

Potential of VNMKV, Parbhani Biomix in Improving Crop Productivity and Soil Health in Marathwada: A Comprehensive Review

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Abstract

Agriculture in the Marathwada region of Maharashtra is predominantly characterized by rainfed farming, variable rainfall, periodic drought, declining soil fertility, nutrient imbalance, and increasing incidence of insect pests and plant diseases. These constraints have created a need for sustainable and locally adaptable agricultural technologies. Microbial consortia, commonly referred to as Biomix, have considerable potential for improving nutrient availability, plant growth, soil biological activity and biological management of pests and diseases. Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani has developed and promoted a Biomix consortium containing beneficial microorganisms with plant-growth-promoting, nutrient-mobilizing, decomposing, biocontrol and entomopathogenic properties. The technology is particularly relevant to Marathwada because its development and evaluation have been closely associated with agricultural problems of the region. The VNMKV Biomix formulation includes microorganisms such as *Trichoderma* spp., *Pseudomonas fluorescens*, PPFM, *Paecilomyces lilacinus*, *Metarhizium anisopliae*, *Azospirillum*, *Gluconacetobacter*, *Aspergillus niger* and *Pseudomonas striata*. Research conducted at VNMKV and in the Marathwada region has evaluated Biomix in crops including turmeric, onion and mango. Studies have reported potential benefits in disease suppression, crop growth, yield and economic returns. In turmeric, Biomix has been evaluated against rhizome rot, while field research in onion has examined Biomix in combination with inorganic fertilizers. Farmer-level studies have also investigated the economic implications and adoption of Biomix in turmeric cultivation in Marathwada. This review summarizes the development, microbial composition, mechanisms of action, crop-wise applications, potential benefits, limitations and future research prospects of VNMKV Biomix in Marathwada. Available evidence suggests that Biomix has potential as a component of integrated nutrient management, integrated pest management and sustainable soil-health management. However, further multi-location and multi-season studies are required to establish crop- and region-specific recommendations.

Keywords: Biomix, biofertilizer, biocontrol, soil health, crop productivity, sustainable agriculture, turmeric.

Introduction

Agriculture is the major livelihood activity in Marathwada, a region comprising Chhatrapati Sambhajnagar, Jalna, Beed, Dharashiv, Latur, Nanded, Parbhani and Hingoli districts. The agricultural economy of the region is strongly influenced by rainfall variability, recurrent drought, soil characteristics, irrigation availability and fluctuations in agricultural input costs. Major crops cultivated in the region include soybean, cotton, pigeon pea, chickpea, sorghum, wheat, sugarcane, turmeric, onion and various horticultural crops. Despite considerable agricultural potential, farmers face several challenges, including declining soil fertility, nutrient imbalance, soil-borne diseases, insect-pest problems and increasing dependence on external inputs.

Beneficial microorganisms play important roles in agricultural ecosystems. They contribute to nutrient cycling, decomposition, biological nitrogen fixation, phosphate solubilization, plant growth promotion and suppression of plant pathogens. Microbial consortia have attracted particular attention because microorganisms with different but complementary functions can be combined in a single formulation.

Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani has developed and promoted Biomix as a microbial consortium for agricultural use. The technology has been particularly associated with the management of diseases and pests in turmeric and other crops of the Marathwada region (Vasantrao Naik Marathwada Krishi Vidyapeeth [VNMKV], 2023).

The present review focuses specifically on VNMKV Biomix and its potential role in sustainable agriculture in Marathwada.

Development of VNMKV Biomix

The development of Biomix at VNMKV was associated with the need for effective biological management of crop diseases and pests. Turmeric cultivation provided an important context because rhizome rot and insect pests can cause considerable losses.

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VNMKV's institutional documentation describes Biomix as a consortium of beneficial microorganisms developed through research conducted by the university. The formulation incorporates organisms having different functions, including biological disease suppression, insect-pest management, nutrient mobilization and plant-growth promotion (VNMKV, 2023). The university has subsequently promoted Biomix through their research stations, extension programmes and Agricultural Technology Information Centre (ATIC). The development of such a consortium represents an important approach to integrated biological crop management, where several microorganisms can potentially provide complementary functions.

Microbial Composition of VNMKV Biomix

VNMKV documentation reports several microorganisms associated with its Biomix formulation.

Table 1. Major microbial groups reported in VNMKV Biomix

Microorganism	Potential agricultural function
<i>Trichoderma</i> spp.	Biological disease suppression
<i>Pseudomonas fluorescens</i>	PGPR and biocontrol
<i>Pseudomonas striata</i>	Phosphate solubilization
<i>Azospirillum</i>	Associative nitrogen fixation and growth promotion
<i>Gluconacetobacter</i>	Nitrogen fixation/growth promotion
PPFM	Plant growth promotion
<i>Aspergillus niger</i>	Decomposition/nutrient mobilization
<i>Paecilomyces lilacinus</i>	Biological control
<i>Metarhizium anisopliae</i>	Entomopathogenic activity

VNMKV documentation describes Biomix as containing multiple microorganisms with complementary biological functions (VNMKV, 2023).

However, it is important to recognize that formulation composition should always be confirmed from the specific VNMKV product specification or batch, because the term Biomix may be used for different microbial combinations.

Functional Role of Microorganisms

Plant-growth-promoting microorganisms

Plant-growth-promoting rhizobacteria can improve plant growth through several mechanisms, including nutrient mobilization, production of growth-promoting substances, siderophore production and suppression of harmful microorganisms.

VNMKV-associated research has characterized PGPR isolates associated with its microbial consortium, including *Pseudomonas* and *Bacillus* species (Neware et al., 2024).

Trichoderma spp.

Trichoderma is one of the most widely studied fungal biocontrol genera.

Its mechanisms include:

- mycoparasitism;
- competition;
- antibiosis;
- production of hydrolytic enzymes;
- rhizosphere colonization; and
- induction of plant defense.

Its inclusion in Biomix provides an important biological disease-management component.

Pseudomonas spp.

Pseudomonas fluorescens is widely recognized as a PGPR and biocontrol organism. It can colonize the rhizosphere and produce compounds that inhibit certain plant pathogens.

Pseudomonas striata is associated with phosphate-solubilizing activity and may contribute to phosphorus availability.

Entomopathogenic fungi

The presence of entomopathogenic fungi such as *Metarhizium* and *Beauveria* provides a biological pest-management component.

These fungi can infect susceptible insect hosts and therefore have potential for incorporation into integrated pest management programmes.

Recent molecular research associated with VNMKV Biomix has characterized fungal isolates including *Beauveria bassiana*, *Metarhizium anisopliae*, *Lecanicillium lecanii* and *Aspergillus niger* (Neware et al., 2025).

Mechanisms of Action of Biomix

The effectiveness of a microbial consortium may result from several simultaneous mechanisms.

Nutrient mobilization

Microorganisms may increase the availability of nutrients through:

- nitrogen fixation;
- phosphorus solubilization;
- mineral nutrient mobilization;
- organic matter decomposition; and
- enhanced rhizosphere activity.

Plant-growth promotion

PGPR may influence:

- root growth;
- nutrient absorption;
- plant biomass;
- chlorophyll content; and
- overall plant vigour.

Biological disease suppression

Beneficial microorganisms may suppress pathogens through:

- competition;
- antibiosis;
- mycoparasitism;
- enzyme production;
- siderophore production; and
- induced resistance.

Biological pest management

Entomopathogenic fungi such as *Metarhizium* and *Beauveria* may contribute to suppression of insect pests.

Organic matter decomposition

Decomposer microorganisms can contribute to the breakdown of organic residues and nutrient cycling.

Application of Biomix in Turmeric

Turmeric is particularly important in the context of VNMKV Biomix research.

Rhizome rot is one of the important diseases affecting turmeric production. Kadam et al. (2019) evaluated different bioagents and microbial consortia against rhizome rot caused by *Pythium aphanidermatum* under experimental conditions at VNMKV, Parbhani.

The Biomix treatment showed substantially improved germination and reduction in disease-related losses compared with the untreated control (Kadam et al., 2019).

These findings demonstrate the potential of microbial consortia for integrated management of turmeric diseases.

Relevance to Marathwada

Turmeric is cultivated in several parts of Marathwada, and the development of VNMKV Biomix provides a regionally relevant biological-management technology.

Economic Impact of Biomix in Turmeric

Suryavanshi et al. (2024) studied the economic impact of Biomix use in turmeric cultivation in the Marathwada region.

The study examined farmers using Biomix developed by VNMKV, Parbhani and considered the economic aspects of Biomix-based turmeric production.

The study is important because agricultural technology should be evaluated not only on biological effectiveness but also in terms of:

- production cost;
- labour requirement;
- yield;
- gross income;
- net income;
- input savings; and
- benefit-cost ratio.

Farmer-level economic evaluation provides an important complement to experimental research.

Biomix in Onion Cultivation

Onion is another economically important crop in Marathwada and adjoining regions.

Garde et al. (2025) conducted a two-year experiment at VNMKV, Parbhani, evaluating different NPK levels along with organic treatments including Biomix and humic acid.

The study reported pooled bulb yields of approximately 24.56 and 24.24 t ha⁻¹ for treatments involving 120% recommended fertilizer dose with humic acid and Biomix, respectively. The Biomix treatment also showed an economically favourable benefit-cost ratio under the experimental conditions (Garde et al., 2025).

The results demonstrate that Biomix can be investigated as part of integrated nutrient management, rather than necessarily being considered a replacement for mineral fertilizers.

Biomix in Horticultural Crops

The potential of VNMKV Biomix has also been investigated in horticultural crops.

Research associated with VNMKV has evaluated Biomix in Kesar mango nursery production.

The microbial consortium was investigated for its influence on plant establishment and growth (VNMKV, n.d.).

The possible benefits of Biomix in horticultural systems include:

- improved root development;
- nutrient mobilization;
- biological suppression of soil-borne pathogens;
- improved seedling establishment; and
- increased plant vigour.

Further studies are required to determine whether the response is consistent across different horticultural crops and production systems.

Biomix and Soil Health

Soil health is determined by physical, chemical and biological properties.

Biomix may contribute primarily through biological processes, including:

- microbial nutrient cycling;
- organic matter decomposition;
- increased microbial activity;
- nutrient mobilization;
- suppression of soil-borne pathogens; and
- improved rhizosphere interactions.

Future studies in Marathwada should therefore measure soil-health indicators along with crop yield.

Table 2. Suggested soil-health indicators

Indicator	Importance
Soil organic carbon	Soil fertility and carbon status
Available nitrogen	Nutrient availability
Available phosphorus	P availability
Available potassium	K availability
Microbial biomass carbon	Biological activity
Dehydrogenase activity	Overall microbial activity
Phosphatase activity	P cycling
Soil respiration	Biological activity
Microbial population	Beneficial microbial abundance
Soil pH	Nutrient availability

Biomix in Integrated Nutrient Management

The use of Biomix should preferably be considered within Integrated Nutrient Management (INM).

A suitable agricultural model for Marathwada could include:

Soil testing → Organic manure → Balanced NPK → VNMKV Biomix → Crop residue management → Appropriate irrigation → Monitoring

The onion research conducted at VNMKV illustrates the importance of evaluating Biomix alongside inorganic fertilizers (Garde et al., 2025).

Therefore, the statement that Biomix completely replaces chemical fertilizers should be avoided unless supported by crop-specific and statistically robust experimental evidence.

Biomix in Integrated Pest Management

VNMKV Biomix has considerable relevance to Integrated Pest Management (IPM) because of the presence of microorganisms with biocontrol and entomopathogenic properties.

A Biomix-based IPM strategy could combine:

1. Resistant crop varieties
2. Crop rotation
3. Soil solarization where appropriate
4. Organic amendments
5. VNMKV Biomix
6. Monitoring of pest populations
7. Biological control
8. Mechanical control
9. Judicious chemical pesticide application when required

Such integration can reduce reliance on a single management method.

Farmer Adoption in Marathwada

Technology adoption is an important component of agricultural sustainability.

VNMKV institutional records document the dissemination of Biomix through its extension network and agricultural technology centers (VNMKV, 2023).

A farmer-level study by Suryavanshi et al. (2024) specifically examined Biomix use in turmeric cultivation in Marathwada. Such studies are valuable because adoption depends not only on biological performance but also on:

- farmer knowledge;
- availability;
- cost;
- ease of application;
- perceived effectiveness;
- extension support; and
- compatibility with existing farming practices.

Advantages of VNMKV Biomix

The potential advantages of VNMKV Biomix include:

Multiple biological functions

A consortium can potentially provide nutrient mobilization, growth promotion and biocontrol simultaneously.

Regional development

The technology has been developed and evaluated by an agricultural university serving the Marathwada region.

Potential disease suppression

Experimental evidence supports its investigation against turmeric rhizome rot.

Potential improvement in crop productivity

Field experiments in crops such as onion provide evidence for further evaluation.

Compatibility with integrated agriculture

Biomix can potentially be incorporated with organic manures, fertilizers and IPM.

Potential economic benefits

Farmer-level research indicates the importance of Biomix in evaluating production economics.

Limitations and Constraints

Despite its potential, Biomix technology has several limitations.

Environmental variability

Microbial performance can change according to:

- temperature;
- soil moisture;
- pH;
- organic matter;
- soil texture; and
- native microbial populations.

Microbial compatibility

All organisms in a consortium must remain viable and functionally compatible.

Shelf life

Temperature and storage conditions can influence microbial viability.

Crop-specific performance

A consortium effective in turmeric may not produce the same response in soybean, cotton or onion.

Pesticide compatibility

Certain fungicides and bactericides can negatively affect beneficial microorganisms.

Need for standardized quality control

Microbial identity, viable count, purity and formulation stability need to be routinely monitored.

Research Gaps in Marathwada

Although VNMKV Biomix has been studied in several agricultural contexts, important research gaps remain.

Multi-location evaluation

Research should be conducted across all major agricultural districts of Marathwada.

Long-term experiments

Most studies evaluate short-term crop responses. Long-term experiments are required to determine effects on soil health.

Crop-specific recommendations

Separate recommendations should be developed for major crops.

Molecular characterization

Molecular tools can help determine microbial identity, abundance and persistence.

Microbiome studies

High-throughput sequencing could determine how Biomix changes native soil and rhizosphere microbial communities.

Economic evaluation

Cost-benefit analysis should be incorporated into field trials.

Climate resilience

The performance of Biomix should be studied under drought and heat conditions typical of Marathwada.

Future Prospects

The future of VNMKV Biomix research in Marathwada lies in combining traditional agricultural knowledge with modern microbial biotechnology.

Potential research directions include:

- indigenous microbial consortium development;
- crop-specific Biomix formulations;
- drought-tolerant microbial strains;
- microbial encapsulation;
- liquid formulations with improved shelf life;
- molecular authentication;
- metagenomic analysis;
- precision microbial application;
- integration with organic farming;

- integrated pest management; and
- farmer-participatory trials.

The use of indigenous microorganisms isolated from Marathwada soils may be particularly promising because such microorganisms may be adapted to local temperature, soil and moisture conditions.

Conclusion

VNMKV Biomix represents a regionally relevant microbial consortium with potential applications in sustainable agriculture in Marathwada. Its development at Vasantao Naik Marathwada Krishi Vidyapeeth, Parbhani is closely associated with agricultural problems of the region, particularly disease and pest management in turmeric.

The available experimental evidence demonstrates potential applications in turmeric disease management and onion production, while farmer-level studies provide evidence regarding its economic and extension dimensions. Molecular studies have further strengthened the scientific understanding of microorganisms associated with the VNMKV Biomix consortium.

The technology has potential to contribute to integrated nutrient management, integrated pest management, biological disease suppression and soil-health improvement. Nevertheless, its effectiveness should be assessed on a crop-, soil- and location-specific basis. Biomix should therefore be viewed as a component of integrated agricultural management rather than automatically as a complete replacement for chemical fertilizers or pesticides.

For Marathwada, future research should concentrate on multi-location trials, long-term soil-health studies, molecular characterization, economic evaluation and farmer-participatory research. Particular attention should be given to major crops such as turmeric, soybean, cotton, chickpea, pigeon pea, onion, sorghum and horticultural crops.

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