower initiation; and the days to fruit set and fruit maturity did not show any significant variation among the treatments. $GA_3$ @ 1500 µM exhibited higher total fresh (193.5 g) and dry shoot (46.13) biomass and highest value (0.92) for harvest index**.**

Among the plants from biostimulant primed seeds of *O. tenuiflorum*, those from chitosan @ $5gL^{-1}$ showed the highest plant height (89.90 cm). The highest number of branches (31) was observed in salicylic acid @ 3000 µM. Salicylic acid @ 1500µM recorded the highest fresh and dry shoot biomass (217.50 and 54.10 g, respectively). The highest harvest index (0.91) was recorded in chitosan @ $10g\ L^{-1}$.

In the transplanted crop, biopriming treatments did not show any significant variation in plant height and number of branches at 90 DAS. *P. fluorescens* exhibited significantly higher basal stem girth (0.98 cm) at 90 DAS. The biopriming treatments did not how any significant effect on phenological parameters in *O. tenuiflorum*. *B. amyloliquefaciens* was observed to have a higher shoot fresh (151.33 g) and dry (38.84 g) biomass.

When transplanted, among all the pretreatments, significantly higher plant height was observed in plants obtained from water soaking. Hot water treatment and BA @ 100 µM recorded higher number of branches. Scarification, IAA @ 0.1 µM and *B. amyloliquefaciens* VLY24 exhibited the minimum number of days to flower initiation. Salicylic acid @ 1500µM recorded the highest shoot biomass. Water soaking, $GA_3$ @ 1500 µM and BA @ 300 µM recorded the highest harvest index.

In the phase of the study, when *O. basilicum* seeds were exposed to physical treatments, germination per cent, survival per cent, root length, seedling length and allometric index did not show any significant variation. Water soaking recorded least mean germination time (4.73 days), maximum germination index (16.13), shoot length (19.23 cm) and seedling vigour index (18.27).

Among the hormonal priming treatments, plants obtained from seeds exposed to BA @ 300 µM recorded maximum germination (80.67 per cent), germination index (29.33), lower (4.10 days) mean germination time and higher (25.75) seedling vigour index. $GA_3$ @ 3000 µM recorded significantly higher shoot length (22.10 cm), root length (16.93 cm) and seedling length (39.03 cm).

Among the biostimulant treatments, the seeds treated with SA @ 1500 µM recorded the highest germination (79.33 per cent), shoot length (20.37 cm) and seedling vigor index (27.92). Salicylic acid @ 3000 µM recorded the highest (35.66 cm) seedling length. Phloroglucinol @ 1µM was observed to give the highest germination index (39.63) and the lowest mean germination time (3.23 days).

Among the biopriming treatments, seeds primed with *Bacillus velezensis* PCSE10 recorded the highest germination (82 per cent), germination index (42.60) and the lowest mean germination time (3.5 days). The highest shoot length (20.70 cm) and seedling length (38.96 cm) was observed in *P. fluorescens*. *B. amyloliquefaciens* recorded the highest root length (18.83 cm), seedling vigor index (31.15) and allometric index (0.95).

In *O. basilicum,* among all the pretreatments tried, *B. velezensis* treatment was observed to have the maximum germination per cent and germination index. Phloroglucinol @ 1µM recorded the least mean germination time. $GA_3$ @ 3000 µM recorded the highest shoot length and seedling length. *B. amyloliquefaciens* was observed to have the highest root length, allometric index and seedling vigour index.

On transplanting, the *O. basilicum* plants obtained from the seeds subjected to physical pretreatments did not show any significant variation in morphological parameters except stem girth at 90 DAS. Hot water treatment exhibited the highest basal stem girth (4.00 cm). Scarification recorded the least number of days (58.00 days) for flower initiation, while the days to fruit set and fruit maturity did not show any significant variation. The total shoot biomass (fresh and dry) and harvest index had no significant effect among the treatments.

In hormonal priming also, no significant difference was observed in morphological parameters except stem girth at 90 DAS. The plants derived from TDZ @ 400 µM primed seeds exhibited significantly higher stem girth (4.03 cm). No significant effect was observed in phenological parameters. $GA_3$ @ 3000 µM recorded the highest shoot biomass (fresh-146.00 g and dry (17.39 g) and harvest index (0.92).

On evaluation of plants derived from biostimulant priming, plant height, number of branches and number of nodes at harvest stage was found statistically on par with all treatments. Higher stem girth (4.73 cm) was recorded in chitosan @10 g $L^{-1}$. Chitosan @ 10g $L^{-1}$ recorded the least number of days (52.00 days) for flower initiation. The number of days to fruit set and fruit maturity did not exhibit significant variation. Salicylic acid @ 3000 µM exhibited the highest fresh (134.17 g) and dry (15.95 g) shoot biomass and harvest index (0.96).

Among the plants derived from biopriming treatments, plant height and stem girth did not show any variation at 90 DAS. *P. fluorescens* registered the highest number of branches (20.40) and number of nodes (205.30). *B. velezensis* recorded the least number of days (48.00 days) to flower initiation, while no significant variation was observed in days to fruit set and fruit maturity. *B. velezensis* also recorded higher leaf biomass (fresh - 99.60 g and dry - 10.55 g), stem biomass (fresh 53.43 g and dry 7.17 g), shoot biomass (fresh -153.03 g and dry - 17.73 g) and harvest index (0.92) The leaf, stem and shoot biomass were found to be on par with that of *B. amyloliquefaciens* and *P. fluorescens.*

On evaluation of *O. basilicum* plants obtained from various seed pretreatments, no significant variation was observed in plant height and number of branches. Chitosan @ 10g $L^{-1}$ registered the highest stem girth (4.73 cm). The minimum days to flower initiation (48.00 days) was recorded in *B. velezensis*, while no significant influence was seen in days to fruit set and days to fruit maturity. *B. velezensis, B. amyloliquefaciens* and *P. fluorescens* were observed to have higher leaf, stem and shoot biomass. Salicylic acid @ 3000 µM recorded the highest (0.96) harvest index.

In the study, among the various seed pretreatments in *O. tenuiflorum*, $GA_3$ @ 1500 µM recorded enhanced germination and plant growth, in terms of germination per cent, seedling length, seedling vigour index, plant height, number branches and shoot biomass. In case of *O. basilicum*, biopriming using *B. velezensis*, *B. amyloliquefaciens* and *P. fluorescens* recorded enhanced germination and plant growth, in terms of higher germination per cent, seedling length, seedling vigour index, leaf , stem and shoot biomass.

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## 7. REFERENCES


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# GERMINATION AND PLANT GROWTH RESPONSES IN *OCIMUM* SPP. TO SEED PRETREATMENTS


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## ABSTRACT

### Germination and plant growth responses in *Ocimum* spp. to seed pretreatments

The present investigation entitled "Germination and plant growth responses in *Ocimum* spp. to seed pretreatments" was conducted in the Department of Plantation Crops and Spices, College of Agriculture, Vellayani during 2018-2020 with the objective to standardize pretreatment of seeds for enhanced germination and plant growth in *Ocimum tenuiflorum* L. and *Ocimum basilicum* L.

The seeds of *Ocimum tenuiflorum* and *Ocimum basilicum* used for the study were sourced from Indian Institute of Horticultural Research, Bengaluru. The study was carried out in two phases: Phase 1- Pretreatment of seeds for enhanced germination, Phase 2- Evaluation of transplanted seedlings derived from pretreated seeds for enhanced plant growth. The seeds of both the species of *Ocimum* were subjected to various pretreatments *viz.*, physical pretreatments, hormonal priming, biostimulant priming and biopriming (using microbes) prior to sowing. The seeds subjected to germination without any pretreatments were taken as the control.

In the first phase of the study, *O. tenuiflorum* seeds when exposed to physical treatments, pretreatment using concentrated sulphuric acid for 1 min recorded maximum germination (85.33 per cent). The hot water treatment (65$^{o}$C for 10 min) recorded the highest seedling length (27.83 cm) and seedling vigour index (19.67) with a germination of 70.66 per cent. Among the hormonal treatments, seeds primed with $GA_3$ @1500 µM recorded the highest germination (96 per cent), seedling length (29.63 cm) and seedling vigour index (28.42). In biostimulant seed priming, the untreated control recorded the highest germination (62.66 per cent) but the highest seedling length (31.29 cm) and seedling vigour index (11.46) were observed with salicylic acid (SA) @ 1500 µM. The seeds when subject to biopriming with microbes, seeds primed with *Bacillus pumilus*

recorded the best germination (72.66 per cent) and seedling vigour index (15.83). The highest seedling length (22.05 cm) was observed with *Pseudomonas fluorescens,* which was on par with that of *B. amyloliquefaciens.* Among all the pretreatments tried, $GA_3$ @ 1500 µM was observed to give maximum germination (96 per cent) and seedling vigour index of 28.42, while SA @ 1500 µM recorded the highest seedling length (31.29 cm) in *O. tenuiflorum.*

When transplanted, *O. tenuiflorum* plants derived from hot water treated seeds recorded the highest number of branches (45.33), fresh (130.10 g) and dry (31.22 g) shoot biomass at harvest (90 DAS), among the physical treatments. Plants derived from $GA_3$ @ 1500 µM treated seeds recorded the highest shoot biomass in terms of fresh (193.50 g) and dry (46.13 g) weight. The plants from SA @ 1500 µM primed seeds- gave the highest shoot biomass with fresh weight of 217.50 g and dry weight of 54.10 g, among various biostimulant priming treatments. Among the biopriming treatments, plants generated from the seeds treated with *B. amyloliquifaciens*, recorded the highest fresh (151.33 g) and dry (38.84 g) shoot biomass which was on par with that treated with *P. fluorescens*. Among all the pretreatments, plants derived from salicylic acid @ 1500 µM treated seeds recorded the highest shoot biomass.

When the *O. basilicum* seeds were exposed to physical treatments, water soaking treatment recorded the maximum seedling vigour index (16.13), while seedling length did not show any significant variation among the treatments. Among the hormonal priming, seeds exposed to BA @ 300 µM recorded the highest germination (80.67 per cent) and seedling vigour index (29.33). The maximum seedling length (39.03 cm) was observed in $GA_3$@ 3000 µM. The seeds treated with SA @ 1500 µM recorded the highest germination (79.33 per cent) and seedling vigour index (27.92), among the biostimulant priming. Maximum seedling length (35.66 cm) was observed in SA @ 3000 µM and was on par with SA @1500 µM. Among the biopriming treatments, seeds primed with *B. velezensis* recorded higher germination (82 per cent), seedling length (37.50 cm) and seedling vigour index (30.72), which were on par with *P. fluorescens* and

*B. amyloliquifaciens*. In *O. basilicum,* among all the pretreatments tried, biopriming with *B. velezensis, B. amyloliquefaciens* and *P. fluorescens* and SA @ 1500 µM recorded higher on par values with respect to germination per cent and seedling vigour index, while $GA_3$ @3000 µM which recorded the highest seedling length.

When transplanted, plants of *O.basilicum* derived from the seeds exposed to physical treatments did not show any significant variation with respect to shoot biomass. In hormonal priming, the maximum fresh (146.00 g) and dry (17.39 g) shoot biomass were observed in plants generated from seeds primed with $GA_3$ @ 3000 µM. On evaluation of plants derived from biostimulant priming, maximum fresh (134.17 g) and dry (15.95 g) shoot biomass were observed in SA@ 3000 µM, which was on par with SA @ 1500 µM. Among the biopriming treatments, plants derived from seeds primed *B. velezensis* recorded the highest fresh (153.03 g) and dry weight (17.73 g) shoot biomass, which were on par with *P. fluorescens* and *B. amyloliquefaciens*. Among all the seed pretreatments tried, plants generated from the seeds primed individually with *B. velezensis*, *B. amyloliquefaciens* and *P. fluorescens* and SA @ 1500 µM recorded higher on par values with respect to shoot biomass.

In the study, among the various seed pretreatments in *O. tenuiflorum,* $GA_3$ @ 1500 µM recorded enhanced germination and plant growth, in terms of germination per cent, seedling length, seedling vigour index, plant height, number branches and shoot biomass. In case of *O. basilicum*, biopriming using *B. velezensis*, *B. amyloliquefaciens* and *P. fluorescens* recorded enhanced germination and plant growth, in terms of higher germination per cent, seedling length, seedling vigour index, leaf, stem and shoot biomass.