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Review

Commercialization prospects of microbial and Soil microbial formulation in Indonesia in agriculture

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Commercialization of microbial products is the final of a series of integrated research. This project started from the laboratories research, semi-field (greenhouse) to the field, and factory scale. The research procedures should be reached, to maintain of the microbial products quality. This paper elevates the status and prospects of commercialization of microbial products for agriculture that can be developed and marketed, including the microbes that are active in the supply of nutrients, produce of plant growth promoting and as a pest controller. Technology of microbial commercialization includes of: discovery, strain development, greenhouse and field testing, formulation and application of products, regulatory, consumer response and market share. An economical aspect of the soil microbial technology by referring to identification and quantification of the cost of research, time required, price, market share and return on investment.

Keywords: commercialization, microbial formulations, prospects, agriculture

INTRODUCTION

The Advancement in the field of agricultural biotechnology is preceded with the high attention to the beneficial microbes for plants as well as environmental arrangement. Bacteria, fungi, microalgae and even viruses have been widely studied and to be improved the potential its usefulness to improve yields.

In conventional farming, farmers still use chemical fertilizers and pesticides to increase production and control of pests and plant diseases. It should be made aware that the activity was often leaves a residue that can harm the environment and human health. The use of chemical fertilizers and pesticides excessively and continuously in intensive farming is very harmful, because it can cause a decrease in the biological life in the soil. Various studies indicate that land intensive agriculture has experienced declining productivity and land degradation, primarily associated with very low C-organic content in the soil, which is < 2 %, even in many intensive paddy fields in Java Island implies < 1 % (Sulistyowati, 2002). To obtain optimum productivity needed C-organic > 2.5 %. It is ironic, if in our country as the wet tropical countries that have abundant sources of organic matter, but have not been able to use it optimally.

Organic farming is growing in line with the emergence of awareness of the importance of preserving the environment and the need for more food that is relatively healthy. In organic farming that do not use chemicals matter such as artificial chemical fertilizers and pesticides, so that the biological agents such as bio-fertilizer, bio-pesticides and bio-decomposer to be one alternative which can be considered (Sumarno and Hasanuddin dan, 2007). Biological agents has several advantages, among them; safe for the environment and human health, not damage the soil ecosystem, soil microbes and do not turn off natural predators, and no accumulated harmful materials on agricultural products. In addition, biological agents can be produced by the method is simple and low cost. Continuity of production of biological agents can be maintained, because the microbes as a producer and the base material for the production media available naturally.

The success at the level on biotechnology research that seeks to improve of effectiveness of microbial capabilities make this activity evolved towards commercialization. Of course this is not an easy trip activities, technological and economic challenges in the market need to be combined to achieve success. Mastery of technology to manufacture, formulation and storage must be able to assure the survival and activity of microbial (Prihastuti dan, 2012). Furthermore, can the resulting microbial products to compete with synthetic

Table 1 The International institutions that provide of microbial isolates.

Abbreviation	Institution name	States
ATCC	*American Type Culture Collection*	Rockville, MD, US
CBS	*Centraalbureau voor Schimmenl Culturen*	Baarn, The Netherlands
CDDA	*Canadian Department of Agriculture*	Ottawa, Canada
CMI	*Commonwealth Mycological Institute*	Kew, United Kingdom
FAT	*Faculty of Agriculture, Tokyo University*	Tokyo, Japan
IAM	*Institute of Applied Microbiology, University of Tokyo*	Tokyo, Japan
NCIB	*National Collection of Industrial Bacteria*	Aberdeen, Scotland
NCTC	*National Collection of Type Cultures*	London, United Kingdom
NRRL	*Northern Regional Research Laboratory*	Peoria, IL, United States
PCC	*Pasteur Culture Collection*	Paris, France

Source: http://www.google.co.id

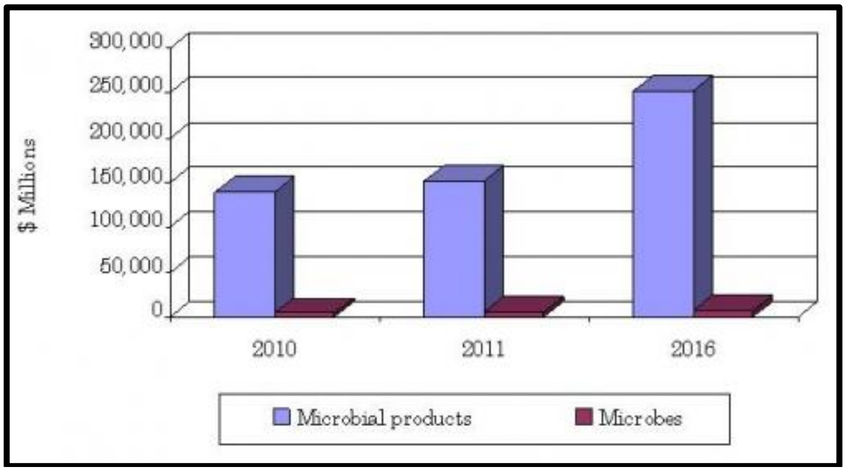

Figure 1. Trend of global market of microbes and microbial products in 2010-2016

materials that more widely available in the market and which have long been known by the user.

This paper aims to provide a brief overview of the status and prospects of commercialization of soil microbes in agriculture, including production technology to face the challenges in its development. To complete the exposure, the results need to be shown some microbial products, both from within and outside the country.

Flows market of microbes and microbial products in agriculture

Many research to explore the types of microbes, not only aims to use, but also it will eventually lead to commercialization. Many international agencies engaged in the storage class and maintenance of microbes that are well structured (Table 1). Equipped with a catalog of the types of microbes that are available, these institutions serve the world in providing microbial isolates for many purposes, such as research, industrial processes or other purposes (BCC Research, 2012).

Different types of soil microbes useful in agriculture are found and developed. Soil microbial product that has the potential to be commercialized, among others: (1) microbial provider of plant nutrients, (2) a biological control agent, (3) plant growth promoting, and (4) active microbial in biodegradation and bioremediation (Hopkins and Dungait, 2010). Soil microbial sale value lies in its ability to increase crop productivity, either through improved soil properties, biotic control, or plant growth promoting (Sandhu et al., 2010). The market prospects of microbial type are quite large, as in line with the government's program in food self-sufficiency and environmental sustainability. On the world market too, the need for microbes and microbial products is increasing and expected to increase further in the coming years (Figure 1).

Table 2 shows the types of microbes that have the potential to be developed and commercialized. The different types of microbes that it requires researchers to be able to maintain and develop each type according to the character and its properties. Some researchers argue that to improve the ability to be integrated of multiple types of microbes in one form formulation. This

Table 2. Types of microbes that have the potential to be commercialized (Kuhad et al., 2008))

selling points of microbe	The types of microbes
Decomposers of organic matter	*Tricoderma, Fusarium, Bacillus, Streptomyces, Clostridium*
Symbiotic nitrogen-fixing	*Rhizobium, Bradyrhizobium, Frankia, Anabaena*
Non-symbiotic nitrogen-fixing	*Azotobacter, Beijerinckia,Aerobacter, Chlorobium, Nostoc*
Nitrogen mineralization	*Bacillus, Pseudomonas, Serratia*
Nitrification	*Nitrobacter, Nitrosomonas*
Denitrification	*Achromobacter, Pseudomonas*
Phosphate solubilization	*Azotobacter, Enterobacter, Bacillus, Aspergillus, Penicillium, Rhizoctonia, Trichoderma*
Sulphate transformer	*Desulfovibrio, Thiobacillus*
Iron transformer	*Ferribacterium, Leptothrix*
Producers of phytohormones	*Azotobacter, Azospirillum, Pseudomonas, Rhizobium, Bacillus, Flavobac-terium, Actinomyces, Nocardia, Fusarium, Gibberella, Aletrnaria, Penicillium*
Producers of siderophores	*Neurospora, Trichoderma, Agaricus, Fusarium, Penicillium,* ericoid mychhorhizae*, Nocardia, Pseudomonas, Bacillus, Aeromonas, Erwinia*
Biotic controls	*Pseudomonas, Bacillus, Streptomyces*

Table 3. Several commercial brands of bio fertilizer in Indonesia (Prihastuti, 2008)

trademarks	biological components	Producer
M-Bio	P solubilizing bacterial, *Lactobacillus* sp, yeast and *Azospirillum*	PT. Hayati Lestari, Tasikmalaya
OST-Rajawali	*Azotobacter*, *Agrobacterium*, *Aspergillus*, *Azospirillum*, *Rhizobium*, Mychhorrhizae	PT. Rajawali Phara Jaya, Jakarta
ABG-Bios	Non-simbiotic nitrogen-fixing, and P solubilizing bacterial	ABG-Team, Bangkit Pertanian Organik Indonesia
Emas	*Azospirillum lipoverum*, *Azotobacter beijerinkii*, *Aeromonas punctata* and *Aspergillus niger*	PT. Bioindustri Nusantara, Purwakarta
Agrobost	*Indigenous* microbe, *Azotobacter*, *Azospirillum*, P solubilizing microbe, *Lactobacillus*, celulolitic microbe	CV. Agrindo Cipta Mandiri
Nodulin-Plus	*Azospirillum*, P solubilizing fungi	Balai Penelitian Bioteknologi Tanaman Pangan
Spora Jamur Mikoriza	Spore of mychhorhizae *Gigaspora margarita*	Pusat Penelitian Perkebunan Jember
Technofert 2000	vesicular-arbuscular mychhorhizae	BPP Teknologi, Serpong
Legin	Rhizobium	Fakultas Pertanian, UGM
Biofosfat	P solubilizing fungi *Aspergillus niger*	Fakultas Pertanian, UGM
Bio P2000Z	Celulolitic microbe, *Lactobacillus* sp, *Pseudomonas* sp, heterotrophic microbe, *Azotobacter* sp, yeast, *Streptomyces* sp	PT. Alam Lestari maju Indonesia
Effective-microorganisms	*Lactobacillus* sp, *Streptomyces* sp, yeast	PT. Songgolangit Persada, Jakarta

situation did support the needs of the market selling value microbes themselves. Formulation of microbes as biological fertilizer which has been widely commercialized already quite a lot (Table 3). May be in the market can realized to provide a form of efficient microbial formulation double in a package? Through better understanding of the nature and character of each isolate of microbes, it is possible only to provide a biological fertilizer containing many types of beneficial microbes in a package.

In addition to biological fertilizer, soil microbes are active in biodegradation of composting organic matter also had the potential to be commercialized. Table 4 shows some of the trademarks of bio-compost starter that is already familiar in the market. Starter of bio-compost is a biological product that is the main component of microbes (both bacterial and fungi) that are active in the degradation of organic matter composed of materials containing cellulose and lignin.

Utilization of microbes as bio-control agents has grown since a hundred years ago, but the development of products for controlling plant no familiar such as biological products other on the market. Beginning with the discovery activities of the entomopathogenic bacteria, fungi, viruses and nematodes are useful as bio-control agents (van Bruggen and Termorshuizen, 2003).

Table 4. Trademarks of bio-compost starter commercial

No.	Name of product	Producer
1.	Green Phosko (GP-1)	Jl. Pungkur 115 B, Bandung
2.	Starbio dan Stardec	PT. Lembah Hijau Multifarm, Solo
3.	Ragi Kompos	CV. Agro Mandiri Sejahtera, Klaten
4.	Agro Rama	CV. Prima Adi Perkasa, Bandung
5.	Ultradec	CV. Bumi Lestari Sejahtera, Surabaya
6.	Decomposer Andalan	PT. ACI, Jakarta Selatan
7.	Bio Super Active-decomposer	PT. Satya Jasa Caraka, Jakarta Selatan
8.	Superdec dan Orgadec	Balit Bioteknologi Perkebunan Indonesia, Bogor
9.	EM4	PT. Songgolangit Persada, Denpasar
10.	Bicom plus	PT. Bio Industri Nusantara, Bandung

Source: http:// www.google.co.id

Table 5. Several trademark of commercial biological control agents.

Trademarks	active material	agent control of
Bacillin WP	*Bacillus thuringiensis* variety Aizawai: 16.000 IU/mg	*Plutella xylostella* dan *Crocidolomia binotalis*
Bactospeine WP	*B. thuringiensis* Berliner variety Kurstaki serotype 3a/3b H. 14: 16.000 IU/mg	*Plutella xylostella*
Bactospeine ULV	*B.* B. *thuringgiensis* Berliner variety Kurstaki serotype 3A/3B strain H.14: 13.000 IU/mg.	*Plutella xylostella.*
C Condor WP	delta endotoxin from *B. thuringiensis* variety Krustaki starin EG 2348 : 10%.	*Plutella xylostella.*
C Costar OF	*B. thuringiensis* variety Kurstaki serotype 3a, 3b, strain SA 12: 36.000 IU/mg	*Plutella xylostella.*
. Cutlass WP	delta endotoxin from *B. thuringiensis* varietas Kurstaki strain EG 237: 10 %	*Plutella xylostella.*
. Delfin WDG	*B. thuringiensis* Berliner variety Kurstaki serotype 3a, 3b strain SA-11: 6,4%	*Spodopetra exigua*
. Dipel WP	*B. B. thuringiensis* varietas Kurstaki strain HD-7: 16.000 IU/mg	*Plutella xylostella* dan *Helicoverpa armigera*
Saco P	*Trichoderma koningii,* minimum 5.000.000 spore/g	*Fusarium* sp.
Ganodium P	*Gliocladium* spp. minimum 15 x 10^6 spore/g	Pe *Sclerotium rolfsii*

Source: http:// www.google.co.id

Several types of biological control agents that thrive in the local market are listed in Table 5. Resources for biological control of pests and plant diseases is an important potential alternative as a substitute for pesticides, and are often recommended to replace chemical based control measures against the disease or to control the disease if controlled with chemicals is not economical (Fravel, 2005). One consideration in choosing a form of biological control agent bio-pesticides are the ability to survive for a long time and it does not require special storage. Strategies for microbial strain selection criteria is based on the ability of colonization, competition, and adaptable in the growth environment (McQuilken et al., 1998).

The steps to commercializing of microbial products

Philosophical understanding of the soil object as a living part, can underlying to the microbiologists to development of the beneficial microbes in agriculture. Root zone (rhizosphere) is seen as a hotspot for soil microbial activity, both of which serve as a nutrient provider, producing organic compounds or other processes that affect plant life [12]. Rhizosphere as a growing environmental of microbial diversity is quite high, as a means media for the ongoing process of feedback effects of microbial activity on root development and plant growth on it (Lynch, 1990).
Figure 2 shows the position of soil microbes in the root system of plants. The presence of high species diversity implies the existence of competition for very high source of nutrition. Each of these different types of microbes will develop different strategies in order to survive, giving rise to various antagonistic synergistic interactions in conjunction with other microbes and plants (Perotto and Bonfante, 1997). Form of a very high diversity of these interactions can be assumed on the basis of the incredible diversity in relation microbes, soil and plants. Understanding the basics of this interaction is very

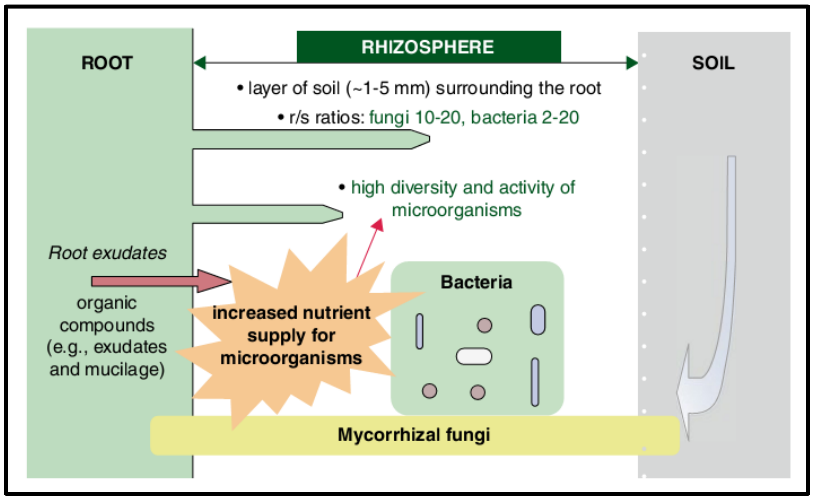

Figure 2. Soil microbes station in the root zone is as a liaison between plant and soil (Richardson et al., 2009)

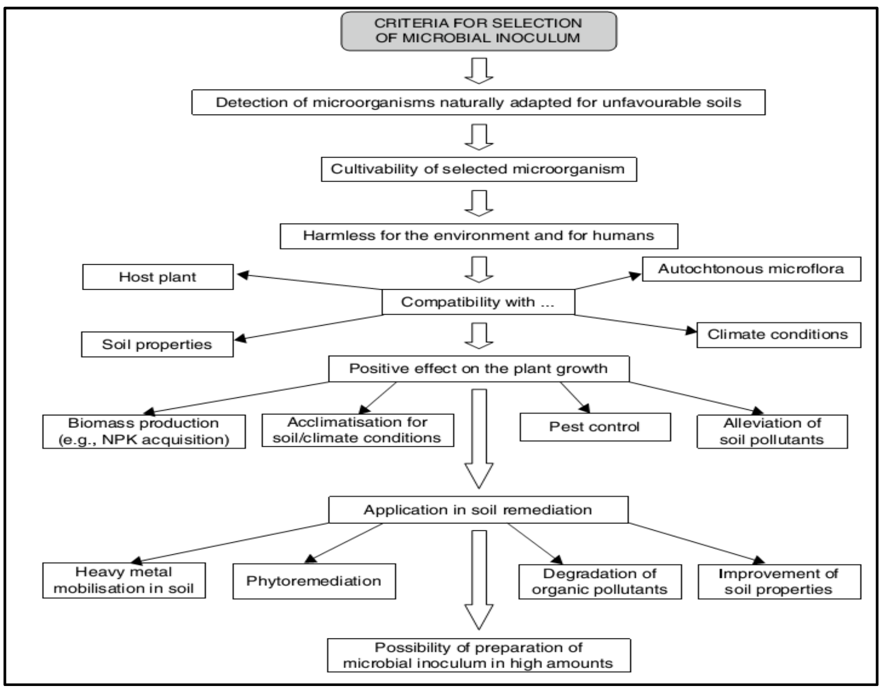

Figure 3. Selection activities of soil microbes (Hrynkiewicz and Baum, 2011)

important to be able to take advantage of soil microbial activity, which can support the success of the commercialization of microbial formulation products.

There are no the complexity of the soil microbial position in their natural environment, giving a picture that is not easy anyway to be able to maintain in the laboratory, to develop it as a useful product. The summary of steps to obtain of a beneficial soil microbes and expand it up can be a microbial product that has a selling value is as follows:

i. Discovery

It is a research activity for isolation, selection and identification of microbes from a variety of source. At this stage, the source of microbes taken from the ground on the plant roots, because of the existence of these positions is very high, either the density or diversity of species. The presence of fungi reached 10-20 times and the abundance of bacteria reach 2-20 times higher than at the rhizosphere other land that is not overgrown (Morgan et al., 2005). Laboratory scale test needs to be done to determine the activity and properties of its characteristics. Figure 3 gives an overview of early to get a beneficial soil microbial isolates in detail (Hrynkiewicz and Baum, 2011).

The phase of microbial discovered is an early stage and deciding to obtain microbial preparations in question in accordance with its intended purpose, including the type of microbes (bacteria, fungi, actinomycetes, yeast or other), microbial benefits (as a nutrient provider, bio-control, producing phytohormones, bioremediation or the other), the characteristics of microbes (living in symbiosis, solitaire, antagonistic, synergistic, or otherwise) and other properties either morphological or physiological.

ii. Development of microbial strains.

The microbial isolates that has been obtained and purify, tested of its capabilities and activities at the laboratory scale. If necessary, microbial isolates that has acquired enhanced through manipulation on laboratory conditions. The simple treatment can be done by mutation and selection, while the more modern way with genetic engineering.

In another case, the microbial inoculum must be economical to mass-produced, so it can be formulated into products cost-effective and easy to implement for the purpose of commercialization (Bashan, 1998). A microbial inoculum was strived for the public on the various types of plants and soil, so that its effectiveness should be relatively easier to be evaluated on a standard scale. All methodological level hierarchies are very important for use in detecting and controlling the interactions between plants and soil microbes are interlinked (Read, 2002).

iii. Testing field.

In order to assure the ability of selected microbes, need to be tested in the field or greenhouse. The principle underlying this activity is an understanding of the complexity of the interactions between plants, microbes and soil as a growth environment. In this case microbial activity assays performed on many treatments that range from soil type, dosage, and commodities to obtain diverse ecological conditions (Wenzel, 2009). Many reports suggest that microbes that have been selected and considered effective in the laboratory, as applied in the field may show different performance than expected (Quan et al., 2003 and Singer et al., 2005).

The possibility exists that the presence of selected microbes applied to the field, was not able to compete with indigenous microbes already present in the soil (Bouchez et al., 2000; Das and Mukherjee, 2007; Mohanty and dan, 2008). The efficiency of microbial performance is a function of the selected microbial ability that is applied to the field to remain active in the natural environment. Scaling up the process involving the interaction of plant-soil-microbe is one of the challenges that must be solved and very important to assess sustainable in the process of production and commercialization of microbial products in agriculture (Standing et al., 2007).

iv. Regulation and standardization.

In assembling products made from raw microbial biotechnology, in addition to quality test and product quality are preferred, also the introduction of market segments need to get attention, so that inventions created could potentially have a major market (captive market). For that we need a strategy to secure market of microbial products through the close link between producers and consumers (Goenadi, 2001).

Basically a biotechnological invention is an idea or a solution to a technical problem, which is very important to obtain legal protection before stepping into the commercialization stage. At this stage a further research is needed before it can be realized in the form of marketable products or processes that can be applied in commercial production. Further the research of microbial products provided benefits in determining the confidence of investors in the commercialization of the resulting technology and also the beliefs of users as consumers of these biological products.

In general, the microbial products require an integrated research to assess product characterization, toxicology testing, environmental impact and sales registers (Doraisamy et al., 2001). The beneficial microbial technology products need to be standardized quality, and accompanied by quality control agencies that have the competence (Saraswati and dan, 2008). Through efficacy trials, microbial products need to get a certificate worth, as well as synthetic chemical products. Government policy through the use of microbial products can be expected to evolve in the future. The use of microbial products is in line with the movement of environmentally friendly and sustainable agriculture, which has been promoted since the beginning of the XXI century.

Aspects of economic to develop microbial products

In fact there are microbes in the wild in an unlimited amount. It's so easy to get a useful source of microbes through isolation techniques and test activities. Microbe is small organisms (micron) with living systems that are simple, very easy to domesticate in a short amount of time anyway. Material of growing media and proliferation of microbes are also widely available naturally, to make a microbial cell proliferation media is cheaper than using synthetic materials.

An economically aspects of the use of microbial products in agriculture can be determined from the decrease in the use of chemical fertilizers and its positive impact on the environment to avoid chemical residues and bioaccumulation, or other environmental pollution. Several studies have shown a decrease in the use of chemical fertilizer P by 50 % and increase soybean yield 20-40 % on application of microbial fertilizers ***Multiguna*** (Saraswati and dan, 2008). Inoculation of biological fertilizer ***Illetrinut*** and N-fertilizer 25 kg/ha can improve dry peanut pods up to 50 % (Harsono et al., 2013).

The use of microbial decomposer of organic material has been widely used to speed up the process of decomposition of plant debris that contains lignin and cellulose to increase the organic matter content in the soil (Zimin et al., 2003). The use of ***M-Dec*** bio decomposer can speed up the composting straw to 12 days to reach the ratio C/N 17, which is usually achieved within two months (Saraswati and dan, 2008).

CONCLUSION

In an effort to support the creation of sustainable agricultural era, the use of soil microbes in agriculture greater to developed. Microbial activity in the rhizosphere contributes significantly to the sustainability of agriculture, through the provision of plant nutrients, production of phytohormones, bio-control and bioremediation agents to improve land that have been damaged. There is required a fundamental understanding of the complex microbial interactions in the rhizosphere and their impact on growth and yield of crops on it.

To continue prioritizing the objectives of microbes in agriculture, need to be developed towards commercialization of the products of the formulation of beneficial microbes. This activity begins with the discovery and development of microbial strains, microbial performance test on a field scale, scaling up microbial cell production and formulation of the product, as well as standardization. Commercialization of microbial formulations products in agriculture is prospective in supporting programs to improve productivity and maintenance of the agricultural environment.

Toward the realization of sustainable agricultural systems, the prospect of commercialization of microbes and microbial products in agricultural field is wide open. Accompanying the creation of these microbial products, hence the need for government's role in regulating the quality of the product to maintain the security and sustainability of production, and increase the confidence of farmers to use it.

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