Biological Forum – An International Journal **16(8): 256-261(2024)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Biofertilizers in India: Growth Patterns and Export Competitiveness

Manojkumar Patil[1*], Ajayakumar[1], Sagar[2], Suman L.[1], B. Nandita[3] and Priyanka V.[1]
[1]Ph.D. Scholar, Department of Agricultural Economics,
University of Agricultural Sciences, GKVK, Bengaluru (Karnataka), India.
[2]Assistant Professor, Department of Agricultural Economics,
University of Agricultural Sciences, GKVK, Bengaluru (Karnataka), India.
[3]Ph.D. Scholar, Department of Agricultural Economics,
University of Agricultural Sciences, Dharwad (Karnataka), India.

(Corresponding author: Manojkumar Patil)*
(Received: 01 June 2024; Revised: 22 June 2024; Accepted: 19 July 2024; Published: 14 August 2024)
(Published by Research Trend)

ABSTRACT: This study explores the growth patterns and export competitiveness of the biofertilizer industry in India, a crucial component in promoting sustainable agriculture. Biofertilizers, containing living microorganisms, enhance soil health and crop productivity, making them integral to India's agricultural strategy. The study examines production trends from 1992 to 2022, revealing significant growth, particularly in liquid-based biofertilizers, which expanded rapidly after their introduction in 2014. The analysis includes the Revealed Comparative Advantage (RCA) index, which tracks India's global market competitiveness in biofertilizers. Despite fluctuations, India's RCA has generally improved, indicating a strengthening position in the global market. The study also evaluates the Export Unit Value (EUV) and Import Unit Value (IUV) of biofertilizers, finding that higher export prices correlate positively with India's RCA, while rising import prices negatively impact competitiveness. Additionally, the Transitional Probability Matrix (TPM) assesses the stability of India's biofertilizer export markets, highlighting strong retention in key markets like Nepal, the Maldives, and Sri Lanka, but also identifying vulnerabilities in markets such as the USA and Kenya. The findings suggest that while India's biofertilizer industry is poised for continued growth, challenges related to market volatility and competition remain. Strategic enhancements in production and export policies are recommended to sustain and strengthen India's position in the global biofertilizer market.

Keywords: Biofertilizers, Export Competitiveness, Revealed Comparative Advantage (RCA), Transitional Probability Matrix (TPM).

INTRODUCTION

Biofertilizers, composed of organic substances containing living microorganisms, have emerged as a sustainable solution to enhance soil health and improve crop productivity (Chittora *et al.*, 2020; Singh *et al.,* 2023). In India, where agriculture plays a pivotal role in the economy, biofertilizers represent a critical strategy to address soil degradation and optimize farming practices. The growing demand for organic products, both domestically and internationally, underscores the significance of biofertilizers. To support this transition toward sustainable agriculture, the Indian government has implemented various incentives and programs aimed at promoting biofertilizer usage. As a result, the biofertilizer market is projected to expand significantly, with estimates indicating growth from $110.07 million in 2022 (Garcha, 2023) to $138 million in 2024, reaching $213.9 million by 2029 at a compound annual growth rate (CAGR) of 9.15% (Mordor Intelligence, 2024).

Despite India's leadership in certified organic production—with approximately 1.3 million certified organic producers as of 2019—the proportion of land dedicated to organic farming remains relatively small, accounting for only 2.0% of the total agricultural area (Bharti and Suryavanshi 2021). In 2021, the organic farming area covered 711,094 hectares, reflecting a modest increase of 3.4% since 2017 (Ministry of Agriculture and Farmers Welfare, Government of India, 2023). Organic farming is concentrated in a few states, with Madhya Pradesh, Rajasthan, and Maharashtra leading in coverage. Notably, Madhya Pradesh alone accounted for around 27% of India's total organic cultivation area in 2019. Although India's per capita expenditure on organic products is currently low—standing at $0.23 compared to the regional average—there is a discernible consumer shift toward organic goods. This shift is driven by perceived benefits such as improved immunity, higher product quality, and increased availability through e-commerce platforms (Khurana and Kumar 2022).

The focus of this paper is to assess the competitiveness of India's biofertilizer industry in the global market and analyze the growth patterns influencing its development. By examining market trends, export

potential, and sector dynamics, our study aims to provide a comprehensive understanding of the factors shaping the future of the biofertilizer industry in India.

METHODOLOGY

A. Data Collection

Secondary data is collected from trade map, global and Indian exports and imports of biofertilizer has been gathered till the most recent year, 2023. This data is utilized to calculate the percentage share of imports and exports of biofertilizer on both the global and national scales. Additionally, data spanning from 2004 to 2023 is considered for the Revealed Comparative Advantage (RCA) and Transitional Probability Matrix related to biofertilizer exports.

HS code: 3101 Animal or vegetable fertilisers, whether or not mixed together or chemically treated; fertilisers produced by the mixing or chemical treatment of animal or vegetable products (excluding those in pellet or similar forms, or in packages with a gross weight of <= 10 kg)

B. Descriptive Statistics

For the study, descriptive statistics such as mean, and percentages were used for analysing the data pertaining to the export and import of biofertilizer at global and National scenario.

C. Compound Annual Growth Rate

The Compound Annual Growth Rates were estimated by using log linear functions which is an appropriate functional form described by Gujarati (1988). Equation to compute CAGR is:

$$Y_t = a\, b^t u_t$$

Where,

Y_t = Production (Dependent Variable) in the time t.

a = intercept

b^t = Regression Coefficient (1 + r)

t = Years which takes value 1, 2, … …, n

u_t = error term for the year t

Taking logarithm to both sides to transform the equation into log linear form for estimation:

logY = loga + t*logb

The compound growth rate (r) of production in percentage is computed by using the function:

CAGR (%) = {Antilog of (ln b)-1} *100

Regression coefficient was tested for significance by using student's t-test

D. Instability

The level of instability is computed from Cuddy Della Valle Index. It is a better measure to compute instability in agricultural production when compared to Coefficient of Variation (CV) as the variation measured by CV can be overestimated as described by Cuddy and Della Valle (1978). The function to estimate instability index is as follows:

$$\text{Cuddy Della Valle Index (CDVI)} = \text{CV}\sqrt{(1 - \bar{R}^2)}$$

Where,

CV is co-efficient of variation, and $\bar{R}^2$ (Adjusted R^2) is the coefficient of determination from a time trend regression adjusted by the number of degrees of freedom.

E. Coefficient of Variation (CV)

Coefficient of Variation was calculated by using the following formula:

CV= (SD/Mean) *100

Where,

SD is Standard Deviation

F. Export Unit Value (EUV) and Import Unit Value (IUV)

To determine the Export Unit Value and Import Unit Value, the following formulas are used:

1. Export Unit Value (EUV):

$$\text{EUV} = \frac{\text{Total Export Value}}{\text{Total Export Quantity}}$$

2. Import Unit Value (IUV):

$$\text{IUV} = \frac{\text{Total Import Value}}{\text{Total Import Quantity}}$$

G. Revealed Comparative Advantage (RCA)

The RCA index measures a country's relative advantage or disadvantage in a particular sector compared to other countries (Balassa, 1977). The RCA is calculated using the following formula:

$$\text{RCA} = \frac{(X_{ij}/X_i)}{(M_{ij}/M_i)}$$

Where:

X_{ij} is the export value of product j by country i.

X_i is the total export value of all products by country i.

M_{ij} is the import value of product j by country i.

M_i is the total import value of all products by country i.

An RCA value greater than 1 indicates that the country has a comparative advantage in the export of that product.

H. Markov Chain Analysis

Exports data for the period 2004 to 2023 were used to analyse the export trade direction of biofertilizers. The major biofertilizer importing countries namely Nepal, Maldives, United States of America, Sri Lanka, Philippines, Malaysia, Japan, Kenya, China, Vietnam and Others. The trade directions of commodities exports were analysed using the first order Markov chain approach. Central to Markov chain analysis is the estimation of the transitional probability matrix P. The elements Pij of the matrix P indicates the probability that export will switch from country i to country j with the passage of time. The diagonal elements of the matrix measure the probability that the export share of a country will be retained. Hence, an examination of the diagonal elements indicates the loyalty of an importing country to a particular country's exports. In the context of the current application, structural changes were treated as a random process with selected importing countries. The average exports to a particular country were considered to be a random variable which depends only on the past exports to that country, which can be denoted algebraically as

$$Ejt = \Sigma E\_(it-1) * Pij + ejt$$

Where,

E_{jt}= Exports from India to jth country during the year t.

E_{it-1}= Exports to i^{th} country during the period t-1

P_{ij}= Probability that the exports will shift from i^{th} country to j^{th} country.

e_{jt}= The error term which is statistically independent of Eit-1.
t= Number of years considered for the analysis
r= Number of importing countries
The transitional probabilities P_{ij} which can be arranged in a (C* R) matrix have the following properties.
$O \leq P_{ij} \leq 1=1$, for all i
Thus, the expected export shares of each country during period ' t ' were obtained by multiplying the export to these countries in the previous period (t-1) with the transitional probability matrix. To estimate the transitional probabilities of the Markov chain model Minimum Absolute Deviations (MAD) estimation procedure was employed, which minimizes the sum of absolute deviations. The conventional linear programming technique was used, as this satisfies the properties of transitional probabilities of non-negativity restrictions and row sum constraints in estimation.
The linear programming formulation is stated as
Min, OP*+le
Subject to, XP*+V=Y
zGP*=1
P*>1
Where,
O- is the vector of zeroes.
P^* - is the vector in which probability Pij are arranged.
I - is an apparently dimensioned vector of area.
e - is a vector of absolute error (1∪1).
Y - is the vector of export to each country.
X - is the block diagonal matrix of lagged values of Y.
V - is the vector of errors.
G - is the grouping matrix to add the row elements of P arranged in P* to unity.
The values in the transitional probability matrix will have different interpretations. The value of diagonal elements indicates the probability of retention of the previous year values, while values in columns reveals probability of gain of a particular country from other countries, values in rows reveals probability that a country might lose to their countries in respect of a specific commodity exports.

RESULTS AND DISCUSSION

A. Temporal Dynamics and Volatility Assessment of Biofertilizers Usage in India

Table 1 outlines the production of biofertilizers in India from 1992 to 2022, distinguishing between carrier-based and liquid-based biofertilizers. The data reveals a long-term upward trend in the production of carrier-based biofertilizers, which were the only type produced until 2014. Starting at 2,005 metric tonnes in 1992-93, production of carrier-based biofertilizers grew steadily, reaching a significant increase by 2013-14 at 65,527.8 metric tonnes. This growth accelerated further in the following years, peaking at 192,329 metric tonnes in 2020-21, before slightly decreasing to 169,379 metric tonnes in 2021-22.

Table 1: Trend and Instability analysis of biofertilizers in India (1992-2022).

Year	Carrier based (in metric tonnes)	Liquid based (in KL)
1992-1993	2005	-
1993-1994	3084	-
1994-1995	5800.5	-
1995-1996	6692.3	-
1996-1997	7406.6	-
1997-1998	7104.6	-
1998-1999	5972.1	-
1999-1990	5716	-
2000-2001	6242.7	-
2001-2002	9019.2	-
2002-2003	7181.7	-
2003-2004	8701.4	-
2004-2005	10479	-
2005-2006	11752.4	-
2006-2007	15871	-
2007-2008	22646.6	-
2008-2009	25065	-
2009-2000	20040	-
2010-2011	37997.6	-
2011-2012	40324.2	-
2012-2013	46836.8	-
2013-2014	65527.8	-
2014-2015	80696	4055
2015-2016	88029	6241
2016-2017	109020	7526
2017-2018	121067	9033
2018-2019	73377	22646
2019-2020	79437	30106
2020-2021	192329	42240
2021-2022	169379	232934
Mean	42826.68	44347.62
SD	50945.24	77387.35
CV	118.96	174.5
CAGR	15.23%	66.84%
CDVI	27.94	58.57

Source: Author's calculations form data obtained from RCONFs through respective state Government

Liquid-based biofertilizers were introduced in 2014-15, with an initial production of 4,055 kilolitres. Over the next several years, production of liquid-based biofertilizers saw rapid growth, reaching a peak of 232,934 kilolitres in 2021-22. The mean production over the period was 42,826.68 metric tonnes for carrier-based and 44,347.62 kilolitres for liquid-based biofertilizers. The standard deviation, which indicates the variability in production, was higher for liquid-based biofertilizers at 77,387.35 kilolitres compared to 50,945.24 metric tonnes for carrier-based. The coefficient of variation (CV) shows that liquid-based biofertilizers had greater variability (174.5%) compared to carrier-based biofertilizers (118.96%). The compound annual growth rate (CAGR) was 15.23% for carrier-based and an impressive 66.84% for liquid-based biofertilizers, reflecting the rapid expansion of liquid biofertilizer production after its introduction. The Cumulative Distribution Variation Index (CDVI) further underscores this trend, with liquid-based biofertilizers showing a much higher CDVI (58.57) compared to carrier-based (27.94), indicating more significant fluctuations in production over the years. These results align with findings from recent studies by Bharti and Suryavanshi (2021); Patel *et al.* (2023) and are supported by data from Mordor Intelligence (2024).

B. Competitiveness Evaluation of Biofertilizers in India

Fig. 1 illustrates the Revealed Comparative Advantage (RCA) of India's biofertilizers exports from 2000 to 2025 (projected). The RCA index, which measures India's relative strength in exporting biofertilizers compared to its overall export performance, reveals significant fluctuations over this period. Beginning at 0.48 in 2004, India's RCA experienced a notable increase, peaking at 0.84 in 2005, indicating a growing comparative advantage in biofertilizers exports. However, this was followed by a sharp decline, reaching a low of 0.13 in 2010, suggesting a period of reduced competitiveness, possibly due to external global market pressures or internal challenges. After 2010, the RCA index gradually recovered, stabilizing around 0.83 between 2015 and 2020, reflecting a sustained period of comparative advantage. In 2021, the RCA surged to 1.19, signifying a strong position in global biofertilizers exports. However, this was followed by a decrease to 0.78, indicating renewed volatility. Overall, the figure highlights the dynamic nature of India's export competitiveness in biofertilizers, with periods of both significant strength and challenge.

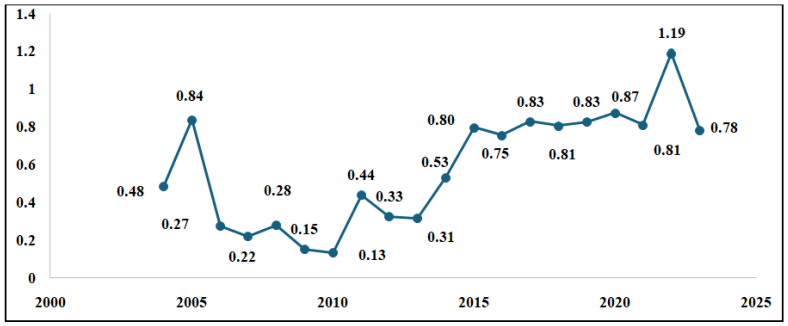

Fig. 1. Revealed Comparative Analysis of biofertilizer in India from 2004-2023.

C. Export and Import Price Dynamics of Biofertilizers in India

The Fig. 2 illustrates the trends in Export Unit Value (EUV) and Import Unit Value (IUV) of biofertilizers in India from 2004 to 2023. The EUV, represented by the blue line, shows a relatively stable and low trend over the years, with a slight increase starting around 2012, peaking modestly before stabilizing. This indicates that the prices at which biofertilizers were exported remained fairly consistent, with only minor fluctuations. In contrast, the IUV, depicted by the orange line, exhibits significant volatility. It starts at a high level in 2004, experiences multiple peaks—most notably around 2010—and then drops sharply by 2011. After this steep decline, the IUV shows a more stable pattern with moderate fluctuations, but still at a higher level than the EUV. The overall trend suggests that biofertilizers were consistently imported at higher and more variable prices compared to their export prices, reflecting possible challenges in the global market or differences in the quality or types of biofertilizers being traded.

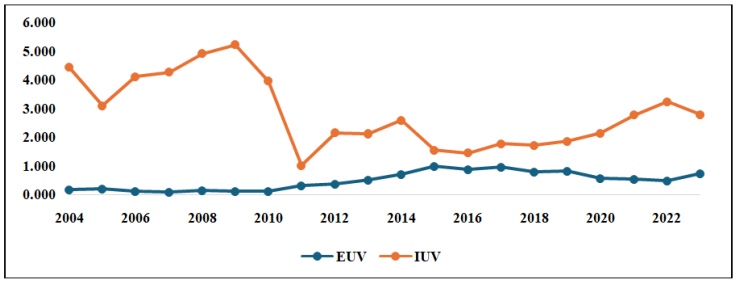

Fig. 2. EUV and IUV of biofertilizers in India 2004-2023.

D. Descriptive statistics of EUV and IUV of Biofertilizers

The Table 2 provides key statistical measures for the Export Unit Value (EUV) and Import Unit Value (IUV) of biofertilizers in India from 2004 to 2023. During this period, the mean EUV was 0.476, while the mean IUV was significantly higher at 2.855, indicating that biofertilizers were imported at much higher prices than they were exported. The standard deviation (SD) for EUV was 0.313, reflecting moderate variability in export prices, whereas the SD for IUV was 1.244, indicating greater fluctuations in import prices. The coefficient of variation (CV) for EUV was 65.802%, suggesting a high degree of relative variability in export prices, while the CV for IUV was 43.578%, showing that import prices, although still variable, were more stable relative to their mean. These statistics highlight the differences in price stability and levels between biofertilizers exports and imports during this time period.

Table 2: Descriptive statistics of EUV and IUV of biofertilizer.

Time period	Statistics	EUV	IUV
2004-2023	Mean	0.476	2.855
	SD	0.313	1.244
	CV	65.802	43.578

E. Correlation of RCA and EUV and IUV

The table 3 shows the correlation between India's Export Unit Value (EUV) and Import Unit Value (IUV) with its Revealed Comparative Advantage (RCA) in biofertilizers. A positive correlation of 0.666 between EUV and RCA suggests that as export prices increase, India's comparative advantage in biofertilizers tends to strengthen, indicating that higher export prices are generally beneficial for India's market position. In contrast, the negative correlation of -0.527 between IUV and RCA implies that rising import prices are associated with a weakening of India's comparative advantage, potentially due to increased costs or competition that negatively impact the country's export competitiveness in biofertilizers.

Table 3: Correlation of RCA and EUV and IUV.

Time	EUV	IUV
RCA	0.666	-0.527

F. Markov Chain Analysis of India's Biofertilizers Export Patterns to Global Markets

Table 4 presents the Transitional Probability Matrix (TPM) for India's biofertilizers exports to various countries between 2004 and 2023. The diagonal elements in the matrix reflect the probability of each country maintaining its trade relationship with India over this period. For example, Nepal shows a high probability of 0.771, indicating a strong commitment to continuing biofertilizers imports from India. Similarly, the Maldives and Sri Lanka exhibit retention probabilities of 0.652 and 0.636, respectively, highlighting their consistent trade ties with India. However, the matrix also reveals the dynamics of market share shifts among these countries. For instance, the USA, with a diagonal probability of 0.49, shows a moderate level of stability, but also a significant likelihood of losing market share to other countries like Nepal (0.257) and Maldives (0.158). Conversely, China, with a perfect probability of 1, demonstrates absolute retention of its market share, indicating no competition from other countries in this period. On the other hand, Vietnam and Kenya show lower stability, with high probabilities of losing their market shares to competitors. The TPM analysis helps in understanding the stability and shifts in India's biofertilizers export markets, suggesting that while certain markets like Nepal and China are highly stable, others are more volatile, requiring targeted strategies to maintain or enhance India's export share. These findings are consistent with results reported by Khurana and Kumar (2022); Sathish Kumar *et al.* (2022).

Table 4: Transitional probability matrix of biofertilizer export from India to world (2004-2023).

Export Destinations	Nepal	Maldives	USA	Sri Lanka	Philippines	Malaysia	Japan	Kenya	China	Viet Nam	Others
Nepal	0.771	0	0	0.01	0	0.035	0.021	0.023	0.013	0	0.127
Maldives	0.017	0.652	0.044	0.001	0.005	0.005	0	0.01	0.003	0.037	0.225
USA	0.257	0.158	0.49	0	0	0	0.087	0	0.008	0	0
Sri Lanka	0	0	0	0.636	0	0	0	0	0	0.123	0.241
Philippines	0	0	0.096	0	0.217	0.21	0	0.353	0.017	0.106	0
Malaysia	0	0.384	0	0	0.428	0	0	0	0	0.188	0
Japan	0.716	0	0	0	0	0	0.284	0	0	0	0
Kenya	0	0	0.294	0	0.626	0	0	0.027	0.052	0	0
China	1	0	0	0	0	0	0	0	0	0	0
Viet Nam	0	0.935	0.051	0	0	0	0	0	0	0.013	0
Others	0	0.704	0	0	0	0	0	0	0	0	0.296

CONCLUSIONS

The present study on reveals significant insights into the evolving landscape of biofertilizers in India. The findings indicate a robust growth trajectory, particularly in liquid-based biofertilizers, which have seen remarkable expansion since their introduction in 2014. The production trends underscore India's commitment to sustainable agriculture, with both carrier-based and liquid-based biofertilizers contributing to this growth, albeit with different levels of stability and growth rates. The analysis of India's export competitiveness through

the Revealed Comparative Advantage (RCA) index highlights a fluctuating but generally positive trend, suggesting that India has managed to maintain a competitive edge in the global biofertilizer market despite facing challenges. The correlation between export unit values (EUV) and RCA indicates that higher export prices tend to strengthen India's comparative advantage, whereas rising import prices have a negative impact. The Transitional Probability Matrix (TPM) further elucidates the dynamics of India's biofertilizer export markets, revealing strong retention rates with key trading partners like Nepal, the Maldives, and Sri Lanka, but also highlighting potential vulnerabilities in markets like the USA and Kenya. China's absolute retention of market share indicates a significant area of strength, while other markets display varying degrees of stability.

Overall, the research concludes that while India's biofertilizer industry is on a growth path with promising export potential, it faces challenges related to market volatility and competition. Strategic efforts to stabilize and expand export markets, coupled with continued innovation in biofertilizer production, will be crucial for sustaining and enhancing India's position in the global biofertilizer market.

FUTURE SCOPE

Future research should focus on exploring the long-term sustainability of the biofertilizer industry in India, particularly in the context of evolving agricultural practices and environmental regulations. Additionally, studies could examine the impact of emerging technologies, such as precision agriculture and biotechnology, on biofertilizer production and application. Further investigation into the effectiveness of government policies and incentives aimed at promoting biofertilizer usage could also provide valuable insights. Expanding the analysis to include a broader range of export markets and competitor countries would enhance understanding of India's position in the global biofertilizer industry.

Acknowledgement. Special thanks are extended to the various government bodies and organizations that provided the necessary data for this study. The corresponding author also appreciates the contributions and insights from colleagues and peers during the preparation of this manuscript.

Conflict of Interest. None.

REFERENCES

Balassa, B. (1977). Revealed comparative advantage revisited: An analysis of relative export shares of the industrial countries, 1953-1971. *The Manchester School of Economic & Social Studies, 45*(4), 327-344.

Bharti, N., and Suryavanshi, M. (2021). Quality control and regulations of biofertilizers: Current scenario and future prospects. In Biofertilizers (pp. 133-141). Woodhead Publishing.

Cuddy, J. D. A., and Della Valle, P. A. (1978). Measuring the instability of time series data. *Oxford Bulletin of Economics and Statistics, 40*(1), 79–85.

Chittora, D., Meena, M., Barupal, T., Swapnil, P., & Sharma, K. (2020). Cyanobacteria as a source of biofertilizers for sustainable agriculture. *Biochemistry and Biophysics Reports, 22,* 100737.

Garcha, S. (2023). Present scenario: Status of the biofertilizer industry in India. In S. Kaur, V. Dwibedi, P. K. Sahu, & G. S. Kocher (Eds.), Metabolomics, proteomes and gene editing approaches in biofertilizer industry (pp. 21-36). Springer, Singapore.

Gujarati, D. N. (1988). Basic econometrics (International ed.). McGraw-Hill.

Khurana, A., and Kumar, V. (2022). Status of biofertilizers and organic fertilizers in India. *Centre for Science and Environment,* 32-48.

Ministry of Agriculture and Farmers Welfare, Government of India (2023). Final estimates of production of major crops.

Mordor Intelligence (2024). India Biofertilizer Market Size and Share Analysis - Growth Trends and Forecasts Up To 2029. Retrieved May 05, 2024, from https://www.mordorintelligence.com/industry-reports/india-biofertilizer-market

Patel, R., Maurya, R., Chaubey, C., Tiwari, H., and Pathak, D. K. (2023). Bio-fertilizers: Present status and future prospects in India, 97-100.

Sathish Kumar, M., Lad, Y. A., Mahera, A. B., and others. (2022). Biofertilizer production in India: Current status, classification and schemes. *International Journal of Chemical Sciences, 20*(3), 430.

Singh, S., Mor, V. S., Bhuker, A., Singh, G., Digamber, & Kumar, R. (2023). Analysing the impact of chemical and biofertilizer seed treatments on the quality of wheat (*Triticum aestivum* L.) seeds. *Biological Forum – An International Journal, 15*(10), 699-705.

Trade Map (2024). Retrieved June 29, 2024, from https://www.trademap.org

How to cite this article: Manojkumar Patil, Ajayakumar, Sagar, Suman L., B. Nandita and Priyanka V. (2024). Biofertilizers in India: Growth Patterns and Export Competitiveness. *Biological Forum – An International Journal, 16*(8): 256-261.