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Prospects for Widespread Adoption of Organic-Based Fertilizers in the Philippines: A Rapid Appraisal

Roehlano M. Briones, Helena Luz C. Pastolero, and Ivory Myka R. Galang

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Abstract

Modern conventional agriculture has relied heavily on inorganic fertilizers to achieve higher crop yields. However, concerns have arisen regarding its ecological and economic sustainability, given its impact on soil health on-site, on pollutants off-site, and of recent bouts of soaring fertilizer prices. This paper reports on a rapid appraisal of the current state and potential expansion of organic fertilizer utilization and availability in the Philippines. The study finds that combining inorganic and organic-based fertilizers allows for a balanced realization of the advantages of each type. Policies and programs of the government do promote both organic agriculture and balanced fertilization, although the budget is strongly biased towards incentivizing farmer purchases of inorganic fertilizer. Policy implications of the study are: 1) Strengthen the NOAP by a) expanding the implementation of PGS and b) aggressively rolling out organic labeling of packaged organic produce; 2) Review the regulatory system and competition oversight for organic fertilizers and biofertilizers; 3) Adopt a phased repurposing of fertilizer subsidy by gradually shifting the allocation from inorganic fertilizer to organic fertilizers, biofertilizers, and area-based R&D to promote adaptive BFS, including soil mapping of all agricultural land in the country; 4) Beyond R&D, DA must invest heavily in extension to promote the widespread adoption of adaptive BFS; 5) Implement a value chain program for the development of the biofertilizer and organic fertilizer industry; 6) Anchor the value chain program on support for commercial networks of private corporations and capacitated FOs, and coordinated with the distribution of organic fertilizer and biofertilizer vouchers; and 7) Integrate value chain development of organic fertilizers and biofertilizers with development of the livestock, poultry, and agro-processing industry.

Keywords: sustainable agriculture, circular agriculture, biofertilizer, organic fertilizer, organic agriculture, integrated nutrient management

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Glossary

Biofertilizers - substances that contain living microorganisms that when applied to seeds, plant surfaces, or soil, colonize the rhizosphere or the interior of the plant and promote growth by increasing the supply or availability of nutrients to the host plant (DA MC 48, 2023, p.2).

Biostimulants – any substance or microorganism that when applied to plants or soil, it stimulates and enhances physiological processes, nutrient efficiency, abiotic stress tolerance and/or crop quality traits regardless of its nutrient content. Biostimulants can be categorized into: humic substances, protein hydrolysates, seaweed extracts, chitosan and other biopolymers, inorganic compounds and microbial inoculants (FPA, 2019, p.7).

Compost – any product in solid or liquid form, of plant (except by-products from petroleum industries) or animal origin, that has undergone substantial decomposition that can supply available nutrients to plants with a total Nitrogen (N), Phosphorus (P_2O_5) and Potassium (K_2O) of 2.5 or less than five percent (2.5-5%) (FPA, 2019, p.7).

Fortified Organic Fertilizer - any decomposed organic product of plant or animal origin is enriched/spiked with microbial inoculants, plant growth substances and/or chemical ingredients to increase its nutrient content to a minimum total N.P.K. of 8%. (FPA, 2019, p.7)

Microbial Inoculants - formulations containing select beneficial microorganisms, including nitrogen-fixing bacteria (e.g., Rhizobia), mycorrhizal fungi, or plant growth-promoting rhizobacteria (PGPR). These inoculants are applied to seeds, roots, or soil to establish beneficial microbial associations with plants. They enhance nutrient uptake, suppress soil-borne pathogens, and contribute to plant health and yield (DA MC 48, 2023, p.2).

Plant Growth Regulator - any organic or inorganic compound, natural or synthetic, which in low concentration promotes or modifies physiological response of the plants (FPA, 2019, p.9).

Raw Material - organic or inorganic materials used in the production of intermediate or finished fertilizer products. These include naturally-occurring and processed minerals such as guano, rock phosphate, potash, limestone, dolomite, peat, gypsum, and sulfur and intermediate materials such as superphosphate, phosphoric acid, sulfuric acid, ammonia, urea, ammonium sulfate and other deposits that are found in nature, mined and used in fertilizer production (FPA, 2019, p.9).

Soil Conditioner / Soil Amendment - organic or inorganic material, natural or synthetic, that is applied to the soil to modify certain soil physical properties, such as structure, moisture retaining capacity, shrinking and swelling capacity or resistance to crusting, and to improve soil chemical or biological conditions. Examples are polyelectrolytes such as complex vinyl and acrylic, gypsum, diatomaceous earth, vermiculite, perlite, and lime (FPA, 2019, p.9).

Prospects for Widespread Adoption of Organic-Based Fertilizers in the Philippines: A Rapid Appraisal

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1. Introduction

1.1. *Context and relevance of the study*

Modern conventional agriculture has relied heavily on chemical fertilizers to achieve higher crop yields. However, concerns have arisen regarding the sustainability of this practice, both from an ecological and economic standpoint. Under the second Sustainable Development Goals, one of the targets is to ensure sustainable food production systems and implement resilient agricultural practices. Organic-based fertilizer has long been recognized as integral to sustainable agriculture (Verma, Pramanik, and Bhaduri 2020).

Recently, the economic rationale has become salient. In 2021, the Philippines grappled with soaring inorganic fertilizer prices, notably urea, which peaked at nearly PHP 3,000 per sack in May 2022, almost triple its value in January 2021. The elevated cost of chemical fertilizers has spurred interest in alternatives, such as nature-based farming and the adoption of organic-based fertilizers. On the other hand, the Department of Agriculture (DA) has provided a massive amount of fertilizer subsidies to mitigate the impact of soaring fertilizer prices on food security. Most of these subsidies have gone to inorganic fertilizers. Although prices have since retreated to Php 1,500 – 1,600 per sack, the subsidy program persists, with fertilizer subsidies for rice production alone allocated a budget of PHP 9.6 billion in 2024.

1.2. *Policy issues*

Policymakers are therefore at a quandary: they need to respond to food security requirements of the country, while ensuring long term sustainability of farming, and maintaining fiscal discipline. Government policies reflect this mix of goals. They recognize the increased cost of applying inorganic fertilizers, which is deemed essential to maintain and increase yields. To protect farmer's income and ensure food security, government has therefore budgeted large subsidies that incentivize continued application of inorganic fertilizers.

At the same time, government has implemented many programs to promote organic-based fertilizers. A particular system of farming, known as organic agriculture, which is entirely free of inorganic fertilizers, is singled out for development and expansion under the Organic Agriculture Act of 2010 (RA 10068). The aim of the Act is to increase soil fertility, farm productivity, reduce pollution and environmental destruction, protect the health of farmers and consumers, and reduce reliance on imported farm inputs. Likewise, the Philippine Development Plan (PDP) 2023-2028 identifies unsustainable farming as a barrier to a modern agriculture and fisheries, with nature-based solutions as a remedial strategy.

The pursuit of the objectives in government laws and plans requires a realistic assessment of the prospects for widespread adoption of organic-based fertilizers. This assessment must take

into consideration the trade-offs from reducing or even foregoing inorganic fertilizers. A systematic way to inform this appraisal is to examine the demand and supply outlook for organic-based fertilizers, which in turn is the basis for framing the policy questions of this study.

1.3. *Policy questions*

The overall objective of the study is to undertake a rapid appraisal of the current state and potential expansion of organic fertilizer utilization and availability in the Philippines. It is motivated by the following policy questions:

- How widespread is the use of organic-based fertilizers in Philippine agriculture? What are key factors affecting adoption?
- What is the supply potential of the organic-based fertilizer value chain? What are the key factors affecting availability and affordability of organic fertilizer?
- What are the prospects for expanding organic-based fertilizer utilization among farmers in the Philippines?
- What are the major programs and policies that shape incentives and constraints towards organic-based fertilizer utilization and availability?
- What are the appropriate policy directions towards the development of organic-based fertilizer value chain?

1.4. *Organization of the paper*

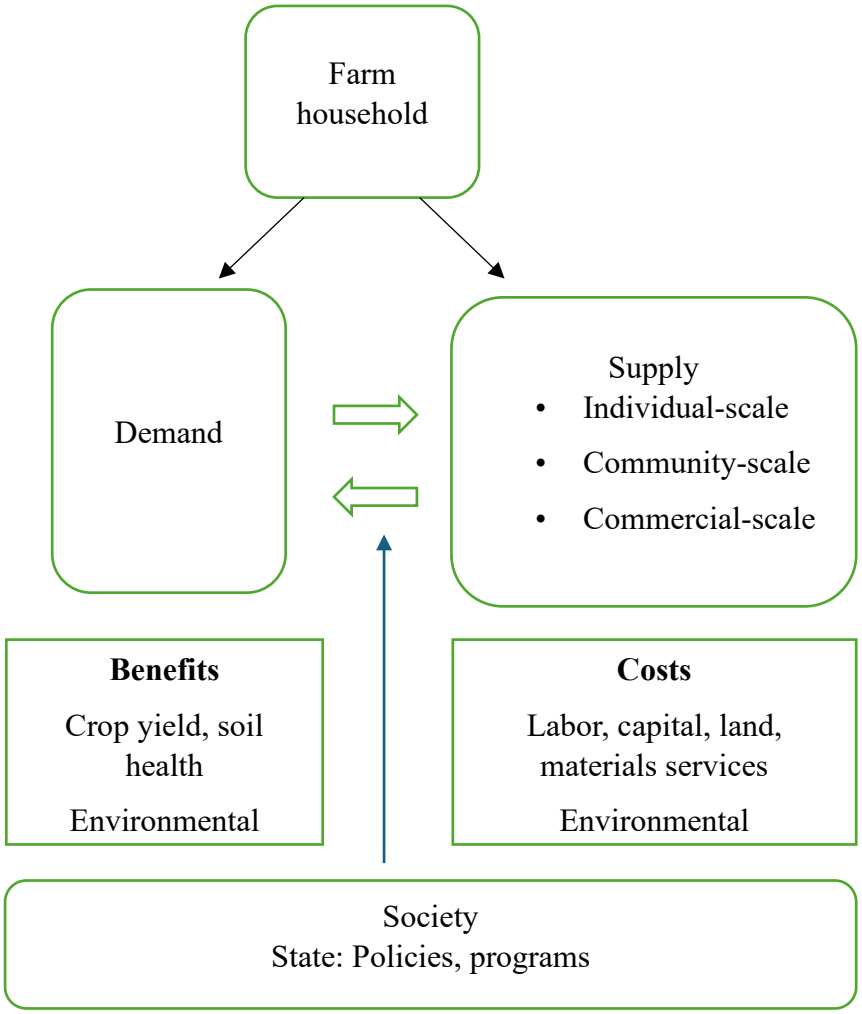
The remainder of this paper is organized as follows: Section 2 presents the method for addressing the policy questions, based on a coherent conceptual framework. Section 3 provides an overview of agricultural production and fertilizer utilization in the country. Sections 4 and 5 offer a comprehensive literature review, respectively covering agronomy and economics related to organic-based fertilizers. Section 6 summarizes the findings from fieldwork. Section 7 concludes and discusses policy directions.

2. Method of the study

2.1. *Demand and supply framework*

The extent and depth of adoption of organic-based fertilizers depends on both demand and supply factors (Figure 1). Demand is determined by prospective benefits of farm households from applying organic-based fertilizers on farms. Benefits from organic-based fertilizer takes the form of nutrients needed for plant growth, as well as conditioning of the soil to promote soil health. Meanwhile, supply of organic-based fertilizers is distinguished by scale of production: first is individual, where the farm household provides for its own organic-based fertilizers; second is community-scale, farmers produce organic-based fertilizers for their own use, as a group, i.e. at the community level; lastly, production can be done by a specialized enterprise, to market to non-members, typically spanning multiple communities, or even larger scales (e.g. nationwide).

Figure 1: Demand-supply framework for determining adoption of organic-based fertilizers



Source: Authors' representation.

The motivation for producing organic-based fertilizers depends on the scale of production. At the individual level, farm households seek greater profit from farm production, within the context of a utility-maximizing consumption unit. At the group level, community production of organic-based fertilizers are organized to meet group objectives. Lastly, production for the market is best described as an activity initiated and sustained by the profit motive.

Supply entails cost, pertaining to factors of production (labor, capital, and land), as well as raw materials (e.g. animal manure, crop residues), and services (e.g. for transport of materials). Farmers weight the benefits and costs of applying organic-based fertilizers, relative to costs and benefits of alternative methods, such as inorganic fertilizers.

Assessment of benefits and costs is also at the social level also considers off-site benefits and costs. Fertilizers (whether inorganic or organic-based) tend to leach nutrients into the soil and water bodies, and also emit greenhouse gases. The state is mandated to frame policies, regulations, and programs that balance costs and benefits of fertilizer use and production for

farmers and society in general. Examples of government programs are subsidies or in-kind transfers of fertilizers, as well as information and promotional efforts through agricultural extension, incentives to commercial producers, etc.

2.2. *The rapid appraisal method*

The rapid appraisal method uses desk review of relevant documents, as well as qualitative data collection from key informants, whether as individuals or as groups. The stakeholders to be covered in this rapid appraisal include actors across different production scales, i.e., individual-scale producers, commercial-scale producers, and community-scale producers, together with relevant government agencies, both at the national and local level.

To identify producers of organic-based fertilizers, an initial list of Farmer Organizations (FOs) is compiled from the listing of High Value Crops Development Program (HCVDP), National Organic Agriculture Program (NOAP), Bureau of Soils and Water Management (BSWM) of DA, Fertilizer and Pesticide Authority (FPA), Philippine Council for Agriculture and Fisheries (PCAF), and Cooperative Development Authority (CDA), of organic fertilizer users, which are usually organic agriculture producers. Municipalities with the highest number of listed FOs are identified for Luzon, Visayas, and Mindanao. Local government units (LGUs) who are willing to coordinate with the research team are identified from these municipalities, who are then requested to contact the listed FOs, as well as other FOs such as those who practice balanced fertilization (both organic and inorganic fertilizers), and even those who practice inorganic fertilizers, as basis for comparison.

Lastly, for commercial scale producers, the research team contacted fertilizer companies near the national capital region (NCR) and in Southern Tagalog (Region IV-A), based on a list of contacts from Fertilizer and Pesticide Authority (FPA), and from the University of the Philippines Los Baños (UPLB).

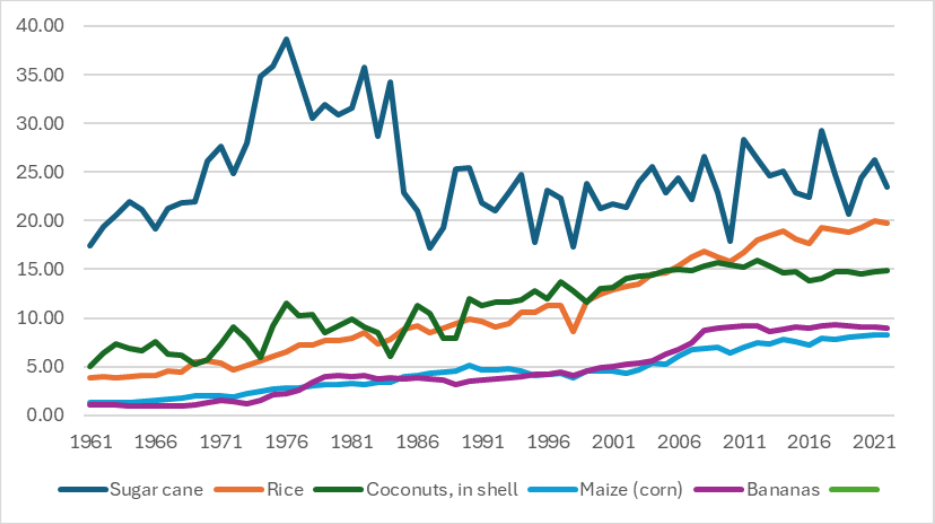
3. Organic-based fertilizers in the Philippines

3.1. *Trends*

Production of crops and application of fertilizers have grown inexorably over the past decades. Annual production of major crops in the Philippines has grown dramatically over time (Figure 2). Since 1961, rice production increased five-fold, while coconut production increased three-fold; maize production increased six-and-a-half times, while banana production increased nearly nine times. Sugarcane production though increased just 30 percent, as it started in 1961 at a high base of 19 million tons.

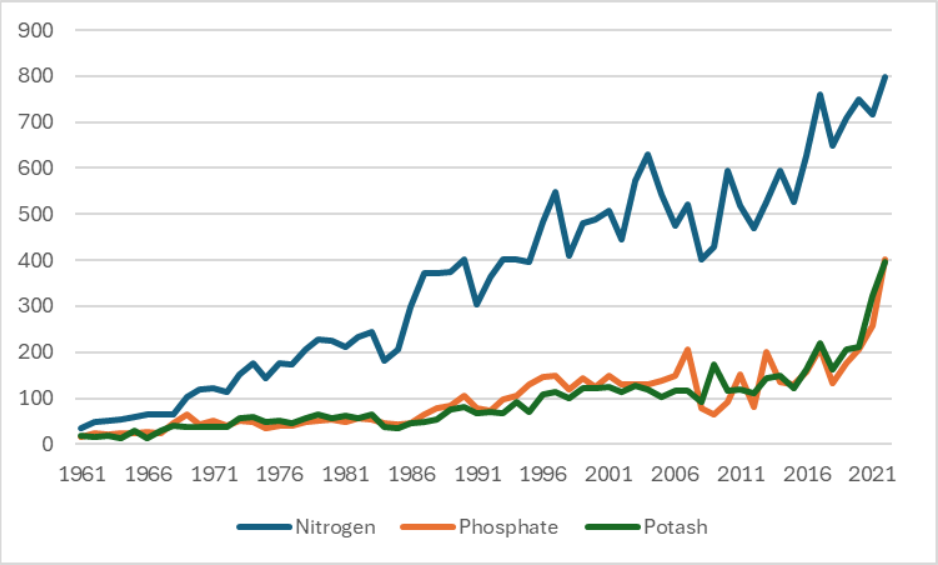
Over the same period, fertilizer use also increased many-fold; nutrient nitrogen increased 5.3 times between 1961 and 2022; nutrient phosphate increased 5.5 times; and nutrient potash increased 5.2 times. This translates to an average annual growth rate of 6.6 percent for nitrogen, 10.0 percent for phosphates, and 9.7 percent for potash. However, growth of fertilizer usage has been far from smooth; standard deviation of the growth rate of nitrogen is 2.6 times that of the mean, while that of phosphate is 3.3 times, and that of potash, 3.6 times.

Figure 2: Production of major crops in the Philippines, 2010 – 2023 ('000 tons)



Source: FAO (2024).

Figure 3: Fertilizer use by nutrient type, 1961-2022 (tons)

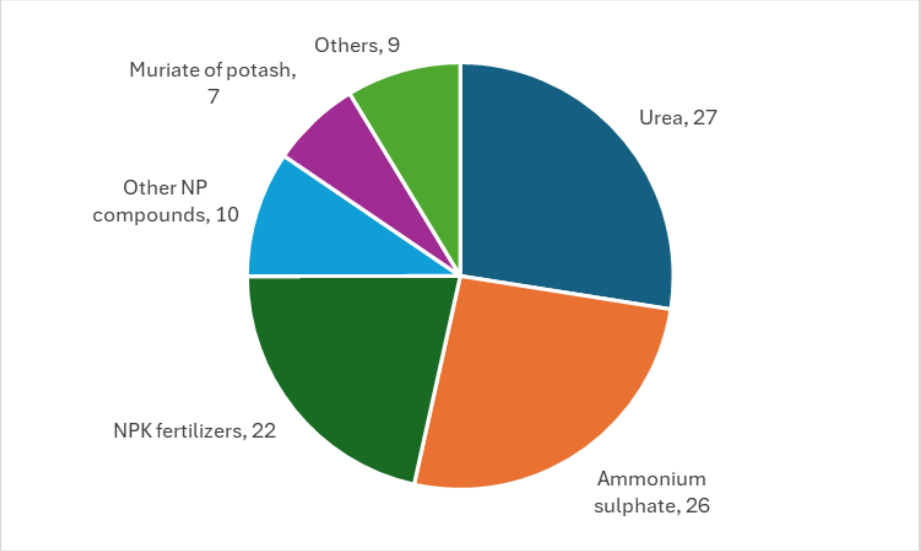


Source: FAO (2024).

The most commonly applied inorganic fertilizers are nitrogenous and complete fertilizers. The breakdown for fertilizer use by type is shown in Figure 4. The most common type of fertilizer applied is urea (46-0-0), followed closely by ammonium sulphate (21-0-0-24S). Complete fertilizers (such as 14-14-14) are also commonly applied. Muriate of potash (0-0-60) accounts for just 7 percent; other fertilizer grades account for the balance of 19 percent. This suggests that nitrogen is the most limiting factor in plant growth, requiring remedial application of nitrogenous fertilizer.

Rising use of mineral fertilizers, especially nitrogen fertilizers, was accompanied by declining application of manure fertilizer. This is confirmed by analysis of nitrogen balance for Philippine soils, conducted by FAO (2023). In the 1960s to 1980s, there were years in which nitrogen was being subtracted from the soil (Table 1). That is, nitrogen removal due to crops was 7 percent greater than nitrogen additions in 1961, and likewise in 1981.

Figure 4: Distribution of total fertilizers applied, Philippines, 2022 (%)



Source: FAO (2024).

Table 1: Nitrogen balance indicators, Philippines, 1961 - 2021

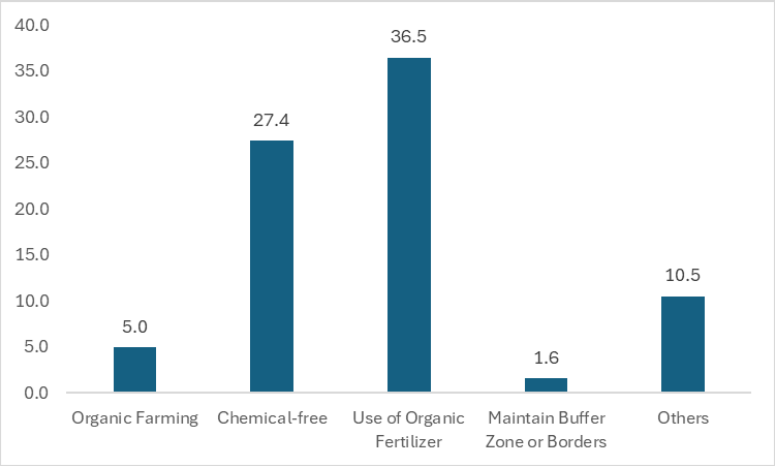
	1961	1981	2001	2021
Total additions (tons)	221,272	439,742	791,954	998,900
Total subtractions (tons)	236,682	469,711	579,165	785,899
Net addition (tons)	-15,410	-29,970	212,789	213,000
Share of manure in additions (%)	39.0	23.9	18.0	15.6
Share of mineral fertilizer in additions (%)	16.2	47.8	64.1	66.8
Ratio of crop removal to additions (%)	107.0	106.8	73.1	78.7

Source: FAO (2024)

However, by 2001, the Philippines was consistently adding nitrogen to the soil, amounting to 213,000 tons, with similar addition in 2021. Crop removals were equivalent to under 80 percent of additions. This is largely due to expanding mineral fertilizer additions, which started out only 16.2 percent in 1961, rising to 48 percent in 1981, and reaching nearly two-thirds of total additions by 2021. Meanwhile, the share of manure, a form of organic-based fertilizer, in nitrogen additions, was 39 percent in 1961, falling to 24 percent in 1981, and dipping further to 18 percent in 2001. By 2021 the manure share was just 16 percent.

Nonetheless, a significant number of farmers continue to apply organic-based fertilizers. The 2022 Cost and Returns Survey of Palay Production provides a breakdown of palay farmers practicing organic/natural farming, by type of practice. Only 5 percent practice full organic farming, although a sizable proportion adopt chemical-free farming (27%); an even larger proportion apply organic fertilizer (37%). However, how much organic fertilizer is being applied is not available.

Figure 5: Share of palay farmers practicing organic/natural farming, 2022 (%)



Note: Others denotes other organic farming practices, not elsewhere classified.

Source: PSA (2023).

3.2. *Policies*

Regulation of the fertilizer industry was established by law in 1973 by Presidential Decree (PD) 135, which created the Fertilizer Industry Authority (FIA); this was subsequently amended by PD 1444 of 1977, converting the FIA to the Fertilizer and Pesticide Authority (FPA). FPA was chartered with considerable powers over the fertilizer industry in the 1970s, although was subsequently deregulated by Executive Order 1028 of 1985. Actual implementation of the deregulation was done starting 1986 under the Aquino administration, as guided by Memorandum circular No. 1, series of 1986.

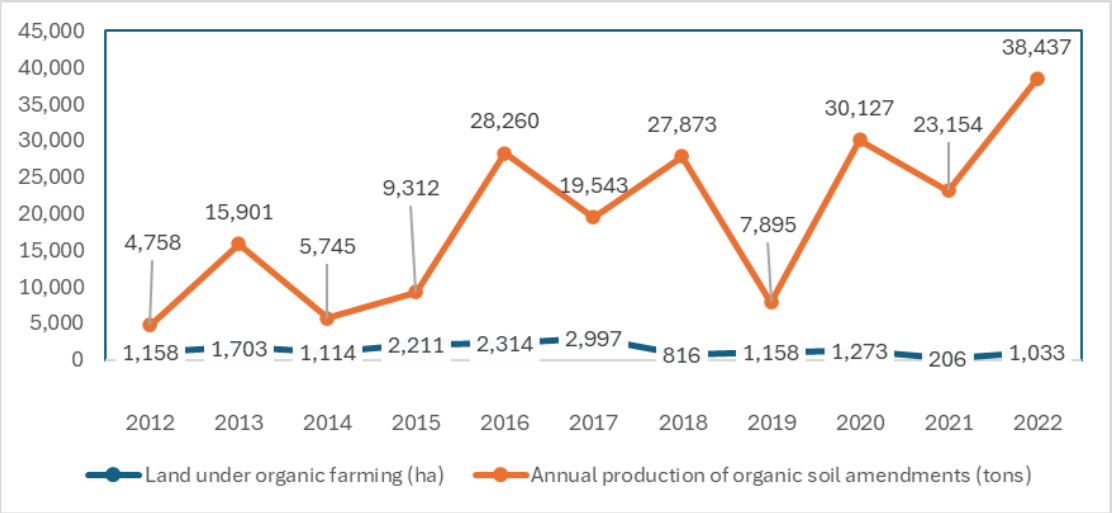
The next landmark legislation was the Organic Agriculture Act of 2010. The Act declared a state policy of promoting and developing the practice of organic agriculture, to enrich fertility of the soil, increase farm productivity, reduce pollution, prevent resource depletion, protect human health, and save on imported farm inputs. "Organic agriculture" under the Act adopts the International Federation of Organic Agriculture Movement's (IFOAM) definition which explicitly excludes all types of synthetic fertilizers within the scope of "organic agriculture".

The Act further prescribes a certification of foods and food control systems, to be done by officially recognized organic certification bodies (OCBs), to provide assurance conform to organic standards. While first party certification (by the producer) and second party certification (by the buyer or industry organizations) is acknowledged, the law prefers third

party or independent certification, and limits organic labeling to food and food establishments that achieve third party certification. The Bureau of Agriculture and Fisheries Standards (BAFS), a Bureau under the DA, is tasked with defining standards for organic certification, accrediting OCBs, and maintaining the official registry of organic food and organic input producers. There are currently three accredited OCBs in the country, namely: a) Organic Certification Center of the Philippines Inspection and Certification Services, Inc. (OCCP-ICSI); b) Control Union Philippines, Inc. (CUPI); and c) Negros Island Certification Services, Inc. (NICERT).

Based on certified organic areas and production, Figure 6 presents trends in organic agriculture area and production of organic soil amendments. Farming area certified as organic remains small, i.e. never exceeding 3,000 ha total for the country; the area actually increased from just over 1,000 ha in 2012, to its peak of 2,997 ha in 2017, but collapsed to 816 in 2018. Since then, the area has struggled to reach just 1,033 ha in 2022, even lower than its base year level.

Figure 6: Organic agriculture indicators, 2012-2022



Source: PSA (2024).

In contrast, production of organic soil amendments has increased nearly eight-fold since 2012, at 4,758 tons, to its peak of 38,437 tons in 2022. However, over the intervening decade the annual production has fluctuated wildly with occasional sharp dips in 2014, 2017, 2019, and 2021.

BAFS standards are codified as the Philippine National Standards (PNS) for organic agriculture. The PNS lists the "permitted substances" for organic agriculture under DA's Department Order (DO) No. 9, Series of 2020, in which explicitly excludes synthetic chemicals. Animal manure is a permitted substance, but only if it undergoes full decomposition.

DA Memorandum Circular (MC) No. 10, series of 2023, places organic soil amendments (OSA) and organic biocontrol agents (OBCA) under the jurisdiction of DA-BAFS for the purpose of product registration. The MC prohibits cross-registration of the same product as OSA or OBCA with BAFS and FPA; it states that FPA regulates the registration of inorganic

(/synthetic/chemical-based) input products. However, the MC is silent about biofertilizers, for which no claim of "organic" is made, which therefore still falls within the regulatory ambit of FPA.

A key barrier to expanding organic farming area is the high cost and tedious requirement for third party certification. RA 11511, an Amendment to the Organic Agriculture Act, attempted to remedy this by introducing a Participatory Guarantee System (PGS). The amendment states that the PGS shall be the mechanism by which smallhold farmers, small-scale fisherfolk, and organizations of these stakeholders, shall achieve organic certification. It therefore offers a community-based yet formal approach to certification

The PGS is initiated with the accreditation of a "core PGS group" by the DA. This core group must obtain a business permit with the city/municipal LGU, whose sole business is to maintain and extend the PGS. A farmer shall obtain organic certification by joining a nearby PGS; alternatively, the farmer may apply a national organization of LGUs initiating organic agriculture; or with an OCB. The PGS is required to conform to the PNS. Recognition of the PGS is limited to the domestic market, and to export markets with whom the Philippines has a mutual recognition agreement for PGS (or similar system).

3.3. *Programs*

3.3.1 National Organic Agriculture Program

The Organic Agriculture Act also establishes a National Organic Agriculture Program (NOAP), for the promotion and commercialization of organic farming practices, as well as a National Organic Agriculture Board (NOAB), to oversee the implementation of the Act. The DA Secretary is appointed the chair of the NOAB. BAFS is assigned to serve as NOAB Secretariat and the lead office for the implementation of organic agriculture programs approved by the NOAB.

The Bureau of Soil and Water Management (BSWM) of DA supports the implementation of NOAB with the provision of a) Composting Facilities for Biodegradable Wastes (CFBW); and b) Small-Scale Composting Facilities (SSCF). The CFBW targets biodegradable wastes (such as wet market and kitchen waste), while SSCF caters to smallhold farmers mostly using farm wastes. Figure 7 shows a rotary composter distributed under the SSCF.Figure 7: Rotary composter provided to the Camarines Sur LGU by the DA-BSWM.

Source: Authors' images.

3.3.2 Balanced Fertilization Strategy

Organic agriculture does not however exhaust the DA's initiatives in the promotion of organic-based fertilizers. It has also promoted the Balanced Fertilization Strategy or BFS (DA-FPA, 2022). Proclamation No. 1071 (series of 1997) authorized DA to adopt BFS. DA Memorandum Circular No. 20, Series of 2020 instructed DA offices to coordinate with the BSWM for technical assistance on the implementation of the Adaptive Balanced Fertilization Management to enhance crop productivity and increase income of rice farmers. DA Memorandum Order No. 74 (2021) provided for scaling balanced fertilization by applying cost-reducing practices. Finally, Special Order No. 286, Series of 2022 created Management and Working committees to initiate and promote the BFS technology.

BSWM is also implementing the National Soil Health Program, which established a nationwide adaptive BFS technology demonstration of 100 ha of rice area per region in 2023. Funded by the National Rice Program (NRP), the demo has already shown that adaptive BFS can increase yield; data with respect to soil health are still being analyzed. The demo is being extended to corn and vegetable areas.

The DA had been providing fertilizers as part of its production support under the various commodity programs, particularly for rice. In 2020, the NRP had a Php 1 billion allocation for providing fertilizers in support of the inbred certified seeds program. Under the General Appropriations Act of 2020, the program is mandated to promote balanced fertilization to increase rice productivity.

The following year, DA rolled out a fertilizer voucher program, initially as part of the NRP. The voucher started out at just Php 2,000 per ha for inbred rice growers, and Php 3,000 per ha for hybrid rice growers, available one-time per budget year per farmer. In 2022, fertilizer grades that can be claimed under the project are Complete, Urea, Ammonium Sulfate, Ammonium

Phosphate, Muriate of Potash, "and other grades that may be allowed by DA-RFO." Starting 2023, the allocation was increased to Php 5,500 per ha, with an explicit allocation of Php 1,500 per ha for "biofertilizers or microbial inoculants", and the remainder for inorganic fertilizer.

4. The Agronomy of Organic-based fertilizers

4.1. *Trends and advantages of inorganic fertilizer usage*

The utilization of inorganic fertilizer is integral to modern conventional agriculture. Al-Kaisi (2020) characterizes conventional agriculture by including the following, among others: a) Open system – the main purpose is production of food that is removed from the farm; b) Imbalance between input and output – within the open system, soil, water, nutrients, and energy are also removed; c) High input of synthetic fertilizers and agricultural chemicals, intensive tillage, and monocropping.

The primary advantage of using inorganic fertilizers is it provides available nutrients immediately, unlike organic materials in organic fertilizers which must undergo decomposition (Chew 2019; Kanton 2016). Farmers perceive that high utilization of inorganic fertilizers can result in high crop yields, which motivates many of them to utilize inorganic fertilizers intensively.

Evidence of the efficacy of inorganic fertilizers, when applied at recommended rates, is firmly established. A longitudinal panel study conducted in China from 2010-2015 observed a significant increase in yield with increased nitrogen (N) fertilizer rates of up to 135kg/ha when applied appropriately (Zhao et al 2010, Zhan et al 2018). The International Rice Research Institute (IRRI) also conducted a Long-term Continuous Cropping Experiment (LTCCE) from 1972 to 1990 (Dawe et al 2000). In the LTCCE, continuous cropping and application of fertilizers were observed to result in a decrease in yield from 1.45% to 1.6%. However, another study considering modified farming practices, including a fallow period from May to July, showed that the decline in yield can be reversed and can essentially be maintained in the long term (Dobermann et al 2000).

The rise of high-yielding varieties of rice during the Green Revolution contributed to the use of inorganic fertilizers to meet their nutrient requirements. According to a study by Moya et al. (2015), the rates of inorganic fertilizers increased from 20-7-11 kg/ha nitrogen, phosphorus, potassium (NPK), respectively, in 1966 to 119-15-21 kg/ha in 2011 during the dry season of rice planting. In the Philippines, the use of inorganic fertilizers was valued at 2.52 mega metric tons (MMT) to increase rice and corn yields (PSA 2024). The utilization of inorganic fertilizers can be beneficial when used at expert-recommended rates (to prevent excessive application).

As rice and corn remain to be the most important agronomic crops of the Philippines, their fertilizer usage is also increased, reaching 4.8M and 2.5M ha, respectively, in 2018. In the same year, the International Fertilizer Association (IFA) found that 384 thousand MT and 107 thousand MT of nitrogen fertilizers was applied to rice and corn, respectively (IFA, 2022). A total of 2.54 MMT of fertilizers was imported in 2023 to support the yields of rice and corn, with 66% of imports consisting of urea (CPBRD 2023).

The Philippine Rice Research Institute (PhilRice) conducted a study in 2019 comparing the utilization of inorganic fertilizers of around 1,800 rice farmers during the dry and wet seasons for four different years (PhilRice 2024). Both the dry and wet season in 2017 was observed to increase the NPK applications at 90-8-15 kg/ha and 94-9-15 kg/ha, respectively. Ilocos Region and Cordillera Administrative Region applied NPK rates at above the average amounts of the country during the 2016 wet season and 2017 dry season, while BARMM was observed to apply fertilizer inputs below the nation's average.

4.2. *Impact of inorganic fertilizers on soil health*

Conventional agriculture causes soil degradation which undermines long term productivity of crop farming. The use of inorganic fertilizers has its own set of disadvantages. The detrimental impacts of excessive chemical fertilization on environmental sustainability, particularly in terms of soil salinity, heavy metal accumulation, as well as off-site damage such as water eutrophication and nitrate accumulation are well documented (Savci 2012). Al-Kaisi (2020) associates conventional agriculture with soil degradation, the diminution of soil organic carbon (SOC), loss of soil functionality, dwindling soil biodiversity, increasing soil acidity, and an overall decline in soil health.

The prolonged use of inorganic fertilizers is associated with "nutrient mining", with failure to replenish vital nutrients in the soil. Soil health degrades as soil organic matter (SOM) declines due to the increased decomposition of SOM that is being processed at a faster rate than stocking it (Pahalvi et al 2021). Further, salts in inorganic fertilizers can build up when used for a long time, resulting in disrupted water and nutrient uptake. Soil microbial populations are also affected due to the decline in SOM with the continuous use of inorganic fertilizers. Food and habitat of soil microbes are reduced which makes the soil ecosystem unfavorable for microorganisms to thrive. Soil management is necessary for maintaining and restoring soil quality such that soil organic matter is increased and the ratio of carbon to nitrogen (C:N) remains within the appropriate rate (between 20:1 to 30:1).

4.3. *Alternatives to conventional agriculture*

These disadvantages of inorganic fertilizers and other modern agricultural practices, have motivated adoption of alternative approaches (Selim 2020; Gruhn et al 2000; Reganold & Wachter 2016). These alternative systems encompass a wide range of approaches, such as organic agriculture, regenerative agriculture, conservation agriculture, circular agriculture, integrated nutrient management, agroecology, and nature-based solutions. A summary of these alternative approaches is provided by Table 2.

Diversity of practices under alternative approaches create conceptual difficulties and definitional ambiguities. Before diving into the various alternative approaches, a key caveat needs to be noted. Sumberg and Giller (2022) point out that "There are important differences in how and to what degree alternative agricultures are defined and specified (p. 5)." The problem is that many of these principles are qualitatively stated, except for a few (i.e. "no soluble mineral fertilizers"); hence, say, "reduced and controlled water application" is difficult to pin down precisely, i.e. how much reduced, what is meant by "controlled"? The binary

comparison between conventional and alternative should be made critically. With this in mind, we nevertheless can identify a number of distinct alternative farm production systems.

The degree of reliance on such fertilizers, as well as other input and crop management practices, vary widely across alternatives. At one end is "organic agriculture", which excludes external inputs that are not organic, natural or naturally derived, i.e. no use of chemically synthesized inputs, no use of soluble mineral fertilizers, and no use of GMOs or derived products (except veterinary medicines). Another alternative system is integrated nutrient management (INM). This is a holistic approach that combines various nutrient sources to maintain soil fertility, increase crop productivity, while minimizing environmental impact. Unlike organic agriculture, this approach emphasizes a balanced approach of utilizing organic and inorganic nutrient sources to meet crop requirements while sustaining soil health (Selim 2020; Finck 1998).

Other alternatives to conventional farming are summarized in Table 2. While each alternative has its distinctive emphasis, common to all these approaches is the integration of farmer knowledge and practices using natural resources, reducing external inputs, while ensuring environmental sustainability.

Organic-based fertilizers are integral to all alternative farming systems. Common to these alternative approaches is the utilization of organic fertilizers. Fertilizers derived from organic sources like animal manure, plant materials, and compost enhance soil quality by improving the soil structure (aggregation) thereby, improving water absorption, aeration and root penetration. They also enhance the availability of essential nutrients, contributing to the N and P in the soil. Organic matter also increases microbial activity in the soil as it provides favorable habitat for microorganisms to thrive. SOM contributes to nutrient cycling in minimizing nutrient losses through different processes such as mineralization and immobilization. The process of mineralization converts organic forms of nutrients into inorganic forms that plants can easily absorb. On the other hand, when soil microorganisms absorb nutrients, this process—called immobilization—temporarily reduces the nutrients available for plants (Chen 2006). The slow-release mechanism of organic-based fertilizers offers a sustainable nutrient supply as they gradually mineralize and are absorbed by plants. This mechanism prevents nutrient losses due to leaching and volatilization (Ranjan 2023). Since Philippines is threatened by natural calamities (typhoons), the use of organic-based fertilizers may be beneficial in areas where there is heavy rainfall and limited irrigation sources.

Organic-based fertilizers are associated with lower carbon footprint versus synthetic fertilizers (He et al 2023). Moreover, organic soil amendments potentially increase the capacity of beneficial soil microorganisms to suppress plant diseases, pathogens and parasites. The slow-release mechanism prevents available nutrients leaching into groundwater and other water resources.

Table 2: Alternative approaches to conventional farming

Alternative approach	Definition	Practices	Differences from Conventional farming	Similarities with Conventional Farming
Agroecology	Application of ecological concepts to optimize interactions between plants, animals, humans and the environment	Polyculture, crop-livestock integration, agroforestry, reliance n ecosystem services	Explicitly integrates social, cultural, and ecological dimensions into farming	Strong focus on sustainable, ecological farming systems that restore ecosystems and promote resilience.
Low External Input Sustainable Agriculture (LEISA)	Reduces reliance on external inputs while maximizing local resources.	Use of local organic inputs, nutrient recycling, integrated pest management, natural water management.	Focuses on minimizing external inputs (synthetic fertilizers).	Similar to organic farming which minimizes chemical inputs and promotes use of local resources.
Permaculture	Focused on creating sustainable, self-sufficient ecosystems that mimic natural patterns.	Polyculture, food forests, rainwater harvesting, natural pest management, and perennial crops.	Permanent and self-sufficient sustaining systems.	Creates a holistic and sustainable system that work with nature.
System of Rice Intensification (SRI)	Use of fewer inputs in rice Farming to improve yield.	Minimal tillage, using cover Crops, crop rotation, composting, and holistic grazing.	Strong emphasis on ecosystem Restoration and carbon sequestration.	Prioritizes soil health, Biodiversity, and reduced chemical inputs.
Conservation Agriculture	Focused on minimal soil disturbance, permanent soil cover, and crop rotation.	Zero or reduced tillage, cover cropping, crop rotation.	Reducing soil erosion and water runoff through minimal disturbances.	Similar to regenerative and agro-ecological systems to promote soil conservation and biodiversity.
Regenerative agriculture	A holistic farming system aimed at restoring soil	Minimal tillage, cover cropping, crop rotation,	Ecosystem restoration and carbon sequestration.	Prioritizes on soil health, biodiversity and

Alternative approach	Definition	Practices	Differences from Conventional farming	Similarities with Conventional Farming
	health and ecosystems, and carbon sequestration.	composting, and grazing.		reduced chemical inputs.
Nature-based Solutions (MacLaren et al 2022)	Optimize agricultural productivity by using natural processes to substitute anthropogenic inputs	Crop rotation, intercropping, addition of fertility crops, adjustment in crop residue management, and reduced tillage.	Focuses on the concept of ecological intensification to boost yield at low nitrogen fertilizer doses.	Use of nitrogen fertilizer, crop rotation and utilizing crop residues.

Source: Canatoy (2024).

4.4. *Impact of shifting to organic agriculture*

Organic farming offers income-generating benefits to farmers. A study by Medina (2011) as cited by Maghirang et al. (2011) found that 840 MASIPAG farmers IN 2007 generated higher income with organic farming than conventional farming. Another study in four provinces with 197 rice farmers observed that while yield was higher with conventional farming, net income was higher with organic farming (Blanquita et al 2016). Similar results were observed with sugarcane farmers in Sagay City, Negros Occidental (Maghirang et al 2011). However, availability of organic-based fertilizers is a concern for most farmers aside from the laborious requirement of producing it on their own.

Animal wastes have an established market for organic fertilizer. Poultry waste is disposed by either selling it to traders, composting it as organic fertilizer or by dumping it to nearby bodies of water (Calub et al 2016). Disposal of swine manure causes environmental and human health concerns as collecting it is a challenge for smallholder and backyard farmers (Catelo et al 2001; Catelo et al2008; ; Paraso 2010). Commercial swine farms have the capacity to process swine manure through a series of physical (drying or solid preparation) and biological (composting or anaerobic digestion) treatments prior to utilizing them as fertilizers for crops (Calub et al 2016). Unlike chicken manure which is relatively dry, swine manure is a slurry, mixed with urine and water which is used to flush them out. The volume of manure generated by the industry is huge but the challenge on maximizing its use as organic fertilizer is even bigger. Cattle, buffalo and goat industries are predominantly managed by smallholder farmers. Collecting and transporting their manure proves to be a limiting factor for processing the product as organic-based fertilizer for commercialization.

These benefits are so widely recognized that it has even been proposed that organic farming can potentially “feed the world”, e.g. Rodale Institute (2024). However, a global study by several authors, such as Barbieri et al (2021), argue that achieving 100% organic agriculture

globally is not feasible, citing limitations in N availability as a main constraint once organic agriculture surpasses a certain threshold.

Can organic agriculture "feed the Philippines"? Unfortunately, no studies have been done in the Philippines to check for the feasibility of 100% organic agriculture. Nonetheless, estimates of Aguilar et al (2024) show conclusively that domestic organic sources are insufficient to shift the country's agriculture entirely to organic farming. Their calculations are based on the potential contribution of organic sources, namely crop wastes, and animal manure. First, they consider the quantity of nutrients N, P, and K imported in 2023, respectively equal to 865,000 tons, 103,000 tons, and 231,000 tons. They then identified the most likely sources of organic materials for providing plant nutrients in the Philippines, namely animal manure, divided into swine and chicken; and commonly used farm waste, categorized in various forms, namely carbonized rice hull, dried coconut husk, sugarcane mudpress, corn cobs, and rice straw. The quantity of each to match the imported nutrient quantity is computed using the nutrient content of each organic material; the largest required quantity is the target quantity, and the nutrient corresponding to the target quantity is the "limiting factor". These calculations are simplified estimates; they do not, for instance, take into account differences in mineralization rates across organic materials. However, these refinements do not alter the main conclusions.

Results are shown in Table 3. For each source, the limiting factor is nitrogen; the lowest quantity required is swine manure, owing to its high nitrogen content. As much as 37.6 million tons of swine manure is needed to provide 850,000 tons of nitrogen (the amount imported in 2023). This is followed by poultry manure at 41.2 million tons computed from the broiler and layer poultry population. On the other hand, very large quantities of plant sources are required, with dried coconut husk requirement going as much as 2.15 billion tons.

Table 3: Plant nutrient imports and required matching quantities from organic sources, 2023 ('000 tons)

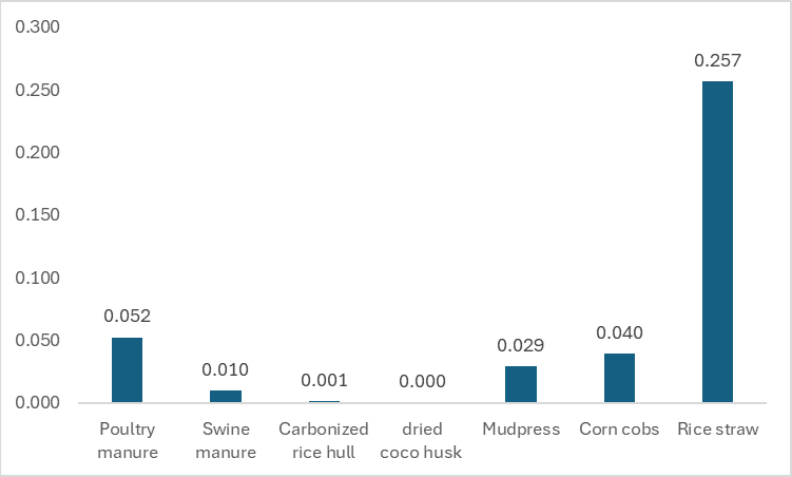
	Nitrogen	Phosphorus	Potassium
Quantity imported	865	103	231
Required quantity to match imported nutrients:			
Poultry manure	41,190	2,739	6,176
Swine manure	37,609	1,839	27,500
Carbonized rice hull	480,556	22,889	25,667
Dried coco husk	2,146,402	515,000	10,891
Mudpress	45,526	9,035	21,000
Corn cobs	60,069	7,203	10,645
Rice straw	52,225	103,000	1,650

Source: Aguilar et al (2024).

Finally, the authors compared the estimated N production of animal and crop wastes in 2023 against the target quantities (estimated equivalent of N from inorganic fertilizers imported). The result, in percent of target quantities, is shown in Figure 7. All are below 1 percent. The

largest percentage is rice straw at 0.26 percent, followed by poultry manure at 0.052 percent. Percentages are vanishingly small for carbonized rice hull and dried coconut husk. The percentages add up to 0.49 percent. Roughly speaking, the various waste sources must increase 200-fold to deliver the same amount of nitrogen as did imported inorganic fertilizers in 2023. This does not even consider the lower bioavailability of nitrogen from organic sources, as discussed above. Finally, organic materials produced in the country are also being used for aquaculture, animal feeds and other industrial uses. Complete replacement of inorganic with organic fertilizers is clearly infeasible, with nitrogen being the main limiting factor, as also determined by global estimates.

Figure 7: Organic N availability as a percentage of imported inorganic N fertilizer, 2023



Source: Aguilar et al (2024).

4.5. *Impact of shifting to integrated nutrient management*

The FPA has recommended the BFS program with the DA and other government agencies concerned in agriculture through their OneDA campaign (FPA 2022). The strategy is a site-specific nutrient management that aims to enhance the efficiency of fertilizer application at the right source, right placement, right amount, and right rate to improve soil health and productivity and prevent the decline in soil fertility (BSWM 2020 cited by FPA 2022). The practice of BFS promotes the practice of integrated nutrient management wherein organic and inorganic fertilizers and other fertilizer products, like biofertilizers, are combined to achieve improved crop yield and productivity with minimal environmental impact. The government hopes to address the challenges with rising costs of fertilizers and environmental concerns through this program.

A study in Eastern Visayas was also conducted to enhance the soil quality and increase crop yields of upland corn in Inopacan, Leyte (Lina et al, 2014). Several treatments of single and combined organic and inorganic fertilizers were used including a 90-60-60 kg/ha N,P_2O_5,K_2O, chicken dung, vermicast, and a combined chicken dung and inorganic fertilizer, combined vermicast and inorganic fertilizer. The researchers found that soil characteristics, such as soil

pH, organic matter, and total nitrogen, and crop characteristics, such as height, ear length, number of grains, increased with the application of organic-based fertilizers. Pure application of inorganic NPK fertilizer and combined inorganic and chicken dung fertilizer contributed more to growing taller and larger ears with more kernels. However, it is important to note that chicken dung is applied at a high rate of 7.5 tons/ha, which can be a deterrent for farmers to adopt the practice of incorporating it with their crop production. As explained in the previous section, solely relying on organic-based fertilizers is not a sustainable option due to the limiting supply of the materials that can be used for farming.

Another study reported that the application of purely chicken dung and chicken dung combined with inorganic fertilizers observed a significant increase in the total nitrogen and available phosphorus, and lowered soil acidity (Alesna and Lina 2022). Aside from the soil benefits of applying combined organic-based and inorganic fertilizers, it was also observed that corn farmers who applied both realized a high return on investment due to the high marketability of ears (Biñas 2021). The studies on organic farming generating high income can complement the practice of integrated nutrient management showing not only the crop production benefits of incorporating organic nutrient sources but also the economic benefits.

Another PhilRice study compares farmers practice with commercially-managed fertilization plots, using inorganic, and various balanced fertilization options. It found that NMP 3 (inorganic+biofertilizers and biostimulants) generated the highest net income amounting to PHP 79,195 per ha and PHP 58,383 per ha, in the DS and WS, respectively. The lowest income, on one hand, was recorded from the farmers' practice. The next highest net income was for the inorganic fertilizer option (PhilRice 2023).

A study of Tulin et al (2016) for site-specific nutrient management in cabbage production showed that understanding farmer practices can effectively propose efficient and sustainable alternative practices through integrated management, thus building their technical knowledge regarding their crop production management. INM can achieve high crop yields while balancing considerations of soil health. However, the system may be difficult to adopt as fertilizer recommendations are highly site specific, entailing regular monitoring to ensure that the right nutrients are applied at the proper rate and timing.

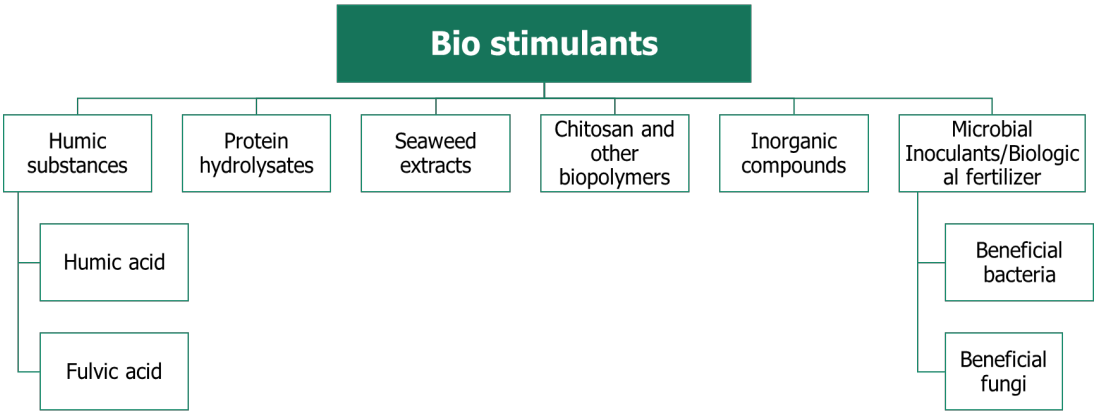
4.6. *Types of organic-based fertilizers*

Organic fertilizers are classified into different types which can be either registered with the FPA for biofertilizers, or BAFS for organic fertilizer. According to the PNS-Organic Soil Amendments, organic fertilizers are products that come in either solid or liquid forms from fully decomposed plant or animal materials that can supply NPK of 5-10%. Meanwhile, inorganic fertilizers, biostimulants, fortified organic fertilizers, genetically modified organisms, decomposers, soil conditioners or soil amendments, plant growth regulators, and raw materials are products registered with the FPA.

Figure 8 shows the classifications of inorganic fertilizers and biostimulants that both offer different benefits to crops (FPA 2019). The FPA further classified biostimulants into different types of substances or microorganisms that stimulate and enhance the physiological processes, nutrient efficiency, and abiotic stress tolerance regardless of their nutrient content when applied in the soil.

Additionally, microbial inoculants or biofertilizers are biologically active products that contain one or a combination of strains of bacteria, actinomycetes, algae or fungi, which can promote nitrogen fixation, decomposition of organic wastes, and solubilization of soil nutrients. The FPA also defines decomposers are similar in that they are also biologically active products that enhance the decomposition of plant or animal residues into compost or soil conditioner, or organic fertilizers.

Figure 8: FPA classifications of biostimulants



Source: Pangga (2024).

Soil conditioners or soil amendments can either be organic or inorganic materials that can change soil physical properties and enhance soil chemical and biological conditions when applied in the soil at 2.5% to less than 5% NPK. Examples of soil conditioners are polyelectrolytes, such as complex vinyl and acrylic, gypsum, diatomaceous earth, vermiculite, perlite, and lime, all of which can modify the structure, moisture content, shrinking and swelling capacity or resistance to soil crusting.

Fortified organic fertilizers are decomposed organic products enriched with microbial inoculants, plant growth substances and/or chemical ingredients to increase their nutrient content to a minimum of 8% total NPK. Plant growth regulators are those that come in low concentrations of natural or synthetic compounds to improve or alter the physiological response of plants. Raw materials can also be organic or inorganic materials for the production of fertilizers.

According to the PNS-OSA (2020), organic plant supplements are products that can supply NPK of not less than 0.5% to not more than 10% for solid supplements and 5% for liquid supplements. Examples include fermented plant juices, fermented fruit juice, fermented fish amino acid, fish emulsions, seaweed extracts, vermi tea, compost tea and other similar products.

Other fertilizer products, such as biochar and microbial inoculants, have been gaining interest in providing other alternatives to inorganic fertilizers. Biochar is a soil amendment that is produced through a process of thermochemical conversion of biomass in an oxygen-limited

environment or pyrolysis. Biochar consists of charred remains of a plant and animal materials or biomass advertised as a safe long-term carbon storage, thus, contributing to carbon sequestration (Pangga 2024). Microbial inoculants contain biologically-active organisms, which may be bacteria, algae, and fungi. These products are beneficial in nitrogen fixation, decomposition of organic residues, and enhancing availability of nutrients. Trichoderma technology developed in UPLB by Dr. Virginia Cuevas is an example of a microbial inoculant that is widely used in the Philippines.

Composting is a natural process of decomposing plant or animal organic matter by microorganisms under a controlled environment. The mineralization rate of organic materials is influenced by resource quality, environmental factors, like temperature, moisture and aeration, and soil pH, nature of soil organisms, and placement of residues. Resource quality is defined by a combination of factors that determine the value of a resource as food for an organism. The resource must meet the organism's physical and chemical requirements for ingestion and colonization to take place (Pangga 2010).

4.7. *Quality considerations in the production organic-based fertilizers*

All organic-based fertilizers need to adhere to rules and regulations set under the Republic Act 10068 where all organic based fertilizers need to conform to the rules and regulations set by BAFS for the PNS-OSA (PNS/BAFS 183:2020). This Standard "applies to organic fertilizers, organic soil conditioners, microbial inoculants, and organic plant supplements. The emphasis on how to minimize contamination from microbiological, physical, and chemical hazards is in accordance with the relevant provisions under the Philippine National Standard (PNS) on the Code of Practice for the Production of Organic Soil Amendments (PNS/BAFS 291:2019)" (BAFS 2020, p.85).

Strict guidelines are set by the agency to ensure quality and safe products for agricultural production, whether it is at the individual or large-scale production. Under the PNS/BAFS 183:2020, the minimum requirements for raw materials are outlined in the Organic Soil Amendments and Plant Supplements Product Standard – Specifications. The list of allowed raw materials is indicated in the National List of Permitted Substances for Organic Agriculture. Verification procedures are conducted on raw materials and a succeeding confirmatory test is performed when the content of raw materials exceeds the allowable values specified in the standards.

Mature compost is characterized by a fine texture, dark color, and a rich earth smell (Pangga 2024). This means that compost should be mature and stable where biological activity has already slowed down and complex organic materials is broken down (Figure 9). The duration of decomposition is an important factor for producing quality organic-based fertilizers, otherwise there are associated risks with using organic matter that is not fully decomposed. Unfinished or immature compost contains high levels of organic acids, high C:N ratio, extreme pH value or high salt content.

Figure 9: Vermicomposting facility in Camarines Sur.

Source: Authors' images.

Some key factors affecting decomposition in organic fertilizer production include temperature, moisture content (MC), oxygen, some physical properties, C:N ratio, and processing/curing time (Campbell 2019 cited by Pedro 2024). A high temperature of 50-60 degrees Celsius should be maintained for effective decomposition. As microorganisms generate heat during aerobic composting conditions, pathogens are also eliminated during the process. A 50-60% MC is also ideal to encourage microbial activity. Excessive moisture can promote anaerobic conditions, thus, hindering decomposition and resulting to noxious odors. A practical way of checking the MC is by taking a handful of substrate materials to be composted and squeezing the water with a hard grip (Pedro 2024). If there is excess amounts of water that drips down, then the substrate material has too much water.

Appropriate physical properties like particle size, structure, and texture are important in the porosity of compost mass. These ensure good aeration while providing good access in regulating water and gas exchange in the compost piles to achieve enhanced decomposition process. Further, this offers a greater available surface area for improved microbial activity, resulting in rapid degradation. Adequate oxygen supply of 10-14% also promotes microorganisms to thrive in aerobic conditions for decomposition. Open windows alone can help this process, with forced aeration systems for commercial-scale production ensuring oxygen penetration and distribution. Another crucial factor in promoting microbial activity is maintaining C:N ratio of between 20-40 which is often suitable for composting depending on the nature of feedstock. Microorganisms require 30 parts carbon for every part of nitrogen for efficient degradation (Campbell 2019 cited by Pedro 2024).. Introducing microbial inoculants in composting can also hasten the decomposition process

Smallholder farmers who opt to produce their own organic fertilizers for personal use do not necessarily have to abide by these guidelines, but it would be highly beneficial for them to

apply these. The skills and knowledge in producing their own organic-based fertilizer can also offer additional income by sales of organic-based fertilizers. However, engagement in the commercialization of organic-based fertilizers should adhere to regulatory guidelines and standards.

5. Economics of Organic-based Fertilizers

5.1. *Farm household production of organic fertilizers*

Although home-produced organic fertilizer saves on purchasing chemical fertilizer, it incurs the opportunity cost of household labor. One advantage of organic fertilizer is the savings in purchasing chemical fertilizers, as organic fertilizers can be produced by the farm household. However, this common notion fails to account for the opportunity cost of labor in fertilizer production. Moser and Barrett (2003) examined the System Rice Intensification (SRI) method in Madagascar and identified the labor-intensive requirements as a hindrance to its widespread application. SRI, a farming approach using low external inputs such as chemical fertilizers and pesticides, has been proven to demonstrate significant yield increase for small holder farmers. However, concerns arise regarding its suitability due to the high opportunity cost associated with the additional labor inputs. Similarly, Daadi and Latacz-Lohmann (2021) noted a substantial one-third increase in overall labor demand in the context of organic fertilizers adoption. This increased labor burden falls on female farmworkers, accounting for additional 5.9 female working days (90%) versus 1.3 male worker days (9%) per acre.

5.2. *Economics of purchased fertilizer*

Organic-based fertilizers purchased from the market will be compared by farmers to inorganic fertilizers in terms of cost and efficacy. As an alternative to farm household production of organic fertilizer, is straight purchase of organic fertilizer (subject to its available in the market). Consider the price of vermicompost at around PHP 400 per 50 kg-bag. At PNS standards, these fertilizers should contain 2.5 percent nitrogen, implying a cost of PHP 320 per kg of nitrogen. On the other hand, current price of urea is about PHP 2,200 per bag of urea, cost of inorganic nitrogen runs to just PHP 96 per kg nitrogen.[1] Moreover, it is all available in mineral form to the plant. However, it is well-known that about half of inorganic nitrogen is lost to the environment.[2] This drives up the cost to about PHP 192 per kg of nitrogen, which is still much cheaper than that of organic nitrogen.

However, efficacy of organic nitrogen is different from that of mineral nitrogen. The former is not immediately available to the plant, unlike mineral nitrogen, as it must undergo microbial action before absorption by the plant. By the same token, it is much better retained in the soil, compared with mineral nitrogen, making it available over multiple croppings.

Inorganic fertilizers deliver macro-nutrients rapidly to plants to support their growth, whereas organic-based fertilizers deliver long term benefits by improved soil health. The ability of inorganic fertilizers to deliver macro-nutrients to support plant growth is consistent with the finding of Seufert et al (2012) that organic agriculture yields tend to be lower than conventional agriculture yields. Yield gaps vary widely though, the smallest being for rainfed

legumes and perennials on weakly-acidic/weakly alkalinic soils (5%), and largest when the two systems are most comparable (34%).

While organic yields over cross sectional studies seem to be lower, sustainability of yields over a time series panel may yield a different story. A long term experiment in China found that the first 12 years of fertilizer application for maize showed the most rapid increase over time for NPK application than for pure manure or combined chemical/manure application. However, from years 13 onward, higher yield increases over time were found for pure manure treatments than with pure NPK treatments (Hui et al 2017).

A combination of inorganic and organic fertilizer realizes both the short-term benefits of mineral fertilizer and the long term benefits of organic fertilizer. This seems to be the best rationale for INM or "balanced fertilization strategy" (BFS). The best long term yields reported by Hui et al (2017) were actually found for the combined chemical and manure treatments. The authors conclude that "We observed that over time chemical fertilizer was not as effective as manure, and the combined use of chemical and organic fertilizers finally enhanced maize yield (p. 942)." Depending on soil fertility improvement over time, the composition of fertilizers can shift increasingly towards replacing inorganic with organic fertilizers.

5.3. *Incentives and impact of farmer adoption*

The adoption of organic fertilizers is influenced by individual, household, social, and environmental factors. Considering the complex nature of human decision-making, Wang et al (2018) analyze diverse psychological and socio-economic variables influencing Chinese apple farmers to transition from chemical to organic fertilizers. Their findings indicate that membership in an agricultural cooperative, subsidies for organic fertilizers, and ownership of large farms are the key factors promoting the adoption of organic fertilizers. Using a time preference framework, Mao et al (2021) emphasized that rice farmers with lower time preferences, usually large-scale farmers, are more inclined to adopt organic practices like the straw incorporation methods.

Daadi and Latacz-Lohmann (2021) examine the organic fertilizers adoption among smallholder maize farmers in Northern Ghana. Their model reveals significant correlations between adoption and household characteristics like age, gender, household head education, size, and location. Additionally, factors like livestock size, farmland ownership, minimum tillage, previous drought experiences, household distance to input market, membership in farmer groups, and access to extension services also drive adoption. Also in Ghana, Avane et al (2021) found that the major constraints to using organic fertilizer were: a) slow release of nutrients into the soil; b) high transportation cost; c) emission of offensive odour; d) high cost of product; and e) limited availability.

Adoption of organic-based fertilizers is associated with greater crop productivity and income. A study for Bangladesh rice farmers controlled for self-selection of organic fertilizer adaptors using propensity score matching (Salam et al 2021). They found that organic fertilizer users achieve 16.67 percent higher yield, while using lower inputs. Based on a stochastic frontier approach, they find the technical efficiency of organic fertilizer users is 3.8 percent higher than non-users. Meanwhile for rice farmers in Ghana, a three-year field study was conducted to compare the effect of different fertilizer treatments, namely: control; NPK;

compost; NPK + biochar; and compost + biochar (Phares and Akaba 2022). They found that the use of compost or NPK alone increases grain yield and net income, but the largest increases are found for compost + biochar.

5.4. *Economies of scale*

Cost per unit of organic-based fertilizer tends to fall with greater specialization and scale of production. The relative disadvantage of farm household production of organic fertilizers compared with more specialized production systems imply the presence of economies of scale. PCAARRD (2014) undertake a cost and returns study for a small-scale, specialized production of compost decomposed with *Trichoderma*. Production scale is 100 bags per 45-day cycle. Per cycle, input requirements are summarized in Table 4. Note that 80 percent of cost consists of raw materials; each cycle takes up about two weeks of labor, of which about 36 percent is for collecting raw materials. At a price of PHP 275 per sack, the net income per cycle is PHP 6,200, or PHP 49,600 per year. Production cost per unit is PHP 213, consisting of PHP 42 labor cost per unit, and PHP 165 material cost per unit, and Php 6 utility cost per unit. Capital expenditure (for asset with 20-year lifespan) is fairly modest, at PHP 240,000. The payback period is about 5 years. At 800 bags per year, the resulting internal rate of return (IRR) is 26%; with a discount rate of 10%, the net present value (NPV) is Php 224,500.

Table 4: Production inputs and cost of organic fertilizer, 45-day cycle (2014)

	Quantity	Unit cost, Php	Cost, Php
Labor (person-days)			
Collection	5		
On-site	9		
Total labor	**14**	**300**	**4,200**
Raw materials			
Chicken manure (bags)	50	150	7,500
Sawdust (bags)	50	150	7,500
Sacks	100	15	1,500
Total raw materials			**16,500**
Utilities			
Electricity (kw-hours)	5	6[3]	300
Diesel (liters)	10	30[4]	300
Total utilities			**600**
TOTAL PRODUCTION COST			**21,300**

Source: PCAARRD (2015).

PCAARRD (2014) performs a profitability analysis at a larger scale of production, i.e. 6,720 bags per year (more than an eightfold increase over the previous case). The fixed asset investment cost is PHP 1,955,550, of which PHP 555,550 consists of equipment, and the balance consists of land and building. Labor production cost per unit is only PHP 26.28 per sack, owing to lower application of labor inputs due to capital substitution. Their costing of raw materials is also much lower, with chicken manure at only PHP 42.86 per bag (50 kg), and carbonized rice hull at PHP 8.33 per bag; adding another PHP 17.05 per bag for a total of PHP 68.24.

Over a 10-year horizon, the payback period is only 2.7 years. The IRR is 31.6%. At a discount rate of 20%, the NPV is Php 0.97 million. This suggests the presence of economies of scale of production, that can be realized for even a small production plant that can be run by modest-size farmer cooperative, assuming the low cost of materials can be realized.

Lack of raw materials has hindered the formation of organic fertilizer value chains. Padilla et al (2017) examines the organic fertilizer value chain in Cagayan Valley. They region's largest commercial producers are limited to merely three farmer cooperatives and one entrepreneur. This is because most value chain actors either produce organic fertilizers solely for their own consumption or are still in the early stages, requiring robust technical and financial support to scale up. They highlighted several perceived challenges impeding the expansion of operations. Notably, they identified the difficulty in the collection/accumulation of crop residues and animal wastes as key obstacles. Input collectors, who are oftentimes students, gather carabao/cattle manures and crop residues from nearby ranches and pasture areas. Meanwhile, chicken dung and swine manure are sourced from commercial poultry and piggery farms. The labor cost associated with input collection is subsumed into the total material inputs costs, which can amount to PHP 100 per bag of vermicompost.

5.5. *Impact of fertilizer subsidy*

On average, DA fertilizer subsidies serve as a transfer scheme for farmers. According to the economic model of profit maximizing enterprise, the purchase of an input is made until the price of the input equals the value of marginal product; the last unit of input purchased in which this condition holds is the **marginal unit**. A subsidy that applies to this marginal unit is called a *marginal subsidy.* A subsidy that applies to a last unit below the marginal unit, is called an *infra-marginal subsidy.* The theory implies that infra-marginal subsidy has no resource allocation impact; instead, the amount of subsidy is simply transferred effectively as income of the farm household. However, a marginal subsidy does affect resource allocation, in that it raises the amount of fertilizer input used in crop production. The difference between the value of marginal product and the without-subsidy market price of fertilizer, equals the welfare cost of the subsidy, also known as the "deadweight loss".

In the Philippines, the amount of fertilizer is PHP 5,500 per farmer per year, applied for a one-time purchase. The latest cost and returns survey estimates the average fertilizer expenditure per ha is PHP 10,649 per cropping, while the average area harvested is 0.9 ha; for the average farmer therefore, the subsidy is infra-marginal. However, the transfer of PHP 5,500 does incur considerable administrative cost, and may cover many farmers who can very well afford the fertilizer themselves. Hence, government may wish to consider more efficient and targeted means of making such transfers, such as the Rice Farmer Financial Assistance (RFFA).

There are however many farmers for whom the subsidy is marginal, thereby inflicting a deadweight loss, as well as incurring environmental costs. The fertilizer discount voucher does become a marginal subsidy for many farmers applying below-average amounts of fertilizer. For instance, in Central Visayas, the average expenditure per fertilizer per farmer (spending per ha multiplied by average area harvested) is only PHP 1,894, which is below the amount of the subsidy. For such farmers, the subsidy serves as an encouragement to apply more fertilizer than is justified by comparison of opportunity cost of fertilizer with the value of

incremental rice output. Moreover, as discussed earlier, it inflicts offsite costs through eutrophication, and undermines long term soil health.

6. Findings from the field appraisal

6.1. *Demand*

6.1.1 Organic agriculture

A major source of demand for organic-based fertilizer are organic growers, who apply a variety of types of organic-based fertilizers. The field appraisal showed a wide variety of practices with respect to organic-based fertilizers, even among organic farming practitioners. In solid form, common types of organic-based fertilizer are compost, vermicompost, and vermicast. Common substrates are crop wastes. When farmers have their own livestock (i.e. backyard piggery), or are near sources of manure (poultry farm, grazing area for carabao), they collect the manure and apply it to their vegetable farms. In Negros Oriental, most organic growers are vegetable farmers; only few sugarcane, rice, or corn farmers have gone organic.

Various types of liquid fertilizers are also applied. Some organic growers produce their own of liquid fertilizers; in one FO in Bicol region, the liquid fertilizer is made with livestock manure (carabao and pig). In Negros Oriental, raw materials used include banana peels, molasses, leftover (fermented) rice, and even fish discards. The resulting mixture is sprayed daily on sugarcane or corn farms.

Organic growers report being able to replicate or even improve upon yields obtained under conventional farming. For an organic FO in Caraga, rice farmers are able to obtain yields of 90 – 100 cavans per ha, compared with just 80 cavans per ha under conventional farming. Corn farmers report a similar improvement in harvest. However, the replication does not happen in the same cropping; sometimes they have to wait for the next cropping to raise yields (about 4 months). With organic farming, their yield is higher and cost is lower due to savings on chemical fertilizers and pesticides. The short conversion period though sounds optimistic; another organic FO in Caraga reports a period of two to three years of low yield, before raising yields back to conventional farming levels. On the other hand, in Negros Oriental, one farmer reported being unable to keep sugarcane yields high when using solely organic-based fertilizer.

Organic farming has encountered significant barriers in increasing the number of adopters. The organic FOs in Caraga admit that recruitment into the organic movement has been incremental; for many farmers, the initial drop in yield is a major disincentive to adopting organic farming. The prohibition against chemical pesticide also introduces risk of loss from pest infestation, for which organic pest control may be seen as poor substitutes. For Bicol, some vegetable growers report dividing their plots into a conventional plot (with chemical spraying) and an organic plot; the latter is the source of household consumption (although surplus organic produce is sold). In the case of Negros Oriental: many farmers tried out organic agriculture with the NISARD, but many could not sustain it – one problem is having sufficient quantities of organic fertilizer, which is a challenge for rice, corn, and sugarcane areas. Lastly, there is no organic label, and therefore no distinction between regular and organic produce in the market.

When there is an organic trading post set up by an NGO, there may be a modest premium over the price of regular produce.

6.1.2 Other demand sources

For major temporary crops, farmers tend to rely mostly or entirely on inorganic fertilizer, although in vegetable farming, use of chicken manure seems common. Among vegetable farmers in Eastern Visayas, Bicol, Central Visayas, and perhaps other regions, application of chicken manure seems to be a common practice. Chicken manure is favored as it is obtained from collection points (chicken farms) in semi-dried form, whereas other livestock (such as backyard piggeries, cattle) are scattered and in wet form. In Negros Oriental, some rice farmers use rice straw treated with Trichoderma inoculant to serve as seed bed for their rice seedlings.

Rice, corn, or sugarcane farmers apply organic-based fertilizer when there is a nearby source; one exception encountered are corn farmers in Bicol. Farmers in Caraga, Central Visayas, and Bicol reportedly use organic sources when convenient and near their farms, i.e. mudcake and molasses near sugar mills; livestock manure for farms near dairy farmers. Corn production in Bicol Region is exceptional: virtually all corn farmers apply chicken manure, even when distant from their farm, as it is well known that the corn does not perform well in the volcanic soil of Bicol if only fertilized with inorganic fertilizer. For one hectare, a typical dose is 40 sacks, applied as basal. This can substitute for 5 bags of synthetic fertilizers. Chemical fertilizers can be applied as side dressing (usually urea), and top dressing. Chicken manure costs PHP 50 per sack; if the chemical fertilizer costs just PHP 1,200 per sack, then the fertilizer cost goes down by PHP 5,000 per ha, while realizing comparable yields as with pure inorganic fertilizer (6 – 9 tons). Note that in large corn-growing regions of the country (Regions 2 and 10), inorganic fertilizer application was around 7-9 sacks per ha in 2023, whereas in Bicol region, inorganic fertilizer application was only 4.3 sacks per ha, perhaps due to this reliance on chicken manure.

Commercial organic fertilizers are applied when provided for free by government; hence a significant market for fertilizer producers is government itself. There are popular commercial liquid organic fertilizers, microbial inoculants, biofertilizers, and the like, which are regularly applied by farmers, as long as these are provided for free. Hence, orders from government programs is a significant market for both community-based small-scale producers (e.g. vermicompost and vermicast), as well as small and medium enterprises. One former licensee of UPLB for Trichoderma inoculant points to traders who supply to government as his primary market. There is also a large procurement of UPLB National Institute of Molecular Biology and Biotechnology (BIOTECH) for DA for distribution of biofertilizers. Some LGUs (such as Bais City and Naga City) are also producing their own organic fertilizer (especially vermicompost and vermicast) for distribution to farmers. On the other hand, there is no guarantee that farmers will continue to apply these commercial biofertilizers when government stops free distribution and/or subsidies. Bais City LGU estimates only 5 percent of their farmers apply BFS on their own; the proportion is higher when there is free biofertilizer or organic fertilizer distribution.

Traditional or new practices of organic-based fertilizer application is not well-informed by the latest science. According to agronomists consulted, application of fertilizer, organic-based or otherwise, should be informed by soil tests. The application of incompletely decomposed manure also runs contrary to PNS which favor fully decomposed manure. Another common practice is to keep rice straws in the field until the next planting. While better than the traditional practice of crop burning, this has the disadvantage of allowing anaerobic decomposition in the soil and thereby emitting greenhouse gases. Instead, aerobic decomposition in compost piles reduces greenhouse gas emissions. Finally, there are also stylized systems or technologies that are becoming popular, such as JADAM, which has won adherents among the organic movement, but is still informed mostly by anecdotal evidence.

6.2. *Supply*

6.2.1 Farm household and community production

Organic growers are actively producing their own fertilizers, whether individually or as a group. Organic growers commit to only organic-based fertilizers; often they would obtain these fertilizers by producing it at the household or community level. Examples of farm household production include some cases in Central Visayas, where farmers made their own concoction of fish amino acid using fish discards and molasses.

In Caraga region, an organic FO does manual composting using water lilies, leguminous plants, i.e. madre de cacao (*Gliricidia sepium*), and coco peat. Shredding though is done by a diesel-powered machine lent by the municipal LGU; members contribute to the fuel cost. A composting cycle takes 30 – 45 days.

Likewise in Bicol, organic growers apply a mix of carbon and nitrogen sources for composting, the latter using a combination of carabao manure and madre de cacao. They put fresh leaves of madre de cacao to 10 or 20 plots. They cover it with soil mixed with cow manure. They buy leaves of madre de cacao (source of nitrogen) for PHP 100 per sack, which is good for a vegetable plot of just 10 x 1 m. Alternatively, for some vegetables they water with extract of carabao manure following its immersion in a drum filled with water; 1 sack of carabao manure produces about 200 liters. They mainly use their own labor to make the fertilizer; they incur additional out of pocket cost for hauling manure (around PHP 200) once a month.

Farmers employing balanced fertilization have also engaged in producing their own compost with support from BSWM. In one case encountered (an FO in Bicol), farmers produced compost, while applying a combination of organic and inorganic fertilizer. They were assisted by BSWM who provided a shredder and rotary composter. The composter shortens the cycle to just one week (7 days), producing 20 – 30 bags per week, although the composter needs to run 8 hours a day. The estimated electricity cost is about Php 300 per week. An additional laborer is needed to collect and shred raw materials (30 percent of which is manure), for at least one day. The rotary composter is not always a successful program; in Region V for example, nearly all the 135 units turned over in 2023 were unused owing to lack of training in the equipment, unsuitable power source, or the receiving FO did not wish to incur electricity expense.

6.2.2 Commercial scale production

Basic forms of organic fertilizer are supplied by cooperatives or microenterprises in rural areas. Using a manual process, one FO in Caraga Region produces compost over a 45 day cycle, with an output of 600 sack (50 kg each); the compost is made to order, with purchases coming from LGUs and other buyers. In addition to compost, they make vermicompost, which is compost with additional 15 days of treatment with worms; during this time, they also collect vermicast. The main cost in composting is labor, which is paid PHP 300 per day, for collecting substrate, turning the compost pile, bagging the compost, and harvesting the vermicast. For 2024, the price per 50-kg sack of compost is PHP 300, while that of vermicast is PHP 500 per 10 kg sack. An estimate provided by a farmer in Samar is a production cost (labor, fuel, electricity) of just PHP 187.50 for a 50-kg sack, hence it is likely a profitable venture for compost sold at PHP 300 per sack, or more.

Another entrepreneur in Caraga into vermicompost produces 150 – 200 sacks per month (40 kg per sack). She sells to individual farmers, LGUs, and DA. Surigao del Norte: Vermicast production at own residence since 2016. Production of 150-200 sacks of 40 kilos, per month Composting facility approx. 300 sqm. She uses raw materials from nearby farms such as banana stalks, rice straws, mushroom, corn cobs, corn husks, and carbonized rice hull from nearby rice mills. She also uses manure from her own piggery and poultry farm.

More sophisticated products such as microbial inoculants are made by SMEs and a few large companies taking advantage of scale economies. One large composting company based in Batangas takes advantage of integrated dairy cattle and manure operation, as well as proximity to large poultry farm clusters in San Jose (Agribusiness How It Works 2023). Meanwhile for microbial inoculants, technology incubators, start-ups, and established companies have licensed organic fertilizer technologies from SUCs such as UPLB. One of these is the Trichoderma product manufacturer. He claims to have introduced additional innovations by improving on the technology for replicating the fungus, after years of doing his own R&D. The company has registered a product with rating of 150 colony-forming units (CFUs), over 200 times greater than the technology of the original inventor (Dr. Virginia Cuevas of UPLB). They are even able to produce up to a billion CFU in recent trials.

An example of the fertilization regime is described below, which applies to banana growing (Biospark Corporation, 2023):

- Apply 18.0 Kgs/ha, twice a year (months 1 and &). At 1,800 hills per ha, this comes to about 5 gm per hill
- Ideally, the inoculant should be mixed thoroughly chemical fertilizer. Assuming 150 kg of Ammosul (21-0-0 24S), this involves mixing 3 kg of inoculant per 50 kg bag of Ammosul.

The product is no longer under patent, hence licensing is no longer required. They can now produce 4 tons of output per month (400 boxes, 40 pouches per box, in 250 gm sachets per pouch). In doing so they employ 15 workers in a one-ha facility based in Batangas. Note that, based on the aforementioned recommendations, for banana alone their annual output is good for about 2,667 ha. The market is a personal network of buyers, which include wholesalers in turn supplying to DA.

6.3. *Programs and policies*

6.3.1 Organic agriculture program

NOAP focuses on disseminating organic farming through livelihood support and community-based certification. The NOAP encourages organizing organic practitioners into FOs, as well as coordinating with and capacitating LGUs in their respective local organic agriculture programs. They also implement the PGS, in cooperation with the Agricultural Training Institute (ATI), the regulatory division of DA Regional Field Offices (RFOs), and LGUs. They provide limited production support through the PGS and the Organic Agriculture Livelihood Program. Since 2021, 238 PGS group trainings have been conducted, of whom 39 groups have completed their certification as organic practitioners. Of these, 22 groups have been accredited as core PGS groups. These core PGS groups have certified a total of 203 total individual farms as organic. The same PGS and PGS-certified groups will also be authorized to produce organic fertilizers, thereby serving as suppliers for DA's organic fertilizer distribution program.

6.3.2 Other government programs and policies

Government is promoting adaptive BFS with input support and extension service, although support and recommendations usually focus on inorganic fertilizers. Input support is also provided for biofertilizers: in the case of DA Region V, for 2023-24 the rice program received PHP 400 million worth of fertilizer discount vouchers (FDV), of which PHP 51 million was for biofertilizers. These vouchers are focused on farmer clusters under the Farm and Fisheries Clustering and Consolidation (F2C2) program; the clusters identify which types of biofertilizers to include as FDVs or as in-kind assistance. Likewise, in 2024, DA Region 7 allotted PHP 333,511,000 for inorganic fertilizer, whether as voucher or in-kind, while spending only PHP 63,347,000 for biofertilizers.

However, recommendations of PhilRice from their Rice Crop Manager (RCM) covers only inorganic fertilizers (although the recommendations take into account existing organic-based fertilizer applications, such as use of rice straw); similarly their Minus One Element Technique (MOET) is calculated for inorganic fertilizers.

Aside from rice, the adaptive BFS demo farms, will soon include corn and vegetables. The latter is under the High Value Crops Development Program (HVCDP); in Region V. This program tends to provide in-kind input support. Common to all these programs however is difficulty in procuring organic fertilizers and biofertilizers – even when there are registered producers or marketing agents in the region, bidding for these products would sometimes fail.

Concerns have been raised about the state of competition and regulation of the organic fertilizer/biofertilizer industries. The Trichoderma producer suggests that big inorganic fertilizer companies are preventing dealer from offering organic-based fertilizers because of their fear of competition. They threaten to back out, which may mean large losses for fertilizer dealers. In fact, a business dispute with a previous co-investor, back when the company was a

UPLB licensee, had kept his production and marketing limited; the co-investor also marketed inorganic fertilizers, which for the informant seemed like a conflict of interest.

He also has problems about actions of regulators and certifiers. The regulators request for information seems to go beyond human and environmental safety, bordering on revealing proprietary information. This is especially the case for the OCB; he has therefore dropped out of registering Trichoderma as OBCA, simply registering his product with FPA as biofertilizer and microbial inoculant.

7. Conclusion and policy directions

The rapid appraisal has found that, though nutrient application in Philippine agriculture is dominated by inorganic, application of organic-based fertilizers is fairly common. This is especially the case in vegetable farming. There is considerable supply potential although a limiting factor is availability of raw material, namely animal and plant waste, and the cost of collecting these materials.

There are favorable prospects for expanding organic-based fertilizer utilization among farmers in the Philippines, as long as difficulties in obtaining adequate raw materials, as well as in marketing of organic-based fertilizers, can be overcome.

The major programs and policies in this space are the national organic agriculture program, the fertilizer component of production support services of the commodity programs, and the R&D and extension programs of government. Unfortunately, budgetary allocations tend to be still biased in favor of support for inorganic fertilizers.

Scientific and economic analysis suggest that combining inorganic and organic-based fertilizers allows for a balanced realization of the advantages of both types of fertilizer. Given these findings, we infer the following implications for policy:

- **Strengthen the NOAP by a) expanding the implementation of PGS; b) aggressively rolling out organic labeling of packaged organic produce.** The organic market is an acknowledged segment for safety-conscious consumers. Thus far a robust organic label has yet to emerge owing to high cost of certification. The PGS must be expanded with adequate funding, in coordination with a NOAP-funded labeling campaign to supermarkets, groceries, wet markets, and other retailers.
- **Review the regulatory system and competition oversight for organic fertilizers and biofertilizers.** Unlike for inorganic fertilizers, which is dominated by long established firms and standardized formulations, a large variety of innovative types of organic fertilizers and biofertilizers vie to be registered and commercially distributed in the Philippines.
- **Adopt a phased repurposing of fertilizer subsidy by gradually shifting the allocation from inorganic fertilizer to organic fertilizers and biofertilizers**. While most fertilizer subsidies are infra-marginal, some does introduce distortions, as well as have harmful off-site effects on the environment. Moreover, the inorganic fertilizer program incurs considerable administrative

cost, with no collateral benefits in terms of promoting technological progress (as farmers need little convincing about the advantages of inorganic fertilizers). Subsidies for organic-based fertilizers should be designed to encourage widespread adoption of BFS (or in some cases, full organic farming), and eventually to be phased out once the farmer has sustainably adopted the new technology.

- **Repurposing can also make funds available for area-based R&D to promote adaptive BFS, including soil mapping of all agricultural land in the country**. We have observed soil profiling and soil mapping in the field under funding from the national commodity programs (namely rice and corn). They have therefore focused on a patchwork of areas planted to the target crops. What is instead vastly preferred is an updated inventory of soil maps under the National Soil Health Program, to be disseminated to LGUs, and the local Agriculture and Fisheries Councils (AFCs) under the Philippine Council for Agriculture and Fisheries.
- **Beyond R&D, DA must invest heavily in extension to promote the widespread adoption of adaptive BFS.** The lead agency here is the BSWM, though funding can be drawn from the Education, Support, Extension, and Training Services (ESETS) of the various commodity programs. The extension program can inform farmers about the advantages of integrated nutrient management (INM), and develop advisory services (such as mobile phone apps) that include organic fertilizer recommendations. The program should also provide training for farmers and FOs for producing of organic fertilizers with quality compliant with PNS.
- **Implement a value chain program for the development of the biofertilizer and organic fertilizer industry**. Small-scale production of organic fertilizers is often romanticized, especially in the organic fertilizer movement. However, this will still fall short of mass production of organic fertilizers, which will require commercial enterprises motivated by profit. Development of value chains is the appropriate strategy for agro-industrialization (Briones 2023), and certainly development of the organic fertilizer industry is no exception.
- **Anchor the value chain program on support for commercial networks of private corporations and capacitated FOs, and coordinated with the distribution of organic fertilizer and biofertilizer vouchers.** Economic and financial sustainability of the organic fertilizer value chain requires robust profitability at all segments of the chain. Such profitability can be strongly supported by an organic fertilizer voucher program. Licensing of new technologies is one entry point for private sector investment. Government can further support value chain development and technology commercialization with a market campaign, aimed at farmers and FOs as end users of biofertilizers, as well as to fertilizer dealers to offer organic fertilizers. This will also countervail the alleged exercise of market power of inorganic fertilizer suppliers to keep organic fertilizers of their shelves.

- **Integrate value chain development of organic fertilizers and biofertilizers with development of the livestock, poultry, and agro-processing industry**. Organic fertilizer production is highly dependent on waste products of other agricultural industries, namely livestock and poultry (manure), as well as agro-processing (including slaughterhouses, dressing plants, fish canneries, grain mills, and other plant processing facilities). The more consolidated and large-scale are the supplying industries, the easier the logistics of collection and decomposition/treatment of raw materials for the downstream fertilizer industry.

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