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Fertilizing the Future: Transitioning to Biofertilizers for Climate- Resilient Agriculture

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Abstract

This report examines the potential of biofertilizers as sustainable alternatives to chemical fertilizers in India, focusing on their role in promoting climate-resilient agriculture. Historically, chemical fertilizers have driven growth in India's agricultural sector, particularly following the Green Revolution. However, their extensive use has led to environmental degradation, soil fertility loss, and health risks due to chemical buildup in soil and water. Recognizing these issues, the Government of India has initiated policies like the PM-PRANAM Yojana, aiming to boost the use of biofertilizers, reduce dependency on chemical imports, and alleviate subsidy burdens.

Biofertilizers, composed of beneficial microorganisms, offer a sustainable solution by improving soil nutrient content and crop yields without harmful side effects. This report applies regression analysis to project future crop yields, revealing that biofertilizers could surpass chemical fertilizers in effectiveness and adoption by 2064, aligning with India’s goals for agricultural sustainability. Ultimately, this study advocates for the increased adoption of biofertilizers to secure long-term food production, enhance soil health, and support India's transition toward sustainable agricultural practices.

Introduction

According to the OEC, India is one of the largest importers of chemical fertilizers in the world followed by Brazil, the United States, and China respectively with total fertilizers worth 8 billion USD being imported in 2021. The average fertilizer application per hectare in India is about 145 kg, which is influenced by states like West Bengal which has a consumption of 122 kg/ha, Haryana 167kg/ha, Punjab 184 kg/ha, Uttar Pradesh and Uttarakhand 127 kg/ha, Andhra Pradesh 138 kg/ha and Tamil Nadu 112 kg/ha, and the remaining states have consumption per hector less than the overall average of 145 kg/ha (Arvind K. Shukla et al., 2022).

Long-term use of fertilizers and manure in excessive amounts may lead to a build-up of heavy metals in soil and plants and their presence in excessive amounts because these accumulate in soil and then bioaccumulate in plants and animals. Excessive use of urea is also a matter of concern as it is reported to lead to a rise in nitrate-linked groundwater pollution in India. Another concern is the transportation of phosphatic fertilizers by surface water flow which may increase the amount of phosphate in drinking water and rivers (Arvind K. Shukla et al., 2022). In addition to these detrimental effects, fertilizers are not doing their job at par. The boost that fertilizers gave to the Indian agroecosystem during and post of the Green Revolution has not been sustained to date. There has been a dip in the growth of food production with respect to the fertilizer being used. A yield of 12 kg on the application of 1 kg of nitrogen, phosphorus, and potassium (NPK) each in the 1960s has reduced to just 5 kg of yield. Similarly, nitrogen use efficiency (NUE) has reduced from 48% in the mid-1960s to 35% in 2018.

These situations lead us to ponder whether the reckless use of chemical fertilizers is really worth it. Are there any alternatives we can use instead of chemical fertilizers that will help the farmers and the country as a whole in maintaining and rather turning the downtrend of growth upside down? Are there any substitutes that will not harm the environment as much as chemical fertilizers and not lead to contamination of natural resources?

Amongst all the technological updates that the country can adopt one of the answers is the use of biofertilizers. Biofertilizers are biologically active products or microbial inoculants, which are definedas formulations containing one or more beneficial bacterial or fungal strains in convenient and affordable carrier materials. Biofertilizers contain microorganisms that promote growth by providing primary nutrients to the host plant as it creates an ecosystem inside the plant (Mazid and Taqi, 2014).

One of the main chemical fertilizers in Urea, the diamide of carbonic acid, is primarily used for the bloom growth of plants. The primary purpose of urea fertilizer is to supply nitrogen to plants, which encourages the growth of green leaves and gives plants a lush appearance. Urea also helps plants during the process of photosynthesis. Urea contains 46% of Nitrogen (N) and is the most concentratedsolid nitrogen fertilizer. Urea changes to ammonium carbonate which may temporarily cause a harmful local high pH in soil. To counter this, the sustainable option available to us is N-fixing biofertilizers like Rhizobium. Microbials like Rhizobium break down atmospheric nitrogen into compounds suitable for plants. Further, the decomposition of the plants and these bacteria results in the release of nitrogen in the free atmosphere again. Similarly, Azotobacter, another N-fixing biofertilizer results in increased nodulation, nitrogen fixation, and ultimately crop yield improvement (Aisha Sumbul et al., 2020).

Another compound fertilizer from NPK is phosphorus, which is also used in the form of DAP with nearly 18% nitrogen and 46% phosphorus. Phosphorus is instrumental in transforming energy from the sun, absorbed by plants, into food, fiber, and oil. It plays a vital role in photosynthesis, the breaking down of sugars, the transfer and storage of energy, cell division, cell enlargement, and the transfer of genetic information (Brett Harman, 2017). Excessive use of phosphorus causes increased growth of algae and large aquatic plants, which can result in decreased levels of dissolved oxygen. It causes eutrophication (a reduction of dissolved oxygen in water bodies caused by an increase of minerals and organic nutrients) of rivers and lakes. This reduced level of oxygen in water ends up suffocating aquatic life. High phosphorus levels can also cause algal blooms, which can create toxins that are dangerous to both human and animal health. Ammonium ions are also found to be toxic to aquatic life. Phosphate Solubilizing Biofertilizers (PSB) is an environmentally friendly approach to enhance yield. PSB improves the uptake of phosphate in various ways. The major means of absorbinginsoluble P compounds is the production of organic acids. India has abundant deposits of rock phosphate, which is not very enriched, PSB has the potential to utilize this resource also (Mazid and Taqi, 2014). Another microbial we have is Phosphate Solubilizing Microorganisms (PSM) which sometimes is known to produce plant growth hormones such as IAA, GA, etc. Apart from being sustainable and environmentally friendly, soluble phosphorus like PSM and PSB increases by 10-20%yield as it is also absorbed easily by plants (Mazid and Taqi, 2014).

The last component of compound fertilizer is potassium (K). Mobilizing the mixture of K into a suitable form for the plants by microorganisms such as Frateuria aurantia are K-solubilizing bacteria,which when used with other biofertilizers have no negative effects. Potassium has a significant role in boosting crop yields and crop quality overall, as well as strengthening plants' defenses against disease. Additionally, potassium shields the plant from the effects of cold or dry weather by bolstering its root system and avoiding wilting. There is no direct effect of uncontrolled use of K on plants, but this can indirectly affect overall plant nutrition as it may hinder plants from taking up other nutrients, especially metals like magnesium, iron, zinc, and calcium.

Many studies have suggested that biofertilizers are more effective when used along with chemical fertilizers. We in this study are trying to assess the individual potency of both types of fertilizers, chemical and bio, by assessing the output using each type. To reduce the exploitation of land in future India and increase the agro-output in the country for the burgeoning population, there are steps to be taken to maintain the health of the natural resources that affect agricultural production. We have seen numerous studies have shown that prolonged and heavy use of fertilizers has affected the soil health and water quality in many regions in India. Now the option in front of us lies in replenishing the lost nutrients and scaling up the output, without further damaging the environment for which the biofertilizers are assumed to be best because no negative effects are passed further by them. Even the Government of India is realizing the urgency of this change and is taking actions such as setting up the National Project on Development and Use of Biofertilizers (NPDB) during the Ninth Plan and rolling out policies like PM PRANAM yojana which is also discussed in this paper. These schemes stimulate the production of indigenous production of biofertilizers as they provide incentives for the saving of import expense of chemical fertilizers.

Literature Review

In 2021 agriculture contributed 20.2% to the country's Gross Value Added, and according to the census of 2011, 54.6% of the population engages in agricultural and related activities. Several schemes post-independence was formulated to promote the agricultural sector which resulted in massive growth in agricultural produce, which is seen through the total production of 52 million tonnes in 1951-52 to 258.21 million tonnes in 2018-19 and was projected to reach a mark of 296.65 million tonnes in 2021-22 (Annual Report, Department of Fertilizers, 2021-22). Events like the Green Revolution absolutely helped India achieve this milestone, as it increased food grain production by
5.6 times in the last seven decades making the agricultural sector a 23% contributor to the Gross Domestic Product (Arvind K. Shukla et al., 2022).

One of the reasons for the giant leap was the contribution of fertilizers in this sector. Fertilizers account for a 50% increase in India's food grain production. The consumption of fertilizers for agricultural use has grown 13 times in 2020 from 1970 (Arvind K. Shukla et al., 2022). The consumption of chemical fertilizers like Urea, and oxides of Potassium and Phosphate has cumulatively been approximately over 1452 lacs tonnes in the period between 2017-2022 (FAIDELHI, 2022). The total fertilizer market in India amounted to INR 5437 billion in 2018 and is
expected to reach 11,116 billion by 2024 with a CAGR of 12.3%. But this unscrupulous excessive use of chemical fertilizers has reduced the efficiency of these chemical fertilizers, mainly Nitrogen and Phosphorus resulting in contamination in soil and groundwater affecting areas like Punjab and Haryana the most. In the 1960s, a yield of 12 kg or more of cereal grains was obtained by applying 1 kilogram each of nitrogen, phosphorus, and potassium. This output, nevertheless, has since dropped to just 5 kg. This has led to a buildup of fertilizer nutrients in the soil and the possibility of environmental leakage (IMPRI, 2023). Nitrogen use efficiency (NUE) in crop production, the proportion of applied nitrogen (N) removed by the harvested yield of crops has declined from 48% in the mid-1960s, during the period of the Green Revolution, to 35% in 2018. Despite the fact that the maximum yield under saturating N input regimes has increased from the period 1961 to 2009 to the period 2010 to 2018, farmers in India still need to significantly improve crop and fertilizer N management by adopting technological innovations and

avoiding N application more than the need ofthe crops to achieve NUE closer to that observed in the regions like North America where NUE is recorded at 53% in 2018. (Bijay Singh, 2022)
To cater to the growing population of the country and to promote agricultural growth government ofIndia provides heavy subsidies for these chemical fertilizers to be used by farmers of the country as most of the fertilizers are imported. Urea being one of the most produced, imported, and used fertilizers in India receives significant subsidies from the government. The MRP of this fertilizer being set at Rs 5,628 per tonne for the last 9 years, has aided in the significant consumption of the chemical fertilizer (IMPRI, 2023). The subsidy burden on the government for fertilizers was at Rs.1.62 lac crores in 2021 and grew almost 39% to 2.25 lac crores in 2022-23.
To tackle these issues, the government rolled out the PM-PRANAM (Promotion of Alternate Nutrients for Agriculture Management Yojana) scheme to boost the indigenous production of biofertilizers and lessen the subsidy burden of the government. These are the two main aims of the scheme, which will induce production within the country under the Aatmanirbhar Bharat agenda andlessen the imports of chemical fertilizers which will lead to the enhancement of soil health and productivity of total agricultural output.
Biofertilizers are products that contain living microorganisms, which through various mechanisms exert direct or indirect beneficial effects on plant growth and crop yield. Under the Essential Commodities Act, 1955, the Indian government has defined "biofertilizer" in the legislation and established an appropriate regulatory framework. It is attempting to encourage the use of biofertilizersby encouraging cooperatives and research institutions to distribute biofertilizers, encouraging public awareness-raising demonstrations carried out by India's extensive agri-extension network, financially supporting biofertilizer-producing units, subsidizing prices, and promoting public-policy initiatives to encourage the production of biofertilizers (K V Praveen et al., 2019). Biofertilizer production grew from about 2,000 tonnes in 1992 to 6,000 tonnes in 2000, at a CAGR of 11.46%; 37,000 tonnes in
2010 at 18.51% CAGR; and 1,39,000 tonnes in 2016 at 30.16% CAGR. The application of biofertilizer increased average output by 1.59 tonnes per hectare. The maximum yield enhancementwas achieved (2.25 tonnes per ha) when nitrogen fixers and phosphate solubilizers were applied together. Nitrogen fixers came in second (2.05 tonnes per ha), followed by phosphate solubilizers (1.15 tonnes per ha), and VAM (0.82 tonnes per ha). Additionally, by fixing nitrogen, phosphating soil, and solubilizing potassium and phosphate, biofertilizers can sustain soil health in terms of all sorts of micro- and macronutrients (Sai Madhav Elisetty, 2020).

Objective

The primary objective of this study is to assess the potential of biofertilizers as sustainable alternatives to chemical fertilizers in enhancing crop yields and supporting climate-resilient agriculture in India. This includes evaluating the effectiveness of biofertilizers in improving crop productivity compared to traditional fertilizers and analyzing their environmental benefits, particularly in mitigating soil degradation, pollution, and nutrient runoff. Additionally, the study explores the economic implications of widespread biofertilizer adoption, with a focus on reducing government spending on subsidies and decreasing dependency on imported fertilizers. Finally, the study aims to support policy recommendations, particularly for initiatives like the PM-PRANAM Yojana, to encourage the adoption of biofertilizers and sustainable agricultural practices across India.

Hypothesis

Null Hypothesis (H0): Biofertilizers will not surpass chemical fertilizers as the primary fertilization method in the future.

Alternate Hypothesis (H1): Biofertilizers will surpass chemical fertilizers as the primary fertilization method in the future.

Data and Methodology

The data is collected from various reports on the consumption and utilization of chemical fertilizers and biofertilizers. The reports include Biofertilizer Statistics and Fertilizer Statistics reports by the Fertilizer Association of India (FAI). Data is also collected from the Fertilizer Report by the Ministryof Statistics and Programme Implementation. The limitation faced by us while collecting data entails not getting information on the exact number of biofertilizers used in the country. This limitation has been overcome by substituting the dispatched amount of biofertilizers as the amount consumed at ground zero.

The method used to analyze data is Regression analysis. Regression analysis enables us to study the future growth in the output of cereals and pulses produced in India. This is done using the consumption of biofertilizers and NPK fertilizers at the current pace, which is measured through Compound annual growth rate (CAGR), as inputs. The study discusses the decreasing usage of NPK fertilizers with respect to the current CAGR and the increasing usage of biofertilizers with respect to the current CAGR. Data collected is from 1950-51 which tells us the total output of cereals and pulsesand area used for cultivation. However, the comparison of yield from biofertilizers and chemical fertilizers is done from 2001-02 because of the lack of availability of data before 2001. Further, data ismanipulated to give more insights into the growing use of biofertilizers from 2001 to 2021.

Data Analysis

We have used the Fertilizer Report by the Ministry of Statistics and Programme Implementation to collect data on the consumption of cereals and pulses over the years in India. This report also containsthe total area cultivated in India from 1950-51. The data in the report is bifurcated into the type of plants produced, such as pulses, cereals, vegetables, etc. We are choosing pulses and cereals for our study, assuming these are the most important types of foods for sustenance. India will have to increasethe production of these food grains to cater to the rising population.

We have conducted the analysis in two parts. In the first part, the regression model is made using inputs- total consumption of NPK fertilizers and Biofertilizers dispatched, as this is taken as a proxy for the total consumption of biofertilizers, for 2022 to 2100 using data from 2001 to 2021 as trainingdata. We then studied the difference in the CAGR between two periods, first with the majority use ofNPK fertilizers and second period with the majority use of biofertilizers. This is decided by the difference between the consumption of NPK fertilizers and biofertilizers over the years which are forecasted using CAGR. The period where the difference is positive is the period where the use of NPK fertilizers is more compared to biofertilizers. The period where the difference is negative is theperiod where the use of biofertilizers is more compared to NPK fertilizers.

Similarly, in the second part of the analysis inputs taken under consideration are the total consumptionof NPK fertilizers and Biofertilizers dispatched, and the total land used to cultivate cereal and pulses from 2001 to 2021. The rest of the process of analysis remains the same for this part. This analysis was divided into two parts to study the effect of total land used to cultivate cereal and pulses and if it increases the R^2

value.

Year	Total cereals(1)	Total pulses (incl.gram)(2)	**Total Output(3) {(1)+(2)}**
2000-01	1,85,739	11,076	**196815.00**
2001-02	1,99,483	13,368	**212851.00**
2002-03	1,63,646	11,125	**174771.00**
2003-04	1,98,280	14,910	**213190.00**
2004-05	1,85,230	13,130	**198360.00**
2005-06	1,95,220	13,380	**208600.00**
2006-07	2,03,080	14,200	**217280.00**
2007-08	2,16,010	14,760	**230770.00**
2008-09	2,19,900	14,570	**234470.00**
2009-10	2,03,450	14,660	**218110.00**
2010-11	2,26,250	18,240	**244490.00**
2011-12	2,42,200	17,090	**259290.00**
2012-13	2,38,790	18,340	**257130.00**
2013-14	2,45,790	19,257	**265047.00**
2014-15	2,34,871	17,154	**252025.00**
2015-16	2,35,218	16,323	**251541.00**
2016-17	2,51,981	23,131	**275112.00**
2017-18	2,59,597	25,416	**285013.00**
2018-19	2,63,133	22,076	**285209.00**
2019-20	2,74,479	23,025	**297504.00**
2020-21 (P)	2,85,279	25,463	**310742.00**
2021-22 (P)	2,88,030	27,690	**315720.00**
CAGR	**1.76%**	**3.53%**	**1.90%**

Table 1: Total Production of cereals and pulses and their CAGR

We have seen steady growth in the total output of cereals with a compound annual growth rate (CAGR) of 1.76% and 2,88,030 thousand tons of production in 2021-22. Pulses have shown a 3.53% CAGR from 2001 to 2021 with 27,690 thousand tons of output in 2021-22. Combining both, 3,15,720thousand tons of pulses and cereals were produced in 2021-22 with a CAGR of 1.9% (Table 1).

Table 2 shows the total consumption of fertilizers including biofertilizers and NPK fertilizers. Further,we can see that throughout the decade consumption of NPK fertilizers has been above 99%, but in 2021 a decline is visible compared to 2001 which is compensated by biofertilizers which were a mere 0.0485% of total fertilizer consumption in 2001 and grew to 0.565% in 2021.

Year	Total Fert Consumption in India (in tons) {(3)+(4)}	% Consumption of N+P2O5+K2O	% Consumption of Biofertilizers
2000-01			
2001-02	1,73,68,129.0	99.9515%	0.0485%
2002-03	1,61,01,130.0	99.9563%	0.0437%
2003-04	1,68,07,457.0	99.9503%	0.0497%
2004-05	1,84,08,828.0	99.9434%	0.0566%
2005-06	2,03,51,658.0	99.9442%	0.0558%
2006-07	2,16,66,745.0	99.9273%	0.0727%
2007-08	2,25,93,531.0	99.8963%	0.1037%
2008-09	2,49,36,178.0	99.8922%	0.1078%
2009-10	2,65,11,754.0	99.9044%	0.0956%
2010-11	2,81,60,200.0	99.8651%	0.1349%
2011-12	2,78,30,000.0	99.8563%	0.1437%
2012-13	2,55,83,000.0	99.8171%	0.1829%
2013-14	2,45,47,900.0	99.7332%	0.2668%
2014-15	2,56,61,900.0	99.6859%	0.3141%
2015-16	2,68,40,600.0	99.6721%	0.3279%
2016-17	2,60,59,900.0	99.5779%	0.4221%
2017-18	2,67,13,400.0	99.5508%	0.4492%
2018-19	2,73,01,500.0	99.7315%	0.2685%
2019-20	2,94,49,800.0	99.7304%	0.2696%
2020-21 (P)	3,27,27,900.0	99.4124%	0.5876%
2021-22 (P)	2,99,65,600.0	99.4350%	0.5650%

Table 2: Total consumption of fertilizers including biofertilizers and NPK fertilizers

For the analysis, we have taken the consumption of NPK fertilizers and biofertilizers asinputs to formulate a regression model to forecast the output of cereals and pulses. The inputs beyond2021 are compounded with respective CAGRs and then put into the regression model to find the output. Table 3 shows the year-on-year consumption of NPK fertilizers and Biofertilizers with a CAGR of 2.61% and 16.8% respectively. Using this data as input and Total Output from Table 1 as output we performed a regression test with Multiple R showing a strong correlation of 0.922. The strong correlation resulted in a higher R^2 value of 85.047% which means that the model could be deployed to forecast the required parameter.

Year	*Total ($N+P_2O_5+K_2O$)*	*Biofert. Despatches(Tonnes)*
2000-01	16702300.00	0.00
2001-02	17359700.00	8429.00
2002-03	16094100.00	7030.00
2003-04	16799100.00	8357.00
2004-05	18398400.00	10428.00
2005-06	20340300.00	11358.00

2006-07	21651000.00	15745.00
2007-08	22570100.00	23431.00
2008-09	24909300.00	26878.00
2009-10	26486400.00	25354.00
2010-11	28122200.00	38000.00
2011-12	27790000.00	40000.00
2012-13	25536200.00	46800.00
2013-14	24482400.00	65500.00
2014-15	25581300.00	80600.00
2015-16	26752600.00	88000.00
2016-17	25949900.00	110000.00
2017-18	26593400.00	120000.00
2018-19	27228200.00	73300.00
2019-20	29370400.00	79400.00
2020-21 (P)	32535600.00	192300.00
2021-22 (P)	29796300.00	169300.00
CAGR	**2.74%**	**16.18%**

Table 3: Year-on-year consumption of NPK fertilizersand Biofertilizers (in tonnes)

Upon performing regression analysis, we got the p-value of 1.33E-09 signifying that there is asignificant impact made by the inputs on the output. We get the following regression equation:

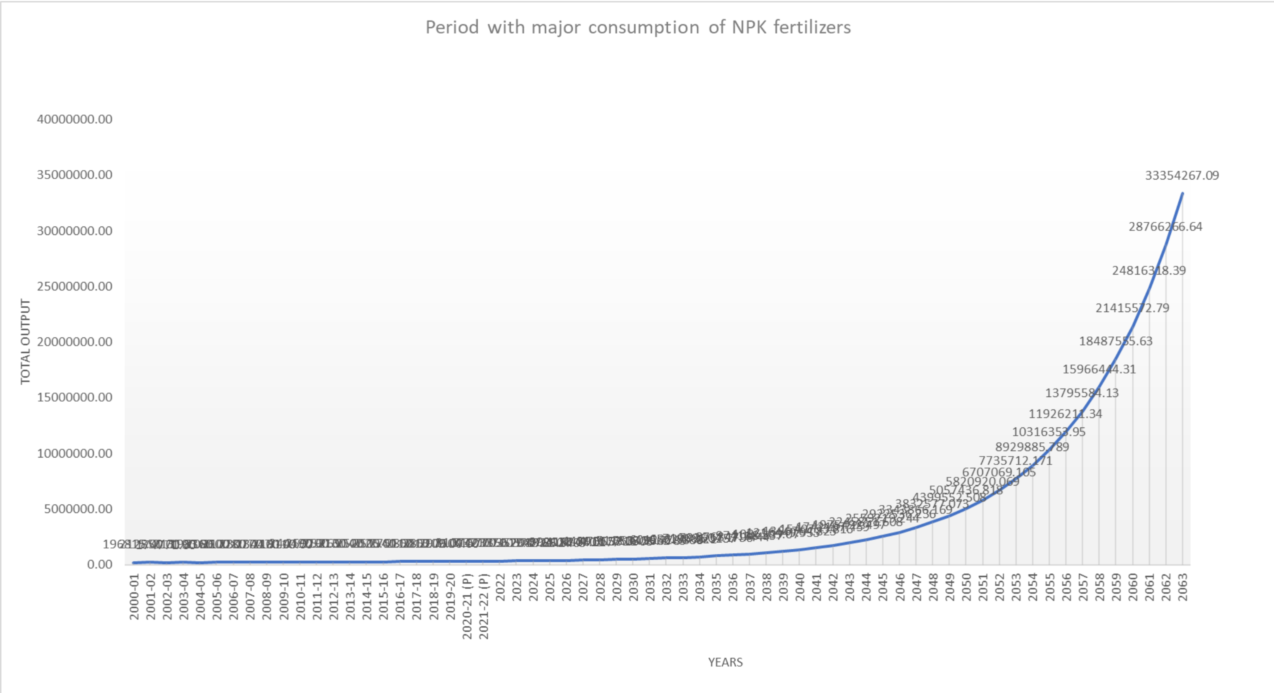
Regression Equation	13084.1018+X1*0.003893254+X2*0.377420256

b_0	130384.1018
b_1	0.003893254
b_2	0.377420256

On compounding consumption of NPK fertilizers and Biofertilizers with a CAGR of 2.74% and 16.8% respectively to ascertain inputs after 2021, we get that till 2063 chemical fertilizers will be used majorly, and from 2064 the use of biofertilizers will be major. Using the regression equation, wecalculated the output for each year till 2100. This period of 100 years was divided into two parts. Thefirst part starts in 2001 and lasts till 2063 denoting the period with major use of NPK fertilizers and the second part starts from 2064 to 2100 denoting the period with major use of biofertilizers.

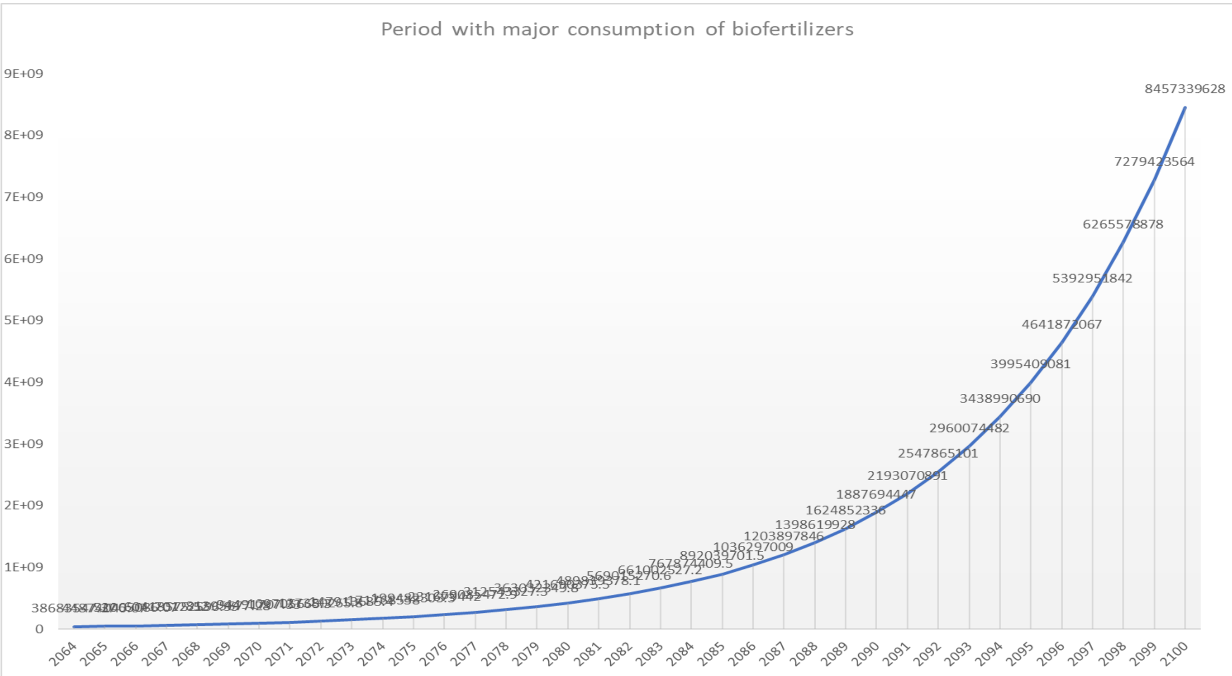
We calculated the CAGR of these two periods to assess the productivity of the two types of fertilizers.The total production of cereals and pulses in the period in which NPK fertilizers are majorly used, i.e.,2063, is assumed to be driven by the heavy use of chemical fertilizers. And vice versa, the total production of cereals and pulses in the period in which biofertilizers are majorly used, i.e., post-2063 till 2100, is assumed to be driven by the heavy use of biofertilizers. The CAGRs thus calculated are compared to assess which period had the most output hence suggesting the productivity of the type of fertilizer.

2001-2063 witnesses a CAGR of 8.488% in the total production of cereals and pulses. Graph 1 showsthe exponential increase in the output.



Graph 1: Period with major consumption of NPK fertilizers

From 2064 biofertilizers take over NPK fertilizers as a majorly used type of fertilizer. The period from 2064 till 2100 shows a CAGR of 15.67% and the curve when plotted on the graph with time on the X-axis shows an exponential trend (Graph 2).



Graph 2: Period with major consumption of biofertilizers

Interpretation

From the given analysis we have seen that second periods in both the scenarios yield higher CAGR where we assume that the output is driven by biofertilizers. This CAGR is very slightly affected by the factor area under cultivation due to which the CAGR changes from 15.67% in the first scenario to15.66% in the second scenario. The output of agriculture indeed depends on various factors such as irrigation and soil type etc., but the output has been heavily aided using fertilizers from the times of the green revolution. The journey of the usage of fertilizers started with chemical fertilizers such as NPK, but we can see that there is a subtle shift taking place in the 21st century. We saw how the CAGR of biofertilizers was more than the chemical fertilizers at the start of the century. But this growth rate is going to take time to completely take over the use of biofertilizers. India is going to be the world's most populous country and it will have to cater to this population financially and health- wise. A shift to biofertilizers might help in this as we calculated that at the given growth rate biofertilizers will have higher output. The introduction of the PM PRANAM yojana will aid the causein three ways, firstly by promoting indigenous biofertilizers, this will give the home market a chance and place to be competitive in terms of their products thus benefitting agricultural output as well as the market of biofertilizers. Secondly, it will lessen the subsidy burden on the government. The government spends thousands of crores in the form of subsidies to cater to farmers who cannot affordimported fertilizers and account for the majority of the farmers in India. Lastly, which is an importantfront to work on, PM PRANAM yojana might help in improving the soil quality which in turn will increase the output. Years of heavy usage of chemical fertilizers have damaged the soil in India.

Various parts of India have been contaminated by different chemicals passed on through the excessiveuse of chemical fertilizers. PM PANAM yojana could change this scenario as the states are promised 50% of the savings done by the state by not importing fertilizers, which incentivizes them to build a conducive environment for the biofertilizer industry, which will increase the usage of biofertilizers and in turn will improve the soil health as there will be less chemical used to add to the contamination.

Suggestion

In this paper, we have shown the growth of all the inputs taken into consideration including the usage of biofertilizers, the area under cultivation of cereals and pulses, and even the usage of NPK fertilizers. To make our argument valid we have shown the growth of each input compounding by the CAGR of the data available to train the regression model, which is all the data available from 2001 to 2021. The problem with the current situation in India is the excessive usage of chemical fertilizers, and in the long run, India needs to think about reducing the usage of chemical fertilizers instead, thesechemical fertilizers should be compensated by the usage of biofertilizers only then India will be able to see sustainable change in the health of the soil and the agricultural output. Another challenge India is facing is constraints on the land used for agricultural activities. The growing population needs to befed and to feed the population food should be produced, India is running out of place to increase its agricultural activities which could help India increase its agricultural output. This constraint makes it more important to increase the efficiency of the fertilizers and the soil to give the desired output. Indiais soon to become the most populous country in the world, this will mean it will have more mouths to feed. The agricultural output is not aligned with the increase in population according to this study serials and pulses are growing at the CAGR of 0.06% and 1.25%. At this growth rate, India will take 80 years more that is in the year 2100 India will reach the mark of producing 6 billion tons of agricultural output in terms of serials and pulses. But India needs to produce

a similar amount in far less time by 2050 it is estimated the population will touch 1.7 billion and feeding this many people will be an issue for India. For this reason, there is a need to increase the agricultural output by
increasing the efficiency of the procedure and the equipment and inputs used in agriculture. For thesame, one of the major steps could be improving soil health by reducing the usage of chemical fertilizers to 0.

Conclusion

Regression analysis of the data reveals that the output produced by the biofertilizers is more as per the CAGR calculated for the period after 2063. Productive analysis done tells that rolling out of PM PRANAM yojana could be a strategic move for India in terms of self-reliance and greater agriculturaloutput. PM PANAM yojana gives a three-pronged advantage which ranges from economical to ecological benefits. These benefits include the promotion of the local market for biofertilizers, decreasing the subsidy burden of the government, and improvement in soil health.

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