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INFLUENCE OF BIO-PRIMING WITH BENEFICIAL MICROORGANISMS ON GROWTH, YIELD AND QUALITY OF AROMATIC TURMERIC (*Curcuma aromatica* Salisb.)

Utpal Singha[1*], Anupam Pariari[1], Rahi Masum Reja[2] and Anasuya Sil[1] and Naseeb Giri[1]
[1]Department of Plantation, Spices, Medicinal, and Aromatic Crops, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India, 741252
[2]Department of Fruit Science, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India, 741252
*Corresponding author E-mail: utpalsingha642@gmail.com
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ABSTRACT

Aromatic turmeric (*Curcuma aromatica* Salisb.) is an important medicinal and aromatic crop valued for its rhizomes rich in essential oils and bioactive compounds, widely used in pharmaceutical, cosmetic, and traditional medicinal preparations. However, poor sprouting often limits crop establishment and productivity. The present study was conducted during 2022-23 and 2023-24 at the Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal to evaluate the effect of microbial bio-priming on germination, growth, yield, and quality of aromatic turmeric. The experiment was laid out in a Randomized Block Design with ten treatments and three replications using the local germplasm 'Goalpokhar Local'. Treatments consisted of hydro-priming and different combinations of *Trichoderma viride*, *Trichoderma harzianum*, and *Pseudomonas fluorescens* used for rhizome bio-priming prior to planting. The results revealed significant variation among treatments for growth, yield and quality parameters. Bio-priming of rhizomes with *Trichoderma harzianum* (10 g/l of water) + *Pseudomonas fluorscens* (10 g/l of water) recorded the earliest sprouting, highest germination percentage, maximum plant height, number of leaves and tillers per clump and greater pseudo stem girth. The same treatment also produced the highest rhizome yield with increased clump weight and number of primary and secondary fingers, resulting in superior projected yield per hectare. Moreover, microbial bio-priming significantly improved quality parameters such as dry matter content, curcumin content, oleoresin and essential oil, while also reducing disease incidence and storage rot of rhizomes. The study demonstrates that microbial bio-priming with *Trichoderma harzianum* and *Pseudomonas fluorescens* is an effective and eco-friendly strategy for improving growth, yield, and quality of aromatic turmeric under Eastern Indian conditions.

***Keywords* :** Aromatic turmeric, Bio-priming, *Trichoderma viride, Trichoderma harzianum*, *Pseudomonas fluorescens*, Yield and quality.

Introduction

Aromatic turmeric (*Curcuma aromatica* Salisb.), a member of the family Zingiberaceae, is an important medicinal and aromatic plant cultivated mainly for its highly fragrant rhizomes. It is considered the second most important species of the genus *Curcuma* after *Curcuma longa* in terms of rhizome production and utilization (Sikha *et al.*, 2015). The species is widely distributed throughout South and Southeast Asia, including India, China and Sri Lanka, and forms an integral component of traditional medicinal systems such as Ayurveda, Siddha and Unani (Ahmad *et al.*, 2011; Anoop, 2015). In India, aromatic turmeric occurs naturally in the Himalayan region, Western Ghats and several eastern states including West Bengal. The rhizomes of aromatic turmeric possess a characteristic camphoraceous aroma and contain several bioactive compounds including curcuminoids, essential oils and oleoresins that contribute to its medicinal and industrial value. These phytochemicals exhibit diverse biological activities such as antioxidant, antimicrobial, anti-inflammatory and anticancer properties (Pant *et al.,* 2013; Revathy and Malathy, 2013; Yu *et al.,* 2011). The essential oil of aromatic turmeric is widely utilized in pharmaceutical, cosmetic and food industries (Pant *et al.,* 2013). Owing to these properties, the crop has gained increasing importance in herbal medicine, skincare formulations and nutraceutical products (Al-Reza *et al.,* 2010; Sikha *et al.,* 2015). Despite its potential, the productivity of aromatic turmeric largely depends on efficient crop establishment, vegetative growth, and rhizome development. The crop is propagated vegetatively through rhizomes, and the performance of planting material plays a crucial role in determining germination, plant vigor, and ultimately yield. Enhancement of early growth attributes such as germination percentage, plant height, number of tillers, and leaf development directly influences biomass accumulation and rhizome yield. In recent years, pre-planting treatments such as bio-priming have gained attention as a sustainable approach to improve crop performance. Bio-priming involves hydration of planting material along with inoculation of beneficial microorganisms, which enhances germination, seedling vigor, and overall plant growth (Rafi and Dawar, 2015). Previous studies have demonstrated that bio-priming with microbial agents can significantly improve growth parameters and yield attributes by enhancing physiological efficiency and nutrient utilization (Menon *et al.,* 2016). Considering the importance of improving growth, yield, and quality traits in aromatic turmeric, the present investigation was undertaken to evaluate the effect of bio-priming treatments on germination, vegetative growth, rhizome yield, and quality parameters of aromatic turmeric.

Materials and Methods

The present investigation entitled "Influence of bio-priming with beneficial microorganisms on growth, yield and quality of aromatic turmeric (*Curcuma aromatica* Salisb.)" was conducted for two consecutive Kharif seasons (2022-23 and 2023-24) at the Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya (BCKV), Mohanpur, Nadia, West Bengal, India. The experimental site is geographically located at 22.94° N latitude and 88.51° E longitude with an elevation of 9.75 m above mean sea level, representing the New Alluvial Zone of West Bengal under a sub-tropical humid climate. The experimental field consisted of sandy clay loam soil with good drainage and moderate fertility status. A locally adapted aromatic turmeric germplasm, 'Goalpokhar Local', was used as planting material. Healthy and uniform rhizomes were collected from farmers' fields of Uttar Dinajpur district, West Bengal. The experiment was laid out in a Randomized Block Design (RBD) with three replications. Each treatment plot measured 3.0 m × 1.0 m, accommodating 40 plants per plot at a spacing of 30 cm × 25 cm. The crop was planted on 1st April during the Kharif season. Healthy rhizomes of turmeric were dipped in different concentrations of bio priming agent for 30 minutes for pre planting rhizome treatment. The treatments consisting of T_1-Hydropriming with distilled water, T_2-*Trichoderma viride* (5 g/l of water), T_3-*Trichoderma viride* (10 g/l of water), T_4-*Trichoderma harzianum* (10 g/l of water), T_5-*Trichoderma harzianum* (20 g/l of water), T_6-*Pseudomonas fluorscens* (10 g/l of water), T_7-*Trichoderma viride* (5 g/l of water) +*Pseudomonas fluorscens* (10 g/l of water), T_8-*Trichoderma viride* 10 g/l of water) +*Pseudomonas fluorscens* (10 g/l of water), T_9-*Trichoderma harzianum* (10 g/l of water) + *Pseudomonas fluorscens* (10 g/l of water) and T_{10}-*Trichoderma harzianum* (20 g/l of water) + *Pseudomonas fluorscens* (10 g/l of water). The field was prepared by thorough ploughing followed by the formation of raised beds. Farmyard manure was applied at 25 t ha^{-1} along with a recommended dose of fertilizers (150:75:150 kg N:P:K ha^{-1}), where half of nitrogen and full phosphorus and potassium were applied as basal, and the remaining nitrogen was top-dressed at 60 days after planting (Tripathi e*t al.,* 2019). Mulching was done using dried paddy straw immediately after planting, and earthing up was carried out at 90 days after planting. The crop was grown mainly under rainfed conditions with supplemental irrigation as required, and manual weeding was performed at regular intervals. The crop was harvested at maturity in early January when the aerial parts dried completely, and rhizomes were cleaned and shade-dried. Observations on growth parameters such as days taken for germination**,** germination percentage at 30 days after planting, plant height (cm), number of tillers and leaves, length and width of leaves (cm), and girth of pseudo stem (cm) were recorded at monthly intervals from five randomly selected plants per plot at 180 days after planting. Yield and yield attributes including clump weight, size, number and weight of primary and secondary fingers, mother rhizome characteristics, yield per plot, and projected yield per hectare were recorded at harvest. Quality parameters such as dry matter content, curcumin content (spectrophotometric method at 425 nm), oleoresin content (Soxhlet extraction), and essential oil content (steam distillation using Clevenger apparatus) were determined after harvest by the following standard procedures. The experimental data were statistically analyzed using analysis of variance (ANOVA) for randomized block design, and treatment means were compared at 5% level of significance.

Results and Discussion

Growth parameters

The results presented in table-1 clearly showed that bio-priming treatments significantly influenced germination and growth in aromatic turmeric. The minimum days taken for germination was recorded in T_9 (17.17 days), followed by T_{10} (19.17 days), T_8 (19.84 days), and T_7 (20.50 days), whereas the control T_1 required 24.83 days. The highest germination percentage was observed in T_9 (94.00%), followed by T_{10} (92.67%) and T_8 (89.66%), while the lowest was recorded in T_1 (79.50%). The improved germination under bio-priming treatments may be due to enhanced seed vigour and protection against soil-borne pathogens, which is supported by the findings of Lingyun *et al.* (2017) and Bhargava *et al.* (2015).

Significant improvement in growth parameters was observed under bio-priming treatments. The maximum plant height was recorded in T_{10} (153.44 cm), closely followed by T_9 (151.59 cm) and T_8 (148.16 cm), whereas the lowest was observed in T_1 (134.06 cm). The number of tillers per clump was highest in T_9 (3.78), followed by T_{10} (3.53) and T_8 (3.48), while T_1 recorded the lowest (2.95). Similarly, the number of leaves per clump was highest in T_{10} (11.24) and T_9 (11.23), compared to the lowest value in T_1 (7.94). Leaf length was maximum in T_{10} (73.29 cm), followed by T_9 (72.48 cm), whereas T_1 recorded the minimum (61.74 cm). Leaf width also followed a similar trend, with the highest value in T_{10} (18.15 cm), followed by T_9 (17.90 cm), and the lowest in T_1 (15.30 cm). These improvements may be attributed to enhanced nutrient uptake and growth-promoting effects of microbial inoculants, as reported by Menon *et al.* (2016) and Kumar *et al.* (2010). The girth of pseudo stem was highest in T_{10} (10.12 cm), followed by T_9 (9.97 cm) and T_8 (9.86 cm), whereas the lowest value was recorded in T_1 (8.82 cm), indicating stronger plant development under combined bio-agent treatments

Table 1 : Effect of bio-priming treatments on germination and growth parameters of aromatic turmeric (*Curcuma aromatica* Salisb.)

Treatments	Days taken for germination (DAP)	Germination percentage (%)	Plant height (cm)	Number of tillers clump^{-1}	Number of leaves clump^{-1}	Length of leaves clump^{-1}	Width of leaves clump-^{1}	Girth of pseudo stem (cm)
T_1	24.83	79.50	134.06	2.95	7.94	61.74	15.30	8.82
T_2	24.50	81.50	138.54	3.03	8.36	61.94	16.51	9.13
T_3	23.50	84.67	141.54	3.17	9.18	67.17	16.60	9.27
T_4	22.34	85.83	144.67	3.18	9.59	67.50	16.74	9.42
T_5	23.17	86.90	146.04	3.19	9.98	68.28	16.75	9.55
T_6	22.50	82.33	139.02	3.08	8.77	66.60	16.58	8.98
T_7	20.50	88.50	147.56	3.16	10.42	69.92	17.22	9.69
T_8	19.84	89.66	148.16	3.48	10.83	70.19	17.39	9.86
T_9	17.17	94.00	151.59	3.78	11.23	72.48	17.90	9.97
T_{10}	19.17	92.67	153.44	3.53	11.24	73.29	18.15	10.12
S.Em (±)	**0.346**	**1.268**	**1.819**	**0.048**	**0.141**	**0.857**	**0.211**	**0.139**
C.D.(P=0.05)	**1.037**	**3.796**	**5.446**	**0.142**	**0.422**	**2.565**	**0.633**	**0.417**

Similar enhancement in plant vigour due to bio-inoculants has been reported by Kevimeo and Tiameren (2013). Overall, the combined application of *Trichoderma harzianum* and *Pseudomonas fluorescens* (T_9 and T_{10}) proved to be the most effective treatments for improving germination and enhancing plant growth in aromatic turmeric. The results highlight the synergistic effect of bio-agents in promoting plant health and productivity under field conditions.

Yield parameters

The results presented in Table-2a and 2b, indicated that bio-priming treatments significantly improved yield attributes and overall productivity of aromatic turmeric. The maximum weight of clump was recorded in T_{10} (416.84 g), followed by T_9 (407.17 g) and T_8 (388.92 g), whereas the lowest was observed in T_1 (284.85 g). Similarly, clump length was highest in T_{10} (20.93 cm), followed by T_9 (20.73 cm), while T_1 recorded the lowest value (17.24 cm). Clump width also showed a similar trend, with the maximum in T_{10}

(15.93 cm) and minimum in T_1 (14.09 cm). The volume of clump was highest in T_{10} (438.48 cc), followed by T_9 (416.57 cc), whereas the lowest was recorded in T_1 (293.10 cc). The increase in clump size and volume under bio-priming treatments may be attributed to enhanced nutrient uptake and better translocation of photosynthates, which is in agreement with the findings of Kumar *et al.* (2010) and Menon *et al.* (2016).

Primary finger attributes were also significantly influenced by the treatments. The highest number of primary fingers per clump was recorded in T_{10} (12.55), followed by T_9 (12.39) and T_8 (11.87), while the lowest was in T_1 (10.02). The maximum weight of primary fingers was observed in T_{10} (186.22 g), followed by T_9 (179.26 g), whereas the lowest was recorded in T_1 (122.14 g). Primary finger length and width were also highest in T_{10} (8.33 cm and 2.53 cm, respectively), followed by T_9 (8.43 cm length and 2.47 cm width), while the lowest values were recorded in T_1 (6.59 cm and 1.87 cm, respectively). These improvements in finger development may be due to the plant growth-promoting activities of bio-agents, which enhance root growth and nutrient availability.

Secondary finger parameters also followed a similar trend. The highest number of secondary fingers per clump was recorded in T_9 (21.55), closely followed by T_{10} (21.36) and T_8 (21.21), whereas the lowest was observed in T_1 (16.81). The maximum weight of secondary fingers were recorded in T_9 (140.65 g), followed by T_{10} (138.00 g), while the lowest was in T_1 (84.64g).

Table 2a : Effect of bio-priming treatments on yield attributes and yield of aromatic turmeric (*Curcuma aromatica* Salisb.)

Treatments	Weight of clump (g)	Length of clump (cm)	Width of clump (cm)	Volume of clump (cc)	Primary finger clump^{-1}			
					Number	Weight (g)	Length (cm)	Width (cm)
T_1	284.85	17.24	14.09	293.10	10.02	122.14	6.59	1.87
T_2	295.90	18.23	14.63	316.21	10.44	129.27	6.81	1.94
T_3	307.83	18.83	15.11	337.73	11.24	136.41	7.54	2.23
T_4	324.58	19.48	15.71	353.66	11.33	152.25	7.65	2.25
T_5	339.71	19.77	15.32	360.38	11.52	159.34	7.88	2.26
T_6	303.43	18.34	14.95	322.84	10.85	144.43	7.40	1.95
T_7	352.59	19.94	15.69	373.30	11.58	165.08	8.01	2.37
T_8	388.92	20.44	15.61	405.89	11.87	173.12	8.28	2.38
T_9	407.17	20.73	15.77	416.57	12.39	179.26	8.43	2.47
T_{10}	416.84	20.93	15.93	438.48	12.55	186.22	8.33	2.53
S.Em (±)	**4.946**	**0.245**	**0.191**	**4.653**	**0.167**	**2.210**	**0.122**	**0.035**
C.D.(P=0.05)	**14.811**	**0.734**	**0.573**	**13.932**	**0.496**	**6.618**	**0.366**	**0.106**

Table 2b : Effect of bio-priming treatments on yield attributes and yield of aromatic turmeric (*Curcuma aromatica* Salisb.)

Treatments	Secondary finger clump^{-1}				Mother rhizome			Yield	
	Number	Weight (g)	Length (cm)	Width (cm)	Weight (g)	Length (cm)	Width (cm)	Yield per plot (kg/3.0 m^2)	Projected yield (t/ha)
T_1	16.81	84.64	2.01	1.65	70.59	5.76	3.25	9.03	22.58
T_2	16.86	93.77	2.14	1.72	72.65	6.01	3.38	9.64	24.11
T_3	17.65	93.86	2.74	1.80	77.16	6.74	3.41	10.75	26.89
T_4	18.80	93.30	3.01	1.88	78.58	6.81	3.71	11.14	27.86
T_5	19.64	100.12	3.14	1.87	80.19	7.01	3.45	11.81	29.53
T_6	17.86	91.81	2.21	1.86	74.31	6.65	3.43	10.00	25.00
T_7	20.56	103.89	3.15	2.01	83.17	7.05	3.81	12.49	31.22
T_8	21.21	133.01	3.62	1.95	82.44	7.45	3.91	13.95	34.88
T_9	21.55	140.65	3.39	2.02	87.21	7.68	4.05	15.31	38.27
T_{10}	21.36	138.00	3.69	2.06	92.56	7.66	4.08	15.45	38.63
S.Em (±)	**0.282**	**1.586**	**0.042**	**0.028**	**1.155**	**0.099**	**0.053**	**0.170**	**0.424**
C.D.(P=0.05)	**0.844**	**4.749**	**0.124**	**0.082**	**3.458**	**0.297**	**0.158**	**0.508**	**1.270**

Secondary finger length and width were highest in T_{10} (3.69 cm and 2.06 cm, respectively), followed by T_9 (3.39 cm and 2.02 cm), whereas the lowest values were observed in T_1 (2.01 cm and 1.65 cm). The increase in number and size of fingers under bio-priming treatments may be attributed to improved rhizome development and efficient utilization of nutrients.

Mother rhizome characteristics were also significantly enhanced by bio-priming treatments. The highest mother rhizome weight was recorded in T_{10} (92.56 g), followed by T_9 (87.21 g), whereas the lowest was observed in T_1 (70.59 g). The maximum length of mother rhizome was recorded in T_9 (7.68 cm), closely followed by T_{10} (7.66 cm), while the lowest was in T_1 (5.76 cm). Similarly, the highest width was recorded in T_{10} (4.08 cm), followed by T_9 (4.05 cm), whereas the lowest was observed in T_1 (3.25 cm). These results indicate better rhizome enlargement under combined bio-agent treatments.

The yield parameters clearly demonstrated the superiority of bio-priming treatments. The highest yield per plot was recorded in T_{10} (15.45 kg per 3.0 m^2), closely followed by T_9 (15.31 kg), whereas the lowest was observed in T_1 (9.03 kg). Similarly, the projected yield was highest in T_{10} (38.63 t ha^{-1}), followed by T_9 (38.27 t ha^{-1}) and T_8 (34.88 t ha^{-1}), while the lowest was recorded in T_1 (22.58 t ha^{-1}). The significant increase in yield under bio-priming treatments may be attributed to improved plant growth, enhanced nutrient uptake, and reduced disease incidence. These findings are in agreement with earlier reports by Reddy *et al.* (2003) and Shabir *et al.* (2013), who observed increased yield and productivity due to the application of *Trichoderma* and *Pseudomonas.* Overall, the combined application of *Trichoderma harzianum* and *Pseudomonas fluorescens* (T_9 and T_{10}) proved to be the most effective treatments in enhancing yield attributes and overall productivity of aromatic turmeric. The results clearly indicate the synergistic effect of these bio-agents in improving rhizome development and yield under field conditions.

Quality Parameters

The data presented in Table-3 demonstrated that bio-priming treatments had a marked effect on the quality attributes of aromatic turmeric. Among the different treatments, the highest dry matter content was recorded in T_{10} (26.65%), followed by T_9 (25.53%) and T_8 (25.06%), whereas the lowest was observed in T_1 (21.61%). The increase in dry matter under bio-priming treatments may be attributed to Curcumin content was significantly enhanced by bio-priming treatments. The highest curcumin content was recorded in T_9 (1.58%), followed by T_{10} (1.49%) and T_8 (1.39%), while the lowest was observed in T_1 (1.12%). The increase in curcumin content may be due to enhanced metabolic activity and synthesis of secondary metabolites induced by beneficial microbes. Similar findings were reported by Singh *et al*. (2013), who observed increased curcumin content in turmeric with bio-inoculation.

Table 3 : Effect of bio-priming treatments on quality parameters of aromatic turmeric (*Curcuma aromatica* Salisb.)

Treatments	Dry matter (%)	Curcumin content (%)	Oleoresin content (%)	Essential oil (%)
T_1	21.61	1.12	6.68	2.26
T_2	22.55	1.16	7.28	2.45
T_3	23.50	1.19	7.62	3.19
T_4	24.42	1.24	7.85	3.60
T_5	24.64	1.29	8.25	3.72
T_6	23.67	1.18	7.41	2.86
T_7	24.85	1.35	8.58	3.96
T_8	25.06	1.39	8.89	4.21
T_9	25.53	1.58	9.09	4.54
T_{10}	26.65	1.49	9.31	4.46
S.Em (±)	**0.353**	**0.019**	**0.117**	**0.049**
C.D.(P=0.05)	**1.057**	**0.056**	**0.350**	**0.147**

Oleoresin content also showed a significant increase under bio-priming treatments. The maximum oleoresin content was recorded in T_{10} (9.31%), followed by T_9 (9.09%) and T_8 (8.89%), whereas the lowest was observed in T_1 (6.68%). This improvement may be attributed to enhanced biochemical processes and accumulation of essential compounds in rhizomes, as supported by earlier findings of Choudhary *et al.* (1996).

Essential oil content was also significantly influenced by the treatments. The highest essential oil content was recorded in T_9 (4.54%), followed by T_{10} (4.46%) and T_8 (4.21%), while the lowest was observed in T_1 (2.26%). The increase in essential oil content may be due to improved synthesis of volatile compounds under the influence of bio-agents. Similar enhancement in essential oil content due to microbial inoculation has been reported by Reddy *et al.* (2011). Overall, the combined application of *Trichoderma harzianum* and *Pseudomonas fluorescens* (T_9 and T_{10}) proved to be the most effective treatments in improving quality parameters such as dry matter, curcumin, oleoresin, and essential oil content in aromatic turmeric. The results indicate that bio-priming not only enhances growth and yield but also improves the biochemical quality of the produce.

Conclusion

The present investigation revealed that bio-priming significantly improved germination, growth, yield, and quality of aromatic turmeric (*Curcuma aromatica* Salisb.). Among the different treatments, the combined application of *Trichoderma harzianum* and *Pseudomonas fluorescens* (T_9 and T_{10}) proved to be the most effective in enhancing plant growth, rhizome yield, and quality attributes such as curcumin, oleoresin, and essential oil content. The findings suggest that microbial bio-priming is an eco-friendly and sustainable approach for improving productivity and quality of aromatic turmeric under field conditions.

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References

Ahmad, S., Ali, M., Ansari, S. H. and Ahmed, F. (2011). Phytoconstituents from the rhizomes of *Curcuma aromatica* Salisb. *J. Saudi Chem. Soc.*, **15(3)**, 287-290.

Al-Reza, S. M., Rahman, A., Sattar, M. A., Rahman, M. O. and Fida, H. M. (2010). Essential oil composition and antioxidant activities of *Curcuma aromatica* Salisb. *Food Chem. Toxicol.*, **48(6)**, 1757-1760.

Anoop, K. (2015). *Curcuma aromatica* Salisb, A multifaceted spice. *Int. J. Phytopharm. Res.*, **6(1)**, 10-15.

Bhargava, B., Gupta, Y. C., Dhiman, S. R. and Sharma, P. (2015). Effect of seed priming on germination, growth and flowering of snapdragon (*Antirrhinum majus* L.). *Nat. Acad. Sci. Lett.* **38(1)**, 81-85.

Choudhury, S.N., Ghosh, A.C., Saika, M., Choudhury, M. and Leclereq, P.A. (1996). Volatile oil constituents of the aerial and underground parts of *C. aromatica* Salisb. from India. *J. Essent. Oil Res.*, **8(6)**, 635-638.

Kevimeo, K. and Tiameren, N. (2013). Biocontrol of rhizome rot disease of ginger (*Zingiber officinale* Rosc.). *Int. J. Bio-resour. Stress Manag.*, **4(2)**, 317-321.

Kumar, S., Arya, M. C. and Singh, R. (2010). Management of sweet pepper diseases and growth promotion by *Pseudomonas fluorescens* and *Trichoderma harzianum* in mid hills of Central Himalayas, India. *Indian Phytopathol.*, **63(2)**, 181-186.

Lingyun, W. U., Dongwei, Y. A. O. and Ming, L. I. (2017). Effects of solid matrix priming with *Trichoderma harzianum* on seed germination, seedling emergence and photosynthetic capacity of eggplant. *Afr. J. Biotechnol.*, **16(14)**, 699-703.

Menon, J. S., Karippai, R. S. and Shaji, J. (2016). Bio priming seed material to enhance yield in offseason green ginger (*Zingiber officinale* Rosc.) cultivation. *Neera*, **21**, 137.

Pant, N., Misra, H. and Jain, D. C. (2013). Phytochemical investigation of ethyl acetate extract from *Curcuma aromatica* Salisb rhizomes. *Arab. J. Chem*., **6(3)**,279-283.

Rafi, H. and Dawar, S. (2015). Evaluation of effective doses for bio priming of leguminous and non-leguminous seeds with microbial antagonists and plant extracts in the management of root rot fungi and promotion of plants. *J. Plant Pathol Microbiol.*, **4(4)**, 1-5.

Reddy, A. S. R., Madhavi, G. B., Reddy, K. G., Yellareddygari, S. K. and Reddy, M. S. (2011). Effect of seed biopriming with *Trichoderma viride* and *Pseudomonas* in chickpea (*Cicer arietinum*) in Andhra Pradesh, India. Plant growth-promoting rhizobacteria (PGPR) for sustainable agriculture. *Proc. of the 2nd Asian PGPR Conf.*, pp.324-429.

Reddy, C. R., Nirnala, R. S. and Ramanamna, C. H. (2003). Efficiency of phytoextracts and oils of certain medicinal plants. *J. Biopestic.*, **2(1)**, 77-83.

Revathy, S. and Malathy, N. S. (2013). Antibacterial activity of rhizome of *Curcuma aromatica* and partial purification of active compounds. *Indian J. pharma. Sci.*, **75(6)**, 732-735.

Shabir, U. R., Dar, W. A., Ganie, S. A., Javid, A., Bhat, G., Hassan, M., Rubina, L., Sumati, N. and Pardeep, K. S. (2013). Comparative efficacy of *Trichoderma viride* and *Trichoderma harzianum* against *Fusarium oxysporum* f sp. Ciceris causing wilt of chickpea. *Afr. J. Microbiol. Res.*, **7(50)**, 5731-5736.

Sikha, A., Harini, A. and Prakash, H. L. (2015). Pharmacological activities of wild turmeric (*Curcuma aromatica* Salisb), a review. *J. Pharmacog. Phytochem*., **3(5)**, 01-04.

Singh, B. K., Ramakrishna, Y., Deka, B. C., Verma, V. K. and Pathak, K. A. (2013). Varieties and planting dates affect the growth, yield and quality of turmeric (*Curcuma longa* L.) in mild-tropical environment. *Veg. Sci.*, **40(1)**, 40-44.

Tripathi, S. K., Sharma, B., Ray, R., Devi, M. and Mishra, P. (2019). Studies on growth and yield of turmeric under different irrigation and nutrient management strategies at West Bengal. *Bull. Env. Pharmacol. Life Sci.*, **8(6)**, 14-20.

Yu, J., Zhou, X., He, X., Dai, M. and Zhang, Q. (2011). Curcumin induces apoptosis involving bax /bcl-2 in human hepatoma SMMC-7721 cells. *Asian Pac. J. Cancer Prev*., **12(8)**, 1925-1929.