# *Original Research Article*

# Enhanced Impact of the Synergistic Power of Mycorrhizae and Root-Promoting Peptides on Root Colonization, Growth and Yield in Multiple Crops

# Abstract

MahaBooster Plus is an innovative plant growth enhancer that combines mycorrhizal fungi with 12 Lateral Root Promoting Peptides (LRPPs) to improve nutrient and water uptake by supporting root development and key growth stages. This study evaluated the effects of MahaBooster Plus on crop yield and related agronomic traits in tomato, brinjal and okra. Laboratory experiments demonstrated that MahaBooster Plus significantly increased root colonization by arbuscular mycorrhizal fungi, achieving up to 80% colonization in tomato and brinjal compared to 50% with a commercial standard. Spore density was also notably higher, with 10 spores/g in tomato and 23 spores/g in brinjal. In tomato, MahaBooster Plus treatment resulted in substantial improvements in fresh root weight, root volume and root density, indicating enhanced nutrient and water absorption potential. Field trial in okra further validated these findings with MahaBooster Plus applied at 4 kg/acre resulted in increased number of fruits per plant, fruit length, fruit girth, fruit weight per plant and total fruit yield. Similarly, in brinjal the same dosage led to significant increases in the number of fruits per plant, fruit weight per plant and fruit yield. These results highlight the potential of MahaBooster Plus to enhance root architecture, yield and overall plant health across multiple crops.

Keywords: Mycorrhizae, MahaBooster plus, Fruit yield, Okra, Brinjal, Tomato

# Introduction

# Efficient nutrient and water uptake are fundamental to robust plant growth, especially under challenging conditions like drought, poor soil fertility and high temperatures. Mycorrhizal fungi form symbiotic associations with plant roots, dramatically expanding the effective root zone through their extensive mycelial networks. This enables plants to access water and nutrients beyond their immediate root area (Rouphael *et al*., 2015; Emmanuel and Babalola, 2020; Wang *et al*., 2021). Arbuscular mycorrhizal fungi (AMF), in particular, significantly modulate plant growth and development by accelerating growth and modifying the biosynthesis of crucial metabolites such as free amino acids, fatty acids and phytohormones, thereby helping plants address various stresses (Begum *et al*., 2020).

# This study investigates MahaBooster Plus, an innovative plant growth enhancer that leverages the synergistic benefits of mycorrhizae and a proprietary blend of 12 Lateral Root Promoting Peptides (LRPPs). The mycorrhizal propagules in MahaBooster Plus establish and maintain a mutualistic relationship with plant roots, while the LRPPs stimulate lateral root development and support critical growth stages, including germination, stem thickening, vegetative expansion, flowering and fruit formation.

# This dual-action formulation delivers a comprehensive suite of distinct benefits, ranging from improved stress tolerance and enhanced growth to environmental safety. Designed for efficacy across diverse soil types and climates, MahaBooster Plus is particularly well-suited for current agricultural conditions, where high temperatures and variable environments often limit crop productivity. With OMRI certification, MahaBooster Plus offers a sustainable, eco-friendly solution to maximize yields while preserving soil and ecosystem health. The present study was planned to precisely ascertain the comparative impact of MahaBooster Plus on root colonization, yield and its attributes in different crops.

# Materials & Method

A series of experiments were conducted under shade net house and field conditions at the AGROCEL Industries Pvt. Ltd. R&D Farm, Koday, Mandvi, Kachchh, India to assess the comparative efficacy of MahaBooster Plus against a leading commercially available arbuscular mycorrhizal fungi (AMF) inoculant. The experimental site featured sandy loam soil, characterized by a light brown colour, good drainage and fair moisture retention. Pre-experimental soil analysis revealed low, optimum and medium status of available nitrogen, phosphorus and potassium, respectively. All necessary agronomic practices were followed as per recommended guidelines for each crop.

To assess the comparative efficacy of MahaBooster Plus on root colonization, controlled experiments were performed using tomato and brinjal seedlings. Seedlings were transplanted in pots containing cocopeat under shade-net conditions. MahaBooster Plus and a commercial AMF check were applied at their recommended dosages directly into the root zone while transplanting. The control group received no inoculant.

Root samples, extracted 21 days after application, were processed using the method by Philips and Hayman (1970). Roots were thoroughly washed with tap water, cleared in a 10% KOH solution for 15 minutes, and then rinsed with tap water. Neutralization was achieved by immersing roots in a 1% HCl solution for 5 minutes before transferring them to a 0.05% Cotton blue staining solution. The percentage of root colonization was subsequently quantified by observing the stained roots under a microscope.

Spore analysis was performed using the wet-sieving and decanting method of Gerdemann and Nicolson (1963). A 10 g sample of rhizosphere cocopeat was mixed with 100 ml of distilled water and stirred vigorously for 1–2 minutes to detach AMF spores. After allowing the mixture to settle for 30 seconds, the supernatant was decanted through a series of sieves (250 µm, 150 µm, 125 µm, 90 µm, 75 µm and 45 µm). Spores retained on the different sieve were rinsed with distilled water, collected on filter paper and then quantified under a microscope.

For further assessing the precise effect of MahaBooster Plus on root development, a separate experiment was conducted in tomato using vertically sectioned pots filled with a uniform soil and farmyard manure (FYM) mixture. The pots were securely fastened for stability before transplanting tomato seedlings into them. MahaBooster Plus was applied to all experimental pots, while a separate set served as the control. At the onset of flowering, pots were carefully opened and roots were gently washed to remove adhering soil. Fresh root weight (g), root volume (cm³) and root density (g/cm³) were measured and recorded.

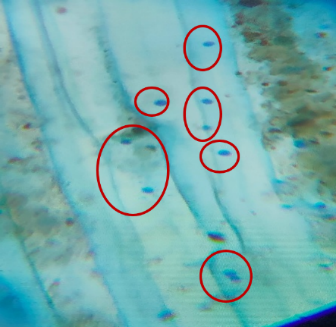
To further authenticate the results obtained in the field experiments were conducted on okra and brinjal using a Randomized Block Design (RBD) with four replications. The treatments included three doses of MahaBooster Plus (2, 4, and 6 kg/acre) applied at 20-25 days after sowing or transplanting in addition to the specified recommended fertilizer dose (RFD). These treatments were compared with a commercial check at 4 kg/acre, also applied with RFD at the same timing. Biometric observations were recorded from five randomly selected plants per plot, measuring number of fruits per plant, fruit length (cm), fruit girth (mm), fruit weight (g), fruit weight per plant (g) and total fruit yield (t/acre). The data were statistically analyzed according to the procedures described by Panse and Sukhatme (1985).

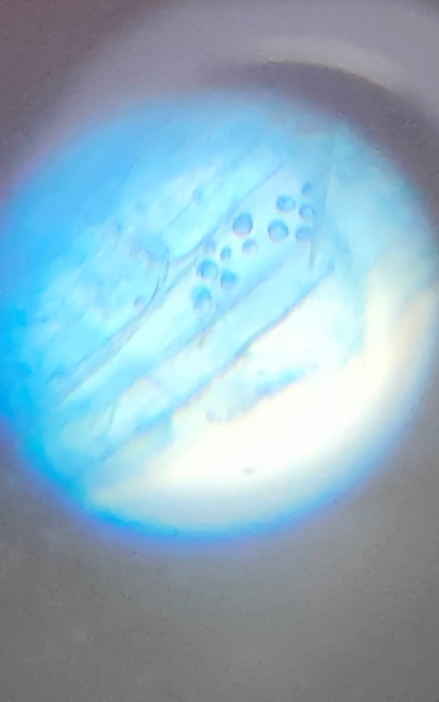
# Result and Discussion

# Laboratory Studies on Mycorrhizal Root Colonization

The comparative performance of MahaBooster Plus against a leading commercial product in root samples of collected and microscopically examined 21 days post-application revealed a significant improvement in root colonization up to 80% with MahaBooster application in both tomato and brinjal compared to only 50% in those treated with the commercial check. This substantial increase highlights the superior ability of MahaBooster Plus to facilitate the dispersal and establishment of mycorrhizal fungi in the rhizosphere. This was further confirmed through spore density analysis in the coco peat rhizosphere using the wet sieving and decanting technique. In the MahaBooster Plus applied cocopeat, spore densities reached 10 spores/g in tomato and 23 spores/g in brinjal compared to 6 spores/g in tomato and 9 spores/g in brinjal in commercial product, indicating intensive fungal activity.

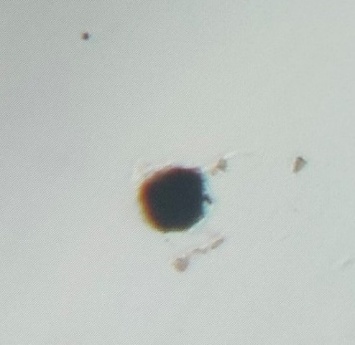
Figure 1. Microscopic view of Mycorrhizal Root Colonization





Brinjal vesicles

Tomato vesicles



Tomato mycorrhizal spore

Brinjal mycorrhizal spore

# Figure 2. Spore analysis of tomato and brinjal

# Root Growth Analysis

The precise impact of MahaBooster Plus on root attributes was indicated in tomato through a controlled pot experiment. The quantitative measurements recorded at the onset of flowering in pots after carefully opening and washing the roots demonstrated significant increases of 465.47%, 331.75% and 38.37% in average fresh root weight, root volume and root density parameters respectively, in MahaBooster Plus-treated plants as compared to the control, (Figure 3). These enhancements in root architecture suggest improved nutrient and water uptake capacity, likely contributing to increased plant vigour and resilience.

Figure 3. Root attributes as impacted by application of MahaBooster plus in tomato

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# Field Experiments

# Okra

The differences among treatments in okra were not statistically significant. However, all MahaBooster Plus treatments produced higher fruit yields than the recommended fertilizer dose (RFD), which yielded 4.48 tons/acre. Yield increases ranged from 13.17% with MahaBooster Plus at 2 kg/acre to 21.88% at 4 kg/acre (Table 1). These improvements were attributed to enhanced plant height, fruit length, fruit count per plant, and fruit yield per plant.

When compared to the leading commercial check (5.24 tons/acre), MahaBooster Plus at 4 kg/acre gave 4.20% higher fruit yield. This yield advantage corresponded with respective increases of 2.72% in plant height, 3.34% in fruit count per plant, 6.95% in fruit length, 5.09% in fruit girth and 4.14% in fruit yield per plant.

Among the tested doses, 4 kg/acre emerged as the most effective rate for MahaBooster Plus. Both lower (2 kg/acre) and higher (6 kg/acre) application rates resulted in yields that were inferior to commercial check. These findings indicate that optimizing the application rate of MahaBooster Plus is essential for maximizing yield benefits in okra, with 4 kg/acre providing the most consistent and favorable results.

Dahilig and Rosales (2023) observe same result as the increase yield of okra by application of mycorrhiza was due to the positive association of number of fruits per plant and fruit length. Dilfuza *et al.* (2021) studies have shown that the AMF significantly increased improved plant height, shoot dry weight, total root length, root volume and root diameter under drought stress. Abdul-Alhussein *et al*. (2019) finding the inoculation with the Mycorrhizae, Biozyme and Phosphalas was superior in giving higher values of yield per plant, total yield, carbohydrate in pods.

# Brinjal

In brinjal, all MahaBooster Plus application resulted in higher fruit yields compared to the recommended fertilizer dose (6.84 tons/acre). Yield increases ranged from no significant change at the 2 kg/acre rate to a notable 15.79% increase at 4 kg/acre (Table 2). These gains were primarily attributed to improvements in both no. of fruit and average fruit weight.

When benchmarked against the leading commercial check, MahaBooster Plus applied at 4 kg/acre at 20–25 days after transplanting exhibited 2.99% higher fruit yield. This advantage was largely due to a 4.47% increase in no. of fruit per plant over the commercial check (11.93 fruits/plant).

The results clearly indicate that the MahaBooster Plus 4 kg/acre application rate is optimal for maximizing yield in brinjal, as both lower (2 kg/acre) and higher (6 kg/acre) doses produced yields inferior to the commercial standard. These findings underscore the importance of precise dose optimization to fully realize the yield benefits of MahaBooster Plus in brinjal cultivation.

Banu *et al*. (2022) study that AM inoculation was found to accelerate yield attributes such as number of fruits per plant, fruit weight, fruit yield in brinjal. Such increase in yield and yield attributes might be due to higher AM root colonization and AM spore population leading to higher P uptake.

# Conclusion

MahaBooster Plus treatment resulted in effective root colonization up to 80% compared to 50% with the commercial standard and increased spore densities in the rhizosphere (10 spores/g in tomato, 23 spores/g in brinjal). In tomato, MahaBooster Plus enhanced fresh root weight, volume and density by 465.47%, 331.75% and 38.37% respectively, indicating improved nutrient and water uptake. Field trials in okra and brinjal palpably exhibited that MahaBooster Plus at 4 kg/acre consistently augmented fruit yield compared to the commercial check. These results demonstrated that MahaBooster Plus significantly improves root attributes with intensive AM fungal colonization and crop yield, with 4 kg/acre identified as the most optimal dose across crops.

Table 1: Impact of different doses of MahaBooster Plus on fruit yield and its attributes in okra

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Tr. No. | Specification | Plant height (cm) | No. of fruits per plant | Fruit length (cm) | Fruit girth (mm) | Fruit weight (g) | Fruit weight per plant (g) | Fruit yield  (t/acre) |
| T1 | RFD + Maha Booster+ 2 kg/acre at 20-25 DAS | 78.95 | 7.14 | 14.54 | 16.22 | 20.27 | 117.02 | 5.07 |
| T2 | RFD + Maha Booster+ 4 kg/acre at 20-25 DAS | 84.90 | 7.74 | 16.00 | 16.72 | 19.81 | 125.79 | 5.46 |
| T3 | RFD + Maha Booster+ 6 kg/acre at 20-25 DAS | 85.80 | 7.56 | 15.31 | 16.55 | 19.92 | 119.15 | 5.09 |
| T4 | Commercial check 4 kg/acre at 20-25 DAS | 82.65 | 7.49 | 14.96 | 15.91 | 19.84 | 120.79 | 5.24 |
| T5 | RDF (60:20:20 NPK kg/acre) | 77.65 | 6.61 | 14.43 | 16.24 | 20.12 | 104.70 | 4.48 |
| SEm ± | | 2.96 | 0.30 | 0.43 | 0.29 | 1.57 | 8.96 | 0.37 |
| CD | | NS | NS | NS | NS | NS | NS | NS |
| CV % | | 7.23 | 8.21 | 5.75 | 3.55 | 15.71 | 15.25 | 14.54 |

Table 2: Impact of different doses of MahaBooster Plus on fruit yield and its attributes in brinjal

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Tr. No. | Specification | No. of fruits per plant | Fruit weight (g) | Fruit weight per plant (g) | Fruit yield (t/acre) |
| T1 | RFD + Maha Booster+ 2 kg/acre at 20-25 DAT | 10.45 | 44.21 | 456.47 | 6.84 |
| T2 | RFD + Maha Booster+ 4 kg/acre at 20-25 DAT | 12.46 | 42.68 | 528.63 | 7.92 |
| T3 | RFD + Maha Booster+ 6 kg/acre at 20-25 DAT | 10.74 | 46.99 | 502.87 | 7.54 |
| T4 | Commercial check 4 kg/acre at 20-25 DAT | 11.93 | 43.26 | 513.1 | 7.69 |
| T5 | RDF (80:40:40 NKP kg/acre) | 10.26 | 44.48 | 456.3 | 6.84 |
| SEm ± | | 0.41 | 1.42 | 26.23 | 0.4 |
| CD | | 1.19 | NS | NS | NS |
| CV % | | 7.17 | 6.39 | 8.54 | 10.77 |

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

# Reference

Abdul-alhussein R. M., Alawi M. M. and Abood H. H. (2019). The response of Okra Abelmoshus esculentus L. to mycorrhizae and biological stimulators (biozyme and phosphalas) on yield and quantity indicators. International Conference on Agricultural Sciences. 388: 012079

Banu, M. B., Mian, M. H., Rahman, M. M., Moslehuddin, A. Z. M. and Matin, M. Q. I. (2022). Assessment of the Effects of Selected AM Strain on the Growth and Yield of Brinjal. *International Journal of Plant & Soil Science*. 34(23): 1538-1547.

Begum, N., Ahanger, M. A., and Zhang, L. (2020). AMF inoculation and phosphorus supplementation alleviates drought induced growth and photosynthetic decline in Nicotiana tabacum by up-regulating antioxidant metabolism and osmolyte accumulation. Environ. Exp. Bot. 176:104088.

Dahilig, M. O. and Rosales, R. J. G. (2023). Short Notes: Application of Vesicular Arbuscular Mycorrhiza: Increasing the Yield of Okra. *Basrah Journal of Agricultural Sciences*. 36(1): 271–275.

Dilfuza Jabborova a.b., Kannepalli Annapurna b., Abdullah M. Al-Sadi C., Sulaiman Ali Alharbi D., Rahul Datta E. and Ali Tan Kee Zuan F. (2021). Biochar and Arbuscular mycorrhizal fungi mediated enhanced drought tolerance in Okra (Abelmoschus esculentus) plant growth, root morphological traits and physiological properties. Saudi Journal of Biological Sciences. 28: 5490-5499.

Emmanuel, O. C. and Babalola, O. O. (2020). Productivity and quality of horticultural crops through co-inoculation of arbuscular mycorrhizal fungi and plant growth promoting bacteria. X-MOL.

Gerdemann, J W and Nicolson, T H. (1963). Spores of mycorrhizal Endogone species extracts from soil wet sieving and decanting. Trans. British Mycological Society 46: 235–244.

Panse VG, Sukhatme PV. (1985). Statistical method for agricultural research workers. ICAR Publication, New Delhi.

Phillips, J M and Hayman, D S. (1970). Improved procedures for clearing roots and staining parasitic and vesicular-arbuscular mycorrhizal fungi for rapid assessment of infection. Transactions of the British Mycological Society 55: 158–161

Rouphael, Y., Franken, P., Schneider, C., Schwarz, D., Giovannetti, M., Agnolucci, M. (2015). Arbuscular mycorrhizal fungi act as biostimulants in horticultural crops. Sci. Horticult. 196, 91–108.

Wang, Y., Zhang, W., Liu, W., Ahammed, G. J., Wen, W., Guo, S. (2021). Auxin is involved in arbuscular mycorrhizal fungi-promoted tomato growth and NADP-malic enzymes expression in continuous cropping substrates. BMC Plant Biol. 21:48.