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In Situ Effect Of Seed Bio-priming Techniques On Seedling Of Vegetable Crops

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Abstract: *The present investigation was carried out to in situ study the effect of seed bio-priming with microbial inoculants on pre and post-emergence mortality, germination, shoot and root fresh weight and vigour index in tomato, brinjal, onion and chilli vegetables at College of Horticulture, S.D. Agricultural University, Jagudan (Mehsana), Gujarat, India during 2017 and 2019. Two Trichoderma spp. (T. harzianum and T. viride), P. fluorescens and hydro priming at 6,12 and 18 hours. Among the treatments minimum pre-emergence mortality per cent (15.22,13.94,15.60 and 18.65), minimum post-emergence mortality per cent (11.50, 10.30, 10.83 and 11.60), minimum days to start germination (3.72, 4.00,4.03 and 4.03), minimum days have taken to 50 % germination (4.72, 5.33, 6.03 and 5.11), maximum final germination percentage (84.89, 82.36, 79.72 and 78.44), maximum root length in centimetre (15.49, 11.51, 8.64 and 15.27), maximum shoot length in centimetre (12.47, 9.88, 14.82 and 15.24), maximum seedling vigour index (2373.43, 1762.31, 1857.90 and 2421.31) maximum fresh root weight in gram (1.45,1.66, 1.68 and 1.46) and maximum shoot fresh weight in gram (2.01,2.47, 3.05 and 2.22) was recorded in T_{10} (bio priming with T. harzianumfor 12 hrs) in tomato, brinjal, onion and chilli vegetables, respectively. The present study thus reveals that seed bio priming with T. harzianum or P. fluorescens for 12 hrs. Reduced pre and post-emergence mortality, enhanced germination, root and shot fresh weight and vigour index in tomato, brinjal, onion and chilli. It is therefore suggested that before sowing tomato, brinjal, onion and chilli seed should be treated with 10 g/kg of T. harzianum or P. fluorescens in 20 ml distilled water for 12 hours.*

Keywords: *biopriming, germination, seedling vigour, Trichoderma, etc.*

I. INTRODUCTION

Horticultural production is primarily involved in the intensive use of resources, such as land, water, labour and inputs such as fertilizers and pesticides. The use of such resources in a concentrated space and time has the potential to negatively impact on the local environment and workers welfare [1]. The use of pesticides and fertilizers are of major concern and minimize their impact on the environment, and safer alternatives have been sort. The use of microbes has been reported over the years to promote growth and yield commonly termed as “bio-fertilizers”. A group of soil-based bacterium that promotes growth has been termed as “Plant Growth-Promoting Rhizobacteria (PGPR)”.

As a consequence, PGPR has the potential to enhance plant health and promote the rate of plant growth without environmental contamination [2]. A range of PGPR have been studied, including the species *Pseudomonas, Bacillus, Enterobacter, Klebsiella, Azobacter, Variovorax, Azosprillum* and *Serratia* [3]. However, the commercial utilization of PGPR in the agriculture industry is disappointing. The successful use of PGPRs is dependent on many factors, including survival of the organism on the seed as well as soil. The interaction with the microflora in the soils and crop, it provides consistent results across a range of environments. However, PGPRs work in different ways and need to understand successful adoption. An important & integral component is to apply the PGPR efficiently, compatible with current agricultural practice. Treating seeds with PGPR offers an economical and efficient application method [4].

Seed treatment with bio-control agents along with priming agents may serve as an important means of managing many soils as well as seed-borne problems and promote the growth of the plant, the process known as “bio-priming”. Biological agents such as beneficial fungi and bacteria are used in bio-priming, which includes *Trichoderma* and *Pseudomonas*.

Seed priming using osmotic solutions has been around for many decades [5]. The concept was extended to hydro priming in cereal and legume crops, and the technique of “on-farm” priming has been revived [6]. More recently the term Bio-priming has been adopted where the seed is immersed in a microbial suspension for a predetermined period, followed by drying of the seed to prevent the onset of germination. It is most appropriate for low-medium volume, high-value crops, such as vegetable seed [4]. Bio-priming treatment is potentially prominent to induce profound changes in plant characteristics and to encourage more

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uniform seed germination and plant growth associated with fungi and bacteria coatings [7].

Major vegetable crops like tomato, chilli, brinjal, onion etc. were hampered with a load of pathogenic seed microflora. These lead to the number of the nursery (*viz.*, seed rot, pre, post-emergence damping-off) and field diseases. The infected seeds thus used are responsible not only for the poor germination seedlings stand but also for the carryover of pathogens to the field. Moreover, as the germination time of most of the vegetable crops is very high viz., tomato, chilli, brinjal and onion as compared to field crops which lead to non-uniform seedling stand and low vigour seedlings. Thus, the present study is going to conduct to find out a suitable bio-priming method with an optimum priming time interval under *in situ* condition.

II. MATERIALS AND METHODS

An experiment was conducted at College of Horticulture, S.D. Agricultural University, Jagudan (Mehsana) Gujarat during and 2017, 2018 and 2019 in greenhouse condition. Fourteen treatments comprise no seed treatment as control (T_1), seed treatment with carbendazim {(2.5g/kg seed)T_2}, hydropriming for 6 hours (T_3), hydropriming for 12 hours (T_4), hydropriming for 18 hours (T_5), biopriming with *T. viride* for 6 hours (T_6), biopriming with *T. viride* for12 hours (T_7), biopriming with *T. viride* for 18 hours (T_8), biopriming with *T. harzianum* for 6 hours (T_9), biopriming with *T. harzianum* for 12 hours (T_{10}), biopriming with *T. harzianum* for 18 hours (T_{11}), biopriming with *P. fluorescens* for 6 hours (T_{12}), biopriming with *P. fluorescens* for 12 hours (T_{13}), and biopriming with *P. fluorescens* for 18 hours (T_{14}) were on Tomato cv. Anand Tomato 2, Brinjal cv. Gujarat Oblong Brinjal 2, Onion cv. Agrifound Light Red and Chilli cv. Gujarat Chilli 3 and replicated thrice.

Healthy seeds (400) were thoroughly sterilized with 0.1% HgCl2 for 2-5 minutes and 2-3 times washed with distilled water before use in experiments. Pre-soak the seeds in the double quantity of water for a given time of interval, mix the formulated product of biopesticide @ 10g/kg seed (solid)), make a heap of the treated seed, cover the heap with a moist jute sack to maintain high humidity, incubate such seeds in high humidity in a shady place for 12 hrs, bioagents adhered to the seed will grow and form a protective layer on the seed coat. Dry, such seed under the shade and such seeds will be used further to see the effect in situ studies the micro plot technique (1m x 1m) is used to see the effect of all the above seed treatment. In nursery study Pre emergence mortality (%), Post-emergence mortality (%), days to start for germination, days have taken to 50% germination, final germination (%), root length (cm), shoot length (cm), root fresh weight (g), shoot fresh weight (g) and Seedling vigour index were observed as per the standard method.

III RESULTS AND DISCUSSION AND DISCUSSION

A. Pre and Postemergence mortality

It is revealed from the data (Table 1) that there was a significant difference in pre-emergence mortality per cent during individual year as well as in pooled in all four crops viz. tomato, brinjal, onion and chilli. The minimum pre-emergence mortality per cent (15.22) was observed in $T_{10,}$ i.e. biopriming with *T. harzianum* for 12 hrs followed by (16.03) $T_{13,}$ i.e. biopriming with *P. fluorescens* for 12 hrs which was at par with treatment (16.81) $T_{7,}$ i.e. biopriming with *T.viride* for 12 hrs and maximum pre-emergence mortality per cent (29.47) was observed in $T_{5,}$ i.e. hydro-priming for 18 hrs followed by (28.25) $T_{1,}$ i.e. non primed seeds (control) in pooled and tomato crop. Similar trends were observed in brinjal, onion and chilli crops as well as individual years.

In the case of post-emergence mortality per cent (Table 2), there was significant difference during the individual year as well as in pooled in all four crops viz. tomato, brinjal, onion and chilli. The minimum post-emergence mortality per cent (11.50) was observed in $T_{10,}$ i.e. biopriming with *T. harzianum* for 12 hrs followed by (12.19) $T_{13,}$ i.e. biopriming with *P. fluorescens* for 12 hrs and maximum post-emergence mortality per cent (21.19) was observed in T_5 i.e.hydro-priming for 18 hrs followed by (20.22) $T_{1,}$ i.e. non primed seeds (control) in pooled and tomato crop. Similar trends were observed in brinjal, onion and chilli crops as well as individual years. These results are under [8]who reported that biopriming with bioagents reducing the incidence of root rot and damping-off of soybean caused by soil-borne fungi. Application of biocontrol agents such as *T. harzianum*, and *B. subtilis* to soybean seeds during priming process (bio-priming) resulted in high suppression in root rots disease incidence under artificially infested soils under greenhouse conditions. The observed improvements due to bio priming of soybean seeds may be due to priming induced quantitative change in biochemical content of the seeds and improved membrane integrity [30]. This may also be due to the proliferation of the bioagent in the primed medium [10]. [11] and [12] also stated that the biocontrol agent might multiply substantially on the seed during bio priming.

B. Germination Per cent (%)

The significant difference in days to start for germination (Table 3) during the individual year as well as in pooled in all four crops viz. tomato, brinjal, onion and chilli. The minimum days to start for germination (3.72) were observed in $T_{10,}$ i.e. biopriming with *T. harzianum* for 12 hrs followed by (4.11) T13, *i.e.* biopriming with *P. fluorescens* for 12 hrs and maximum days to start for germination (6.61) was observed in $T_{5,}$ *i.e*. hydro-priming for 18 hrs followed by (6.28) $T_{1,}$ i.e. non primed seeds which were (6.00) at par with $T_{11,}$ *i.e*. biopriming with *T. harzianum*for 18 hrs in pooled and tomato crop. Similar trends were observed in brinjal, onion and chilli crops as well as individual years.

In case of days taken to 50 % germination (Table 4), there was significant difference during the individual year as well as in pooled in all four crops viz. tomato, brinjal, onion and chilli. The minimum days taken to 50 % germination (4.72) was observed in $T_{10,}$ i.e. biopriming with *T. harzianum* for 12 hrs followed (5.00) by T_{13} i.e.biopriming with *P. fluorescens* for 12 hrs and maximum days taken to 50 % germination (7.89) was observed in $T_{5,}$ i.e. hydro-priming for 18 hrs followed by (7.61) $T_{1,}$ i.e. non primed seeds (control) in pooled and tomato crop. Similar trends were observed in brinjal, onion and chilli crops as well as individual years.

Similarly, in the case of final germination per cent (Table 5), there was significant difference during the individual year as well as in pooled in all four crops viz. tomato, brinjal, onion and chilli. The maximum germination per cent (84.89) was observed in T_{10} i.e.biopriming with *T. harzianum* for 12 hrs followed by (83.50) $T_{13,}$ i.e. biopriming with *P. fluorescens* for 12 hrs and minimum germination per cent (71.39) was observed in $T_{5,}$ i.e. hydro-priming for 18 hrs followed by (73.28) $T_{1,}$ i.e. non primed seeds (control) in pooled and tomato crop. Similar trends were observed in brinjal, onion and chilli crops as well as individual years. The primed seed might have shown higher field emergence or germination due to the production of microbial seed leachates that provide the source of carbon and nitrogen in the initial few days. Still, after that, the translocation of quantum and nature (qualitative and quantitative) of photosynthates in the form of root exudates would determine the proliferation of the microbial inoculants [13]. In the present study, enhancement of seed germination and reduce the number of days required for germination in tomato, brinjal, chilli and onion might be due to production of growth regulators by *P. fluorescens* and *T. harzianum*. This study is in close agreement with the results reported by [14] in soybean, [15] in chickpea and [16] in chickpea and rajma.

C. Root-Shoot length and Vigour Index

It is revealed from the data (Table 6) that there was a significant difference in root length during the individual year as well as in pooled in all four crops viz. tomato, brinjal, onion and chilli. The maximum root length in centimetre (15.49) was observed in $T_{10,}$ i.e. biopriming with *T. harzianum* for 12 hrs followed by (15.17) $T_{13,}$ i.e. biopriming with *P. fluorescens* for 12 hrs and minimum root length (10.27) was observed in $T_{5,}$ i.e. hydro-priming for 18 hrs followed by (11.01) $T_{1,}$ i.e. non primed seeds (control) in pooled and tomato crop. Similar trends were observed in brinjal, onion and chilli crops as well as individual years.

In case of shoot length (Table 7) there was significant difference during the individual year as well as in pooled in all four crops viz. tomato, brinjal, onion and chilli. The maximum shoot length in centimetre (12.47) was observed in $T_{10,}$ i.e. biopriming with *T. harzianum* for 12 hrs followed by(11.67) $T_{13,}$ i.e. biopriming with *P. fluorescens* for 12 hrs and minimum shoot length (7.85) was observed in T_5 i.e.hydro-priming for 18 hrs followed by (8.19) $T_{1,}$ i.e. non primed seeds (control) in pooled and tomato crop. Similar trends were observed in brinjal, onion and chilli crops as well as individual years.

Similarly, in the case of vigour index (Table 8), there was significant difference during the individual year as well as in pooled in all four crops viz. tomato, brinjal, onion and chilli. The maximum vigour index (2373.43) was observed in $T_{10,}$ i.e. biopriming with *T. harzianum* for 12 hrs followed by (2241.26) $T_{13,}$ i.e. biopriming with *P. fluorescens* for 12 hrs and minimum vigour index (1293.36) was observed in $T_{5,}$ i.e. hydro-priming for 18 hrs followed by (1406.47) $T_{1,}$ i.e. non primed seeds (control) which were at par with (1493.16) T_{11} i.e.biopriming with *T. harzianum* for 18 hrs in pooled and tomato crop. Similar trends were observed in brinjal, onion and chilli crops as well as individual years. Growth promoting bacteria can promote growth and biomass production in different plant species. *Pseudomonas spp*. Promote plant growth by increasing nutrient absorption (e.g., N, P, K) and providing hormones in the rhizosphere, [17] and [18]. These results are following [19]. Some researcher reported that the beneficial effect of priming by [20]; [21], [22] in tomato, [23], [24] in maize [25] in sorghum [26] in lentil and [27] in cowpea.

D. Root Shoot Fresh Weight

It is revealed from the data (Table 9) that there was a significant difference in fresh root weight during the individual year as well as in pooled in all four crops viz. tomato, brinjal, onion and chilli. The maximum root fresh weight in gram (1.45) was observed in $T_{10,}$ i.e. biopriming with *T. harzianum* for 12 hrs followed by (1.37) $T_{13,}$ i.e. biopriming with *P. fluorescens* for 12 hrs and minimum root fresh weight (1.04) was observed in $T_{5,}$ i.e. hydro-priming for 18 hrs which was at par with (1.06) T_1 i.e.non primed seeds (control) in pooled and tomato crop. Similar trends were observed in brinjal, onion and chilli crops as well as individual years.

In case of fresh shoot weight (Table 10), there was significant difference during the individual year as well as in pooled in all four crops viz. tomato, brinjal, onion and chilli. The maximum shoot fresh weight in gram (2.01) was observed in $T_{10,}$ i.e. biopriming with *T. harzianum* for 12 hrs followed by (1.94) $T_{13,}$ i.e. biopriming with *P. fluorescens* for 12 hrs and minimum shoot fresh weight (1.50) was observed in T_5 i.e.hydro-priming for 18 hrs followed by (1.53) $T_{1,}$ i.e. non primed seeds (control) in pooled and tomato crop. Similar trends were observed in brinjal, onion and chilli crops as well as individual years. Coated seeds by bioagents and seed bio priming cause a significant increase of vegetative growth of many crops [11]. The enhancing effect of bio – priming on increasing vegetative growth parameter of these vegetable crops might be attributed to its efficiency in supplying the biologically fixed nitrogen, dissolved immobilized induce exudates of some hormonal substances like gibberellic acid, cytokinins and auxins which could stimulate nutrients absorption as well as photosynthesis

process which subsequently increased growth. These results are following the findings of [8], [28], [10] and [29].

IV. CONCLUSIONS

Overall bio priming with *Trichderma harzianum* for 12 hours or *Pseudomonas fluorescens* for 12 hours depicted minimum pre and post-emergence mortality, maximum germination, maximum root and shoot length, maximum root and shoot fresh weight and seedling vigour index in respect to all the crops evaluated in situ /nursery condition.

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Table 1: Effect of seed bio-priming on pre-emergence mortality of vegetables in situ or nursery condition

Treat.	Tomato				Brinjal				Onion				Chilli			
	2017	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**
T_1	27.57 (21.00)	35.35 (33.00	33.97 (30.75)	32.30 (28.25)^{ab}	29.21 (23.33)	28.98 (23.00)	29.32 23.50)	29.17 (23.28)ab	28.84 (22.80)	29.10 (23.20)	28.81 (22.75)	28.92 (22.95)^{a}	30.81 (25.75)	30.31 (25.00)	30.56 (25.38)	30.56 (25.38)^{a}
T_2	23.88 (16.00)	25.46 (18.00	25.83 (18.50)	25.06 (17.50)^{ghi}	24.53 (16.75)	24.47 (16.67)	25.83 (18.50)	24.94 (17.31)hij	25.30 (17.80)	24.70 (17.10)	25.20 (17.65)	25.07 (17.52)^{fg}	27.05 (20.20)	27.32 (20.60)	26.80 (19.85)	27.05 (20.22)^{gh}
T_3	26.42 (19.33)	32.04 (27.67	31.61 (27.00)	30.03 (24.67)^{bcd}	27.14 (20.33)	27.37 (20.67)	28.13 (21.75)	27.55 20.92)cde	27.54 (20.90)	27.04 (20.20)	27.51 (20.85)	27.36 (20.65)^{bcd}	29.21 (23.33)	29.47 (23.75)	28.81 (22.75)	29.17 (23.28)^{cd}
T_4	24.93 (17.33)	28.98 (23.00	28.07 (21.66)	27.33 (20.66)^{efg}	25.45 (18.00)	25.70 (18.33)	26.73 19.75)	25.96 18.69)fgh	26.18 (19.00)	25.64 (18.25)	26.14 (18.93)	25.99 (18.73)^{def}	28.07 (21.66)	28.13 (21.75)	27.85 (21.35)	28.02 (21.59)^{efg}
T_5	28.12 (21.75)	36.35 (34.67	34.74 (32.00)	33.07 (29.47)^{a}	30.09 (24.66)	30.31 (25.00)	29.81 (24.25)	30.07 (24.64)a	28.98 (23.00)	29.96 (24.50)	29.40 (23.65)	29.45 (23.72)^{a}	30.87 (25.85)	30.64 (25.55)	30.88 (25.87)	30.80 (25.76)^{a}
T_6	25.26 (17.75)	29.43 (23.67	28.82 (22.75)	27.83 (21.39)^{def}	25.80 (18.50)	26.19 (19.00)	27.08 (20.25)	26.36 (19.25)efg	26.36 (19.25)	26.00 (18.80)	26.35 (19.22)	26.24 (19.09)^{cdef}	28.16 (21.80)	28.37 (22.10)	28.33 (22.05)	28.29 (21.98)^{def}
T_7	23.71 (15.75)	25.22 (17.67	24.71 (17.00)	24.55 (16.81)^{hi}	24.19 (16.33)	24.21 (16.33)	25.46 18.00)	24.62 (16.89)ij	24.88 (17.25)	24.23 (16.50)	25.05 (17.44)	24.72 (17.06)^{gh}	27.33 (20.60)	27.05 (20.25)	27.26 (20.50)	27.21 (20.45)^{gh}
T_8	26.00 (18.75)	31.61 (27.00	31.13 (26.25)	29.58 (24.00)^{cde}	26.15 (19.00)	26.42 (19.33)	27.84 (21.33)	26.81 (19.89)def	26.19 (19.00)	25.67 (18.32)	25.87 (18.55)	25.91 (18.62)^{ef}	29.42 (23.65)	29.25 (23.40)	29.35 (23.55)	29.34 (23.53)^{bc}
T_9	24.30 (16.50)	27.15 (20.33	26.73 (19.75)	26.06 (18.86)^{fgh}	24.93 (17.33)	24.97 (17.33)	26.42 (19.33)	25.44 (18.00)ghi	24.88 (18.00)	25.00 (17.40)	25.52 (18.08)	25.33 (17.83)^{fg}	28.13 (21.75)	27.68 (21.10)	28.16 (21.80)	27.99 (21.55)^{fg}
T_{10}	22.60 (14.33)	23.44 (15.33	23.94 (16.00)	23.33 (15.22)^{ij}	23.16 (15.00)	19.18 (10.33)	24.34 (16.50)	22.22 (13.94)k	23.68 (15.66)	23.01 (14.90)	24.14 (16.25)	23.61 (15.60)^{h}	26.33 (19.20)	25.81 (18.50)	25.64 (18.25)	25.93 (18.65)^{i}
T_{11}	26.85 (20.00)	33.92 (30.67	33.20 (29.50)	31.32 (26.72)^{j}	27.94 (21.50)	28.07 (21.67)	28.98 (23.00)	28.33 (22.06)bc	28.13 (21.75)	28.46 (22.25)	27.95 (21.50)	28.18 (21.83)^{ab}	30.38 (25.10)	30.05 (24.60)	30.22 (24.85)	30.21 (24.85)^{ab}
T_{12}	25.63 (18.25)	30.97 (26.00	30.64 (25.50)	29.08 (23.25)^{cde}	25.94 (18.66)	25.94 (18.67)	27.59 (21.00)	26.49 (19.44)efg	26.84 (19.90)	26.61 (19.60)	26.79 (19.84)	26.75 (19.78)^{bcde}	29.25 (23.40)	28.84 (22.80)	28.98 (23.00)	29.03 (23.07)^{cde}
T_{13}	23.17 (15.00)	24.21 (16.33	24.53 (16.75)	23.97 (16.03)^{hi}	23.75 (15.75)	23.68 (15.67)	24.90 (17.25)	24.11 (16.22)j	24.52 (16.75)	24.00 (16.08)	24.70 (16.98)	24.41 (16.60)^{gh}	26.98 (20.10)	26.69 (19.70)	26.22 (19.05)	26.63 (19.62)^{hi}
T_{14}	26.45 (19.75)	33.30 (29.67)	32.41 (28.25)	30.72 (25.89)^{abc}	27.42 (20.75)	27.61 (21.00)	28.53 (22.33)	27.85 (21.36)bcd	27.46 (20.80)	27.59 (21.00)	27.30 (20.55)	27.45 (20.78)^{bc}	30.21 (24.85)	29.78 (24.20)	29.72 (24.10)	29.90 (24.38)^{abc}
S.Em+	**1.07**	**0.32**	**0.41**	**0.79**	**0.84**	**0.54**	**0.53**	**0.40**	**0.62**	**1.16**	**0.48**	**0.43**	**0.40**	**0.78**	**0.49**	**0.31**
CD 0.05	**3.11**	**0.93**	**1.21**	**2.31**	**2.43**	**1.56**	**1.52**	**1.11**	**1.80**	**3.36**	**1.39**	**1.20**	**1.16**	**2.26**	**1.42**	**0.86**
YXT				**1.94**				**NS**				**NS**				**NS**
CV %	**7.34**	**1.87**	**2.47**	**4.25**	**5.55**	**3.59**	**3.34**	**4.26**	**4.07**	**7.66**	**3.15**	**5.31**	**2.40**	**4.74**	**2.98**	**3.51**

* Figures in parenthesis are retransformed value

Table 2: Effect of seed bio-priming on post-emergence mortality of vegetables in situ or nursery condition

Treat.	Tomato				Brinjal				Onion				Chilli			
	2017	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**
T_1	23.95 (16.00)	28.07 (21.67)	28.97 (23.00)	27.00 (20.22)^{ab}	23.94 (16.00)	24.47 (16.67)	24.14 (16.25)	24.18 (16.31)^{ab}	25.09 (17.50)	25.51 (18.10)	25.39 (17.90)	25.33 (17.83)^{ab}	25.60 (18.20)	25.07 (17.50)	25.28 (17.77)	25.32 (17.82)^{a}
T_2	20.24 (11.50)	21.96 (13.50)	23.69 (15.66)	21.97 (13.55)^{hi}	20.97 (12.33)	20.98 (12.33)	20.25 (11.50)	20.73 (12.05)^{hi}	21.54 (13.00)	20.33 (11.60)	20.75 (12.07)	20.87 (12.22)^{gh}	22.12 (13.70)	21.36 (12.85)	21.40 (12.82)	21.63 (13.12)^{hij}
T_3	22.75 (14.50)	26.19 (19.00)	27.37 (20.66)	25.44 (18.05)^{cde}	22.97 (14.75)	23.17 (15.00)	22.36 (14.00)	22.83 (14.58)^{cde}	23.95 (16.00)	23.67 (15.70)	23.44 (15.35)	23.69 (15.68)^{cd}	24.56 (16.80)	23.98 (16.05)	24.06 (16.14)	24.20 (16.33)^{bcd}
T_4	21.31 (12.75)	23.30 (15.17)	24.71 (17.00)	23.11 (14.97)^{gh}	21.55 (13.00)	21.68 (13.17)	20.98 (12.33)	21.40 (12.83)^{gh}	22.56 (14.25)	21.44 (12.90)	21.54 (13.00)	21.85 (13.38)^{fg}	22.89 (14.65)	22.24 (13.90)	22.33 (13.95)	22.49 (14.17)^{fgh}
T_5	24.20 (16.33)	28.98 (23.00)	29.82 (24.25)	27.67 (21.19)^{a}	24.51 (16.75)	24.96 (17.33)	25.09 (17.50)	24.85 (17.19)^{a}	25.35 (17.85)	26.33 (19.20)	25.72 (18.35)	25.80 (18.47)^{a}	25.79 (18.45)	25.60 (18.20)	25.71 (18.33)	25.70 (18.33)^{a}
T_6	21.80 (13.33)	24.02 (16.08)	25.64 (18.25)	23.82 (15.89)^{fg}	22.08 (13.66)	21.96 (13.50)	21.32 (12.75)	21.79 (13.30)^{fg}	23.01 (14.80)	22.69 (14.40)	21.99 (13.55)	22.56 (14.25)^{ef}	23.69 (15.66)	22.79 (14.55)	22.56 (14.23)	23.01 (14.81)^{efg}
T_7	19.70 (11.00)	21.32 (12.75)	22.97 (14.75)	21.33 (12.83)^{ij}	20.46 (11.75)	20.38 (11.67)	19.58 (10.75)	20.14 (11.39)^{ij}	21.13 (12.50)	19.85 (11.05)	20.24 (11.48)	20.40 (11.68)^{hi}	21.71 (13.20)	20.01 (12.40)	20.91 (12.25)	21.21 (12.62)^{ijk}
T_8	22.56 (14.25)	25.59 (18.17)	26.73 (19.75)	24.96 (17.39)^{def}	22.57 (14.25)	22.78 (14.50)	22.08 (13.66)	22.48 (14.14)^{def}	23.75 (15.75)	22.20 (13.80)	22.98 (14.76)	22.98 (14.77)^{de}	24.16 (16.30)	23.47 (15.40)	23.69 (15.65)	23.77 (15.78)^{cde}
T_9	20.97 (12.33)	23.11 (14.92)	24.14 (16.25)	22.74 (14.50)^{gh}	21.24 (12.66)	21.48 (12.92)	20.69 (12.00)	21.14 (12.53)^{gh}	22.21 (13.80)	20.99 (12.35)	21.02 (12.45)	21.42 (12.87)^{g}	22.69 (14.40)	21.95 (13.50)	21.92 (13.45)	22.19 (13.78)^{ghi}
T_{10}	19.09 (10.25)	20.25 (11.50)	21.33 (12.75)	20.23 (11.50)^{k}	19.46 (10.66)	19.35 (10.50)	18.59 (9.75)	19.14 (10.30)^{k}	20.48 (11.75)	19.08 (10.20)	19.39 (10.54)	19.65 (10.83)^{i}	20.95 (12.30)	20.24 (11.50)	19.82 (11.00)	20.33 (11.60)^{k}
T_{11}	23.52 (15.50)	26.91 (20.00)	28.47 (22.25)	26.30 (19.25)^{bc}	23.68 (15.66)	23.69 (15.67)	23.43 (15.33)	23.60 (15.55)^{bc}	24.71 (17.00)	24.55 (16.80)	24.62 (16.87)	24.63 (16.89)^{bc}	25.16 (17.60)	24.71 (17.00)	25.03 (17.42)	24.97 (17.34)^{ab}
T_{12}	22.16 (13.75)	24.72 (17.00)	26.19 (19.00)	24.36 (16.58)^{ef}	22.14 (13.75)	22.37 (14.00)	21.75 (13.25)	22.09 (13.67)^{efg}	23.35 (15.25)	23.16 (15.00)	22.49 (14.15)	23.00 (14.80)^{de}	23.78 (15.80)	23.09 (14.95)	23.07 (14.87)	23.31 (15.21)^{def}
T_{13}	19.58 (10.75)	20.98 (12.33)	21.95 (13.50)	20.84 (12.19)^{jk}	20.02 (11.25)	20.11 (11.33)	19.20 (10.33)	19.78 (10.97)^{jk}	20.91 (12.25)	19.58 (10.75)	19.83 (11.02)	20.10 (11.34)^{hi}	21.25 (12.65)	20.55 (11.85)	20.48 (11.75)	20.76 (12.08)^{jk}
T_{14}	23.37 (15.25)	26.55 (19.50)	27.95 (21.50)	25.96 (18.75)^{bcd}	23.16 (15.00)	23.57 (15.50)	22.76 (14.50)	23.16 (15.00)^{bcd}	24.53 (16.75)	24.29 (16.45)	24.14 (16.25)	24.32 (16.48)^{bc}	24.94 (17.30)	24.52 (16.80)	24.76 (17.06)	24.74 (17.05)^{abc}
S.Em+	**0.85**	**0.34**	**0.53**	**0.36**	**0.70**	**0.41**	**0.60**	**0.31**	**0.46**	**0.71**	**0.43**	**0.31**	**0.49**	**0.92**	**0.16**	**0.32**
CD 0.05	**2.45**	**0.99**	**1.54**	**1.01**	**2.02**	**1.18**	**1.73**	**0.86**	**1.34**	**2.04**	**1.25**	**0.87**	**1.43**	**2.65**	**0.47**	**0.90**
YXT				**NS**				**NS**				**NS**				**NS**
CV %	**6.71**	**2.42**	**3.58**	**4.40**	**5.47**	**3.19**	**4.80**	**4.58**	**3.47**	**5.45**	**3.34**	**4.19**	**3.63**	**6.93**	**1.22**	**4.55**

* Figures in parenthesis are retransformed value

Table 3: Effect of seed bio-priming on days to start germination of vegetables in situ or nursery condition

Treat.	Tomato				Brinjal				Onion				Chilli			
	2017	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**
T_1	6.00	6.33	6.50	6.28^{ab}	6.33	6.67	7.00	6.67^{ab}	6.33	6.33	6.50	6.39^{a}	6.33	6.33	6.50	6.39^{a}
T_2	4.33	4.00	4.50	4.28^{ghi}	4.67	4.67	5.00	4.78^{fgh}	4.66	4.25	4.50	4.47^{ef}	4.66	4.25	4.50	4.47^{ef}
T_3	5.33	5.67	5.67	5.56^{cd}	6.00	6.00	6.33	6.11^{bcd}	5.66	5.75	5.50	5.64^{bcd}	5.66	5.75	5.50	5.64^{bcd}
T_4	4.67	4.67	5.00	4.78^{efg}	5.00	5.00	5.33	5.11^{efg}	5.00	5.33	4.66	5.00^{de}	5.00	5.33	4.66	5.00^{de}
T_5	6.33	6.50	7.00	6.61^{a}	7.00	7.33	7.50	7.28^{a}	6.66	6.50	6.00	6.39^{a}	6.66	6.50	6.00	6.39^{a}
T_6	5.00	5.00	5.33	5.11^{def}	5.33	5.00	5.50	5.28^{ef}	5.33	5.50	5.00	5.28^{cd}	5.33	5.50	5.00	5.28^{cd}
T_7	4.33	4.00	4.50	4.28^{ghi}	4.67	4.33	4.50	4.50^{ghi}	4.67	4.25	4.67	4.53^{ef}	4.67	4.25	4.67	4.53^{ef}
T_8	5.33	5.33	5.50	5.39^{cde}	5.67	5.67	6.00	5.78^{cde}	5.66	5.75	5.50	5.64^{bcd}	5.66	5.75	5.50	5.64^{bcd}
T_9	4.67	4.33	5.00	4.67^{fgh}	5.00	4.67	5.33	5.00^{fg}	5.00	4.67	5.33	5.00^{de}	5.00	4.67	5.33	5.00^{de}
T_{10}	3.67	3.50	4.00	3.72^{i}	4.00	3.67	4.33	4.00^{i}	4.00	3.75	4.33	4.03^{f}	4.00	3.75	4.33	4.03^{f}
T_{11}	5.67	6.00	6.33	6.00^{abc}	6.33	6.50	7.00	6.61^{ab}	6.00	6.25	5.66	5.97^{ab}	6.00	6.25	5.66	5.97^{ab}
T_{12}	5.00	5.00	5.33	5.11^{def}	5.33	5.33	5.50	5.39^{def}	5.33	5.50	5.33	5.39^{bcd}	5.33	5.50	5.33	5.39^{bcd}
T_{13}	4.00	3.67	4.67	4.11^{hi}	4.33	4.00	4.33	4.22^{hi}	4.33	4.00	4.50	4.28^{f}	4.33	4.00	4.50	4.28^{f}
T_{14}	5.67	5.67	6.00	5.78^{bcd}	6.00	6.33	6.33	6.22^{bc}	6.00	6.00	5.66	5.89^{abc}	6.00	6.00	5.66	5.89^{abc}
S.Em±	**0.42**	**0.43**	**0.34**	**0.21**	**0.41**	**0.47**	**0.40**	**0.23**	**0.35**	**0.39**	**0.37**	**0.20**	**0.35**	**0.39**	**0.37**	**0.20**
CD 0.05	**1.21**	**1.25**	**0.99**	**0.59**	**1.18**	**1.36**	**1.16**	**0.63**	**1.02**	**1.13**	**1.06**	**0.57**	**1.02**	**1.13**	**1.06**	**0.57**
YXT				**NS**				**NS**				**NS**				**NS**
CV %	**14.47**	**15.03**	**11.01**	**13.51**	**13.00**	**15.14**	**12.15**	**13.44**	**11.48**	**12.84**	**12.08**	**12.14**	**11.48**	**12.84**	**12.08**	**12.14**

Table 4: Effect of seed bio-priming on days taken to 50 % germination of vegetables in situ or nursery condition

Treat.	Tomato				Brinjal				Onion				Chilli			
	2017	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**
T_1	7.00	8.50	7.33	7.61^{ab}	7.75	8.00	8.33	8.03^{ab}	8.33	8.33	8.00	8.22^{a}	7.33	7.50	7.33	7.39^{a}
T_2	5.67	5.33	5.33	5.44^{ghij}	6.33	5.67	6.33	6.11^{fghi}	7.00	6.33	6.50	$6.61d^{ef}$	6.00	5.67	5.66	5.78^{de}
T_3	6.33	7.67	6.50	6.83^{bcde}	7.00	7.33	7.50	7.17^{bcde}	7.66	7.50	7.33	7.50^{b}	6.67	7.00	6.33	6.67^{abc}
T_4	5.67	6.00	6.00	5.89^{fgh}	6.67	6.00	6.50	6.39^{efgh}	8.00	6.67	7.66	7.44^{b}	6.00	6.00	5.66	5.89^{cde}
T_5	7.00	8.67	8.00	7.89^{a}	8.00	8.67	8.50	8.39^{a}	8.33	8.67	8.50	8.50^{a}	7.33	7.67	7.50	7.50^{a}
T_6	6.00	6.33	6.00	6.11^{efg}	6.67	6.33	6.50	6.50^{defgh}	7.33	7.33	7.00	7.22^{bcd}	6.33	6.00	6.33	6.22^{bcd}
T_7	5.33	5.33	5.00	5.22^{hij}	6.00	5.67	6.00	5.89^{ghi}	6.66	6.00	6.33	6.33^{ef}	5.66	5.33	5.33	5.44^{de}
T_8	6.33	7.00	6.50	6.61^{cdef}	7.00	7.00	6.66	6.89^{cdef}	7.66	7.00	7.33	7.33^{bc}	6.67	7.00	6.67	6.78^{ab}
T_9	5.67	5.67	5.33	5.56^{ghi}	6.33	6.00	6.33	6.22^{fgh}	7.00	6.50	6.66	6.72^{cde}	6.00	6.00	5.66	5.89^{cde}
T_{10}	5.00	4.50	4.67	4.72^{j}	5.67	5.00	5.33	5.33^{i}	6.33	5.75	6.00	6.03^{f}	5.33	5.00	5.00	5.11^{e}
T_{11}	6.67	8.33	7.00	7.33^{abc}	7.50	7.67	8.00	7.72^{abc}	8.00	8.00	7.66	7.89^{ab}	7.00	7.67	6.66	7.11^{a}
T_{12}	6.00	6.33	6.33	6.22^{defg}	6.75	6.33	6.67	6.58^{defg}	7.33	7.50	7.00	7.28^{bcd}	6.33	6.00	6.00	6.11^{bcd}
T_{13}	5.33	4.67	5.00	5.00^{ij}	6.00	5.33	5.67	5.67^{hi}	6.66	6.00	6.33	6.33^{ef}	5.67	5.33	5.25	5.42^{de}
T_{14}	6.67	8.00	6.67	7.11^{abcd}	7.33	7.33	7.50	7.39^{bcd}	8.00	7.75	7.66	7.81^{ab}	7.00	7.33	7.00	7.11^{a}
S.Em±	**0.44**	**0.52**	**0.40**	**0.27**	**0.39**	**0.56**	**0.52**	**0.27**	**0.42**	**0.34**	**0.40**	**0.21**	**0.35**	**0.61**	**0.39**	**0.25**
CD 0.05	**1.26**	**1.52**	**1.16**	**0.75**	**1.11**	**1.63**	**1.51**	**0.75**	**1.20**	**1.00**	**1.15**	**0.60**	**1.02**	**1.76**	**1.12**	**0.70**
YXT				**NS**				**NS**				**NS**				**NS**
CV %	**12.50**	**13.74**	**11.35**	**12.64**	**9.85**	**14.75**	**13.21**	**12.73**	**9.66**	**8.41**	**9.66**	**9.28**	**9.60**	**16.46**	**10.88**	**12.71**

Table 5: Effect of seed bio-priming on final germination % of vegetables in situ or nursery condition

Treat.	Tomato				Brinjal				Onion				Chilli			
	2017	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**
T_1	60.54 (75.33)	59.00 (73.00)	58.03 (71.50)	59.19 (73.28)^{j}	59.00 (73.00)	58.67 (72.50)	57.92 (71.33)	58.53 (72.28)^{jk}	56.05 (68.33)	53.87 (64.75)	52.93 (63.20)	54.28 (65.43)^{ij}	55.43(67.33)	55.84 (68.00)	53.56 (64.25)	54.94 (66.53)^{j}
T_2	66.08 (83.00)	65.53 (82.33)	63.96 (80.25)	65.19 (81.86)^{bcd}	64.14 (80.50)	64.53 (81.00)	62.53 (78.25)	63.74 (79.92)^{bcd}	60.99 (76.00)	60.78 (75.50)	62.71 (78.50)	61.49 (76.67)^{bcd}	60.37 (75.00)	61.34 (76.50)	60.81 (75.75)	60.82 (75.75)^{bc}
T_3	63.31 (79.33)	62.58 (78.33)	60.65 (75.50)	62.18 (77.72)^{gh}	60.53 (75.33)	60.31 (75.00)	59.16 (73.25)	60.00 (74.53)^{hi}	58.56 (72.33)	57.42 (70.50)	57.72 (71.00)	57.90 (71.28)^{fg}	57.93 (71.33)	58.35 (72.00)	57.09 (70.00)	57.79 (71.11)^{gh}
T_4	64.89 (81.50)	64.91 (81.50)	62.53 (78.25)	64.11 (80.42)^{de}	63.30 (79.33)	63.44 (79.50)	61.50 (76.75)	62.75 (78.53)^{de}	59.98 (74.50)	59.22 (73.33)	61.53 (76.80)	60.24 (74.88)^{cde}	59.33 (73.50)	60.33 (75.00)	59.82 (74.25)	59.83 (74.25)^{cde}
T_5	58.69 (72.50)	58.15 (71.67)	57.09 (70.00)	57.97 (71.39)^{k}	58.56 (72.33)	58.15 (71.67)	57.40 (70.50)	58.04 (71.50)^{k}	54.33 (65.50)	52.52 (62.50)	51.49 (60.75)	52.78 (62.92)^{j}	53.71 (64.50)	54.42 (65.67)	52.52 (62.50)	53.55 (64.22)^{k}
T_6	64.51 (81.00)	64.13 (80.50)	61.83 (77.25)	63.49 (79.58)^{ef}	62.88(78.75)	63.18 (79.17)	60.65 (75.50)	62.24 (77.81)^{ef}	59.65 (74.00)	58.36 (72.00)	60.99 (76.00)	59.67 (74.00)^{def}	59.00 (73.00)	59.87 (74.33)	59.50(73.75)	59.46 (73.69)^{def}
T_7	66.41 (83.50)	66.01 (83.00)	64.51 (81.00)	65.64 (82.50)^{bc}	64.33 (80.75)	65.00 (81.67)	63.60 (79.75)	64.31 (80.72)^{bc}	61.32 (76.50)	61.84 (77.25)	63.08 (79.00)	62.08 (77.58)^{abc}	60.65 (75.50)	61.09 (76.17)	60.99 (76.00)	60.91 (75.89)^{bc}
T_8	63.78 (80.00)	63.29 (79.33)	61.21 (76.33)	62.76 (78.55)^{fg}	61.33 (76.50)	61.21 (76.33)	59.65 (74.00)	60.73 (75.61)^{gh}	59.00 (73.00)	58.85 (72.75)	59.82 (74.25)	59.23 (73.33)^{ef}	58.35 (72.00)	58.89 (72.83)	58.03 (71.50)	58.42 (72.11)^{fg}
T_9	65.53 (82.33)	65.52 (82.33)	63.54 (79.66)	64.86 (81.44)^{cd}	63.60 (79.75)	64.03 (80.33)	62.12 (77.66)	63.25 (79.25)^{cde}	60.56 (75.33)	59.82 (74.25)	61.86 (77.25)	60.75 (75.61)^{bcde}	59.88(74.33)	60.88 (75.83)	60.32 (75.00)	60.36 (75.05)^{bcd}
T_{10}	68.03 (85.50)	67.39 (84.67)	67.20 (84.50)	67.54 (84.89)^{a}	65.83 (82.75)	66.29 (83.33)	64.51 (81.00)	65.54 (82.36)^{a}	62.89 (78.75)	63.66(79.75)	64.27 (80.66)	63.61 (79.72)^{a}	62.02 (77.50)	62.60 (78.33)	63.43 (79.50)	62.68 (78.44)^{a}
T_{11}	61.21 (76.33)	60.76 (75.67)	58.78 (72.66)	60.25 (74.89)^{ij}	60.21 (74.80)	59.43 (73.67)	58.68 (72.50)	59.44 (73.66)^{ij}	56.85 (69.50)	54.77 (66.25)	55.38 (67.25)	55.67 (67.67)^{hi}	56.04 (68.33)	56.56 (69.17)	54.84 (66.33)	55.81 (67.94)^{ij}
T_{12}	64.16 (80.50)	63.77 (80.00)	62.01 (77.50)	63.31 (79.33)^{efg}	62.35 (78.00)	62.13 (77.67)	60.10 (74.66)	61.53 (76.78)^{fg}	59.51 (73.75)	57.93 (71.33)	60.54 (75.33)	59.33 (73.47)^{ef}	58.67 (72.50)	59.11 (73.17)	58.35 (72.00)	58.71 (72.56)^{efg}
T_{13}	67.07 (84.33)	61.90 (83.67)	65.63 (82.50)	66.42 (83.50)^{ab}	64.51 (81.00)	65.51(82.33)	63.96 (80.25)	64.66 (81.19)^{ab}	61.89 (77.33)	61.37 (76.50)	63.61 (79.75)	62.29 (77.86)^{ab}	61.21 (76.33)	61.67 (77.00)	62.03 (77.50)	61.63 (76.94)^{ab}
T_{14}	62.37 (78.00)	63.54 (77.33)	59.81 (74.25)	61.36 (76.53)^{hi}	60.09 (74.66)	59.87 (74.33)	58.35 (72.00)	59.44 (73.66)^{ij}	58.35 (72.00)	56.06 (68.33)	56.78 (69.50)	57.06 (69.94)^{gh}	57.08 (70.00)	57.61 (70.83)	56.15 (68.50)	56.95 (69.78)^{hi}
S.Em±	**0.88**	**0.77**	**0.50**	**0.40**	**0.66**	**0.71**	**0.56**	**0.35**	**0.95**	**1.20**	**0.78**	**0.58**	**0.57**	**0.65**	**0.77**	**0.38**
CD 0.05	**2.55**	**2.24**	**1.43**	**1.11**	**1.90**	**2.05**	**1.63**	**0.98**	**2.75**	**3.47**	**2.27**	**1.64**	**1.65**	**1.89**	**2.22**	**1.06**
YXT				**NS**				**NS**				**NS**				**NS**
CV %	**2.38**	**2.11**	**1.39**	**2.01**	**1.83**	**1.97**	**1.60**	**1.81**	**2.77**	**3.56**	**2.28**	**2.91**	**1.68**	**1.91**	**2.27**	**1.97**

* Figures in parenthesis are retransformed value

Table 6: Effect of seed bio-priming on root length (cm) of vegetables in situ or nursery condition

Treat.	Tomato				Brinjal				Onion				Chilli			
	2017	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**
T_1	10.75	10.63	11.64	11.01^{i}	7.50	7.70	7.56	7.59^{jk}	5.50	5.15	5.36	5.34^{jk}	10.77	10.43	10.36	10.52^{ij}
T_2	14.00	14.53	14.83	14.45^{bc}	9.90	11.53	9.55	10.33^{bcd}	7.90	7.65	7.95	7.83^{bcd}	14.02	15.00	12.78	13.93^{bc}
T_3	12.00	11.90	13.15	12.35^{fg}	8.40	8.90	8.47	8.59^{ghi}	6.40	5.95	6.33	6.23^{hi}	12.02	12.00	11.25	11.76^{fgh}
T_4	13.33	13.60	14.29	13.74^{cd}	9.50	10.67	9.72	9.96^{cde}	7.50	7.00	7.39	7.30^{def}	13.35	13.67	12.55	13.19^{cd}
T_5	10.00	9.87	10.93	10.27^{j}	7.20	7.47	7.28	7.32^{k}	5.20	4.90	5.28	5.13^{k}	10.05	9.97	10.10	10.04^{j}
T_6	13.00	13.10	14.02	13.37^{de}	9.30	10.10	9.43	9.61^{def}	7.30	6.45	7.15	6.97^{efg}	13.04	13.13	12.36	12.84^{de}
T_7	14.20	14.77	15.05	14.67^{ab}	10.00	11.93	9.89	10.61^{bc}	8.00	7.85	8.09	7.98^{bc}	14.24	15.27	13.25	14.25^{b}
T_8	12.50	12.27	13.54	12.77^{efg}	8.75	9.27	8.98	9.00^{fgh}	6.75	6.70	6.57	6.67^{gh}	12.55	12.27	11.75	12.19^{efg}
T_9	12.33	14.20	14.58	13.70^{cd}	9.70	11.20	10.13	10.34^{bcd}	7.70	7.40	7.62	7.57^{cde}	12.40	14.63	11.53	12.85^{de}
T_{10}	15.00	15.63	15.85	15.49^{a}	10.50	12.67	11.35	11.51^{a}	8.50	8.80	8.63	8.64^{a}	15.03	16.07	14.70	15.27^{a}
T_{11}	11.33	11.00	12.35	11.56^{hi}	7.75	8.00	7.89	7.88^{ijk}	5.75	5.50	5.65	5.63^{jk}	11.35	10.90	10.77	11.01^{hi}
T_{12}	12.75	12.60	13.85	13.07^{def}	9.00	9.60	9.25	9.28^{efg}	7.00	6.25	6.94	6.73^{fgh}	12.78	12.60	12.02	12.47^{def}
T_{13}	14.80	15.20	15.52	15.17^{ab}	10.20	12.20	10.54	10.98^{ab}	8.20	8.45	8.27	8.31^{ab}	14.84	15.60	13.95	14.80^{ab}
T_{14}	11.75	11.60	12.88	12.08^{gh}	8.10	8.60	8.34	8.35^{hij}	6.10	5.75	5.92	5.92^{ij}	11.78	11.60	10.94	11.44^{gh}
S.Em±	**0.63**	**0.47**	**0.04**	**0.25**	**0.62**	**0.45**	**0.03**	**0.26**	**0.43**	**0.39**	**0.15**	**0.19**	**0.03**	**0.47**	**0.03**	**0.29**
CD 0.05	**1.84**	**1.36**	**0.12**	**0.72**	**1.79**	**1.31**	**0.10**	**0.73**	**1.24**	**1.13**	**0.44**	**0.52**	**0.08**	**1.35**	**0.08**	**0.85**
YXT				**NS**				**NS**				**NS**				**0.76**
CV %	**8.65**	**6.27**	**0.52**	**6.01**	**11.94**	**7.87**	**0.62**	**8.19**	**10.58**	**10.12**	**3.77**	**8.70**	**0.36**	**6.19**	**0.41**	**3.72**

Table 7: Effect of seed bio-priming on shoot length (cm) of vegetables in situ or nursery condition

Treat.	Tomato				Brinjal				Onion				Chilli			
	2017	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**
T_1	8.33	8.20	8.05	8.19^{jk}	6.30	6.23	6.14	6.22^{jk}	10.30	9.95	10.15	10.13^{i}	11.35	11.23	11.20	11.26^{jk}
T_2	11.00	10.90	10.75	10.88^{cd}	8.90	9.10	8.85	8.95^{bc}	12.90	13.50	13.06	13.15^{cd}	14.04	14.13	13.95	14.04^{cd}
T_3	9.00	8.97	8.66	8.88^{hi}	7.00	6.97	6.92	6.96^{ghi}	11.00	11.25	11.08	11.11^{gh}	12.05	11.97	11.94	11.99^{hi}
T_4	10.50	10.37	10.06	10.31^{de}	8.20	8.37	8.09	8.22de	12.20	12.75	12.53	12.49^{de}	13.52	13.37	13.39	13.43^{de}
T_5	8.00	7.90	7.65	7.85^{k}	6.00	5.87	5.95	5.94^{k}	10.00	9.75	9.87	9.87^{i}	11.05	10.87	10.95	10.96^{k}
T_6	10.00	9.93	9.78	9.90^{ef}	7.90	8.00	7.84	7.91^{ef}	11.90	12.00	12.18	12.03^{ef}	13.06	12.97	13.00	13.01^{ef}
T_7	11.33	11.30	11.05	11.23^{bc}	9.20	9.33	9.10	9.21^{abc}	13.20	13.80	13.35	13.45^{bc}	14.30	14.43	14.25	14.33^{bc}
T_8	9.33	9.27	9.02	9.21^{gh}	7.40	7.27	7.17	7.28^{fgh}	11.40	12.30	11.25	11.65^{fg}	12.35	12.23	12.18	12.25^{gh}
T_9	10.75	10.80	10.28	10.61^{cd}	8.60	8.83	8.48	8.64^{cd}	12.60	13.10	12.99	12.90^{cd}	13.73	13.80	13.65	13.73^{cd}
T_{10}	12.25	12.73	12.42	12.47^{a}	9.80	10.03	9.82	9.88^{a}	14.80	15.00	14.65	14.82^{a}	15.22	15.33	15.18	15.24^{a}
T_{11}	8.50	8.43	8.23	8.39^{ijk}	6.50	6.47	6.38	6.45^{ijk}	11.70	10.60	11.66	11.32^{fgh}	11.55	11.40	11.45	11.47^{ijk}
T_{12}	9.75	9.60	9.36	9.57^{fg}	7.60	7.67	7.53	7.60^{efg}	13.70	11.65	13.20	12.85^{cd}	12.80	12.63	12.57	12.67^{fg}
T_{13}	11.75	11.77	11.48	11.67^{b}	9.40	9.77	9.42	9.53^{ab}	13.50	14.25	14.03	13.93^{b}	14.77	14.97	14.67	14.80^{ab}
T_{14}	8.75	8.70	8.45	8.63^{hij}	6.80	6.73	6.67	6.73^{hij}	10.80	10.90	10.75	10.82^{h}	11.80	11.67	11.72	11.73^{hij}
S.Em±	**0.51**	**0.39**	**0.04**	**0.19**	**0.55**	**0.41**	**0.02**	**0.21**	**0.42**	**0.49**	**0.03**	**0.23**	**0.46**	**0.41**	**0.03**	**0.19**
CD 0.05	**1.47**	**1.14**	**0.11**	**0.55**	**1.59**	**1.18**	**0.07**	**0.58**	**1.21**	**1.42**	**0.08**	**0.65**	**1.34**	**1.18**	**0.10**	**0.52**
YXT				**NS**				**NS**				**NS**				**NS**
CV %	**8.84**	**6.86**	**0.69**	**6.53**	**12.11**	**8.89**	**0.52**	**8.71**	**5.97**	**6.98**	**0.38**	**5.31**	**6.16**	**5.47**	**0.45**	**4.78**

Table 8: Effect of seed bio-priming on vigour index of vegetables in situ or nursery condition

Treat.	Tomato				Brinjal				Onion				Chilli			
	2017	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**
T_1	1437.00	1374.40	1408.00	1406.47^{k}	1007.00	1009.67	977.00	997.89^{lm}	1079.00	978.53	978.00	1011.84^{h}	1489.00	1472.80	1473.00	1478.27^{j}
T_2	2075.00	2095.13	2053.00	2074.38^{cd}	1513.00	1671.27	1440.00	1541.42^{cd}	1581.00	1597.43	1597.00	1591.81^{cd}	2105.00	2228.53	2229.00	2187.51^{c}
T_3	1666.00	1634.70	1647.00	1649.23^{ij}	1160.00	1190.70	1127.00	1159.23^{ij}	1259.00	1212.36	1236.00	1235.79^{g}	1717.00	1726.30	1726.00	1723.10^{hi}
T_4	1942.00	1955.32	1905.00	1934.11^{ef}	1404.00	1515.22	1367.00	1428.74^{ef}	1468.00	1448.12	1448.00	1454.71^{ef}	1975.00	2029.57	2029.00	2011.19^{de}
T_5	1305.00	1274.07	1301.00	1293.36^{l}	955.00	956.40	932.00	947.80^{m}	996.00	916.28	916.00	942.76^{h}	1361.00	1368.77	1368.00	1365.92^{k}
T_6	1863.00	1853.65	1839.00	1851.88^{fg}	1355.00	1431.65	1304.00	1363.55^{fg}	1421.00	1326.75	1327.00	1358.25^{f}	1905.00	1939.08	1939.00	1927.69^{ef}
T_7	2132.00	2164.63	2114.00	2136.88^{bc}	1550.00	1737.58	1514.00	1600.53^{bc}	1622.00	1671.76	1672.00	1655.25^{bc}	2155.00	2263.07	2263.00	2227.02^{bc}
T_8	1746.00	1708.00	1722.00	1725.33^{hi}	1236.00	1261.73	1195.00	1230.91^{hi}	1325.00	1380.82	1381.00	1362.27^{f}	1793.00	1784.12	1784.00	1787.04^{gh}
T_9	1900.00	2058.60	1980.00	1979.53^{de}	1400.00	1609.67	1445.00	1484.89^{de}	1529.00	1521.53	1521.00	1523.84^{de}	1942.00	2156.65	2156.00	2084.88^{d}
T_{10}	2329.00	2402.30	2389.00	2373.43^{a}	1680.00	1891.93	1715.00	1762.31^{a}	1772.00	1900.71	1901.00	1857.90^{a}	2344.00	2459.93	2460.00	2421.31^{a}
T_{11}	1514.00	1470.47	1495.00	1493.16^{k}	1066.00	1065.77	1035.00	1055.59^{kl}	1213.00	1066.33	1166.00	1148.44^{g}	1565.00	1542.42	1542.00	1549.81^{j}
T_{12}	1811.00	1776.67	1799.00	1795.56^{gh}	1295.00	1342.30	1253.00	1296.77^{gh}	1527.00	1276.93	1277.00	1380.31^{f}	1855.00	1847.55	1847.00	1849.85^{fg}
T_{13}	2239.00	2256.77	2228.00	2241.26^{b}	1588.00	1808.53	1601.00	1665.84^{ab}	1678.00	1733.37	1734.00	1715.12^{b}	2260.00	2353.38	2353.00	2322.13^{b}
T_{14}	1599.00	1569.07	1584.00	1584.02^{j}	1112.00	1138.93	1080.00	1110.31^{jk}	1217.00	1137.64	1138.00	1164.21^{g}	1651.00	1647.20	1647.00	1648.40^{i}
S.Em±	**80.92**	**72.28**	**19.11**	**34.20**	**65.64**	**65.81**	**14.60**	**31.48**	**43.35**	**54.67**	**27.47**	**32.42**	**45.63**	**67.44**	**29.42**	**28.50**
CD 0.05	**234.35**	**209.34**	**55.35**	**95.90**	**190.12**	**190.62**	**42.28**	**88.29**	**125.55**	**158.35**	**79.57**	**94.26**	**132.16**	**195.33**	**85.21**	**79.91**
YXT				**NS**				**NS**				**121.78**				**NS**
CV %	**7.68**	**6.85**	**1.82**	**6.04**	**8.69**	**8.13**	**1.97**	**7.06**	**5.34**	**6.92**	**3.45**	**5.42**	**4.24**	**6.10**	**2.66**	**4.56**

Table 9: Effect of seed bio-priming on fresh root weight (g) of vegetables in situ or nursery condition

Treat.	Tomato				Brinjal				Onion				Chilli			
	2017	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**
T_1	1.02	1.04	1.11	1.06^{j}	1.22	1.27	1.33	1.27^{jk}	1.24	1.25	1.22	1.24^{jk}	1.03	1.02	0.99	1.01^{j}
T_2	1.26	1.25	1.38	1.30^{cd}	1.45	1.50	1.65	1.53^{cd}	1.47	1.58	1.56	1.54^{cd}	1.28	1.30	1.32	1.30^{d}
T_3	1.09	1.10	1.20	1.13^{hi}	1.29	1.33	1.43	1.35^{hi}	1.31	1.41	1.35	1.36^{gh}	1.10	1.12	1.13	1.12^{h}
T_4	1.20	1.22	1.31	1.24^{def}	1.40	1.44	1.59	1.48^{def}	1.42	1.53	1.50	1.48^{def}	1.22	1.24	1.27	1.24^{e}
T_5	1.01	1.02	1.08	1.04^{j}	1.22	1.24	1.30	1.25^{k}	1.24	1.20	1.18	1.21^{k}	1.03	1.00	0.98	1.00^{j}
T_6	1.18	1.19	1.28	1.22^{efg}	1.39	1.41	1.55	1.45^{ef}	1.42	1.48	1.46	1.45^{ef}	1.20	1.21	1.24	1.22^{ef}
T_7	1.32	1.30	1.40	1.34^{bc}	1.54	1.56	1.68	1.59^{bc}	1.57	1.62	1.60	1.60^{bc}	1.34	1.37	1.35	1.35^{c}
T_8	1.13	1.14	1.23	1.17^{gh}	1.33	1.35	1.47	1.38^{gh}	1.36	1.50	1.39	1.42^{fg}	1.16	1.14	1.17	1.16^{g}
T_9	1.21	1.23	1.34	1.26^{de}	1.42	1.46	1.63	1.50^{de}	1.45	1.55	1.53	1.51^{de}	1.25	1.28	1.30	1.28^{d}
T_{10}	1.42	1.44	1.48	1.45^{a}	1.61	1.65	1.73	1.66^{a}	1.65	1.70	1.68	1.68^{a}	1.45	1.49	1.43	1.46^{a}
T_{11}	1.05	1.05	1.14	1.08^{ij}	1.25	1.29	1.36	1.30^{ijk}	1.27	1.29	1.25	1.27^{ij}	1.07	1.05	1.04	1.05^{i}
T_{12}	1.16	1.15	1.25	1.19^{fgh}	1.37	1.38	1.51	1.42^{fg}	1.40	1.45	1.43	1.43^{f}	1.19	1.17	1.20	1.19^{fg}
T_{13}	1.38	1.30	1.43	1.37^{b}	1.58	1.60	1.70	1.63^{ab}	1.60	1.65	1.62	1.62^{ab}	1.40	1.42	1.38	1.40^{b}
T_{14}	1.07	1.06	1.17	1.10^{ij}	1.27	1.30	1.40	1.32^{hij}	1.30	1.33	1.29	1.31^{hi}	1.10	1.08	1.07	1.08^{i}
S.Em+	**0.03**	**0.03**	**0.03**	**0.02**	**0.04**	**0.02**	**0.03**	**0.02**	**0.03**	**0.04**	**0.03**	**0.02**	**0.02**	**0.02**	**0.03**	**0.01**
CD 0.05	**0.09**	**0.08**	**0.09**	**0.04**	**0.10**	**0.06**	**0.10**	**0.05**	**0.08**	**0.10**	**0.08**	**0.05**	**0.07**	**0.07**	**0.08**	**0.04**
YXT				**NS**				**NS**				**NS**				**NS**
CV %	**4.43**	**3.98**	**3.93**	**4.11**	**4.48**	**2.80**	**3.79**	**3.75**	**3.41**	**4.25**	**3.17**	**3.65**	**3.26**	**3.27**	**3.90**	**3.49**

Table 10: Effect of seed bio-priming on fresh shoot weight (g) of vegetables in situ or nursery condition

Treat.	Tomato				Brinjal				Onion				Chilli			
	2017	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**	**2017**	**2018**	**2019**	**Pooled**
T_1	1.51	1.52	1.55	1.53^{jk}	2.02	2.04	1.98	2.01^{hi}	2.52	2.47	2.48	2.49^{ij}	1.81	1.95	1.79	1.85^{b}
T_2	1.80	1.79	1.89	1.83^{cd}	2.30	2.33	2.36	2.33^{bc}	2.80	2.87	2.86	2.84^{c}	2.10	2.06	2.18	2.11^{b}
T_3	1.61	1.62	1.66	1.63^{ghi}	2.12	2.13	2.10	2.12^{fgh}	2.62	2.64	2.57	2.61^{h}	1.91	1.81	1.93	1.88^{b}
T_4	1.73	1.74	1.80	1.76^{e}	2.24	2.26	2.29	2.26^{cde}	2.74	2.78	2.75	2.76^{de}	1.03	2.03	2.10	1.72^{b}
T_5	1.49	1.48	1.52	1.50^{k}	2.00	2.02	1.95	1.99^{i}	2.50	2.42	2.45	2.46^{j}	1.79	2.18	1.75	1.91^{b}
T_6	1.69	1.70	1.76	1.72^{ef}	2.20	2.22	2.24	2.22^{cdef}	2.70	2.72	2.80	2.74^{ef}	1.99	1.98	2.04	2.00^{b}
T_7	1.87	1.86	1.91	1.88^{bc}	2.38	2.36	2.39	2.38^{cd}	2.88	2.95	2.91	2.91^{b}	2.17	2.09	2.22	2.16^{b}
T_8	1.63	1.63	1.71	1.66^{fgh}	2.14	2.16	2.12	2.14^{efg}	2.64	2.75	2.60	2.66^{gh}	1.93	2.34	1.96	2.08^{b}
T_9	1.75	1.76	1.82	1.78^{de}	2.27	2.30	2.32	2.30^{bcd}	2.77	2.82	2.84	2.81^{cd}	2.05	1.90	2.14	2.03^{b}
T_{10}	1.98	2.00	2.04	2.01^{a}	2.50	2.44	2.47	2.47^{a}	3.02	3.08	3.04	3.05^{a}	2.30	2.00	2.35	2.22^{ab}
T_{11}	1.56	1.55	1.60	1.57^{ij}	2.07	2.08	2.02	2.06^{ghi}	2.57	2.53	2.51	2.54^{i}	1.86	2.25	1.84	1.98^{b}
T_{12}	1.65	1.66	1.73	1.68^{fg}	2.16	2.19	2.15	2.17^{defg}	2.66	2.67	2.70	2.68^{fg}	1.95	1.92	1.99	1.95^{b}
T_{13}	1.93	1.95	1.95	1.94^{b}	2.45	2.40	2.42	2.42^{ab}	2.96	3.01	2.95	2.97^{b}	5.16	2.23	2.26	3.22^{a}
T_{14}	1.58	1.59	1.63	1.60^{hi}	2.10	2.11	2.08	2.10^{fghi}	2.66	2.59	2.64	2.63^{gh}	2.13	1.88	1.89	1.97^{b}
S.Em±	**0.03**	**0.02**	**0.03**	**0.02**	**0.11**	**0.27**	**0.03**	**0.04**	**0.03**	**0.04**	**0.03**	**0.02**	**0.89**	**0.03**	**0.03**	**0.30**
CD 0.05	**0.09**	**0.05**	**0.10**	**0.04**	**NS**	**0.78**	**0.09**	**0.10**	**0.08**	**0.12**	**0.08**	**0.06**	**NS**	**0.10**	**0.08**	**NS**
YXT				**NS**				**NS**				**NS**				**NS**
CV %	**3.31**	**1.71**	**3.25**	**2.86**	**8.46**	**2.10**	**2.38**	**5,21**	**1.71**	**2.58**	**1.77**	**2.06**	**71.28**	**2.91**	**2.44**	**42.77**