COMMERCIAL ORGANIC FERTILIZER PRODUCTION

Issues and prospects

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FOREWORD

With the presidential announcement in April 2021 banning the import of chemical fertilizer a hitherto absent discourse was launched on organic agricultural inputs. Obviously, a market was immediately created for alternatives to chemical fertilizers. The question was, 'can enough be produced?' In other words, is there sufficient availability of biomass? There were other questions that were asked and not completely answered: a) would they be crop-specific and sensitive to climatic and soil variations? b) how will quality be assured and by whom? c) how about distribution problems? d) how about adaptation-readiness? e) is the institutional arrangement amenable to such a shift?

The policy-shift itself was prompted by well researched but largely ignored theses on the long-term ills of chemical inputs, not just for soil fertility but the general health of people. Interestingly, this study was initiated long before the decision to ban chemical fertilizer inputs. Fortuitously, therefore, much of the information collected and analyzed was used to the Institute's considered response to the decision: 'Transition to organic fertilizer: issues, challenges and strategies,' as well as an 18-month 'roadmap' which the Institute formulated and submitted to policy-makers.

This report, then, in its initial conceptualization, anticipates the policy decision and in fact delves into the details that tend to get lost, footnoted or ignored in the sweep of rhetoric and misplaced enthusiasm. Importantly, it maps the terrain in which strategies flowing from policy decisions get played out. It also reveals to those who believe or would have the world believe that non-chemical inputs are something new to Sri Lanka.

The truth is that there have always been players outside hegemonic paradigms and this is true of agriculture as well. And it is not some romantic or idyllic exercise that householders with disposable income and excess leisure time indulge in. The study, after all, is about the production of organic fertilizers for commercial purposes. There are costs and benefits involved and these are calculated by the relevant entrepreneurs. They have, probably without exception, experienced all kinds of issues. After the policy-decision referred to above, such initiatives got greater visibility, which revealed potentials and also shortfalls, indicating that many pieces of the puzzle have to be fitted in and fitted in accurately for a clearer and healthier picture to emerge.

To the credit of the research team, they have drawn from the information collected and the analysis of the same elements of a 'way forward.' Practical experience at a larger/national scale over the past 12 months or so have essentially reiterated their observations. If the policy-recommendations are given the attention they deserve, the future of green agriculture would be that much less dismal.

Malinda Seneviratne
Director/CEO

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EXECUTIVE SUMMARY

Organic matter content in the soil is a vital indicator of soil fertility that is crucial for maintaining soil sustainability by improving physical, chemical and biological properties. However, the organic matter content in Sri Lankan soils are inherently low and it was drastically reduced with the continuous crop cultivation and causes further depletion of soil fertility level. Long term use of synthetic fertilizers also contributes to depletion of soil fertility with direct implications on reducing productivity in agricultural lands. Hence, in order to reach optimal productivity in agricultural lands sustenance of organic matter content in soil is key.

Due to the importance of upgrading soil fertility level to enhance the productivity in agricultural lands as well as minimizing the negative impacts of the use of synthetic fertilizer, in 2021, the government made a policy decision to transform the conventional agriculture in to green agriculture. Accordingly imports of agrochemicals were banned from May 2021, and farmers were encouraged to use organic fertilizers for their cultivations. Consequently, demand for organic fertilizers in the country was suddenly increased and ample quantity of organic fertilizers were not available within the local market to cater the demand. As a remedy there is a need to increase the organic fertilizer production in commercial scale. However, majority of the organic fertilizer producers in the country are small scale producers and there is a need to uplift these producers to commercial scale organic fertilizer producers as well as promote the involvement of new entrepreneurs for commercial scale organic fertilizer production. Hence, this study was conducted to investigate the present status of the commercial scale organic fertilizer production sector in the country, the constraints faced by organic fertilizer producers and to find out the possible strategies to enhance the local commercial scale organic fertilizer production.

Primary data was collected from 120 commercial scale organic fertilizer producers in the country. In addition to that key informant interviews were conducted with the relevant officials to collect information regarding the organic fertilizer production sector in the country.

Findings revealed that the major type of organic fertilizer produced by the sample producers was compost and the production of liquid organic fertilizers and vermicompost was minimal. Varied input materials were used for organic fertilizer production on location based availability. A majority of producers possessed a greater understanding of the nutrient composition of raw materials used in organic fertilizer production. The main method used for composting was windrow method while use of rapid composting methods was minimal. Average monthly production is highly varied, depending on the availability of raw materials and market demand. Average cost of production for compost is 18 rupees per kilogram and for liquid fertilizer 280 rupees for one litre. More than 80 percent of producers received a training on organic fertilizer production. All of the sample producers were aware on the quality

certification of organic fertilizers and received the quality certificate issued from department of agriculture for their products.
Increased input prices and scarcity of input materials, lack of robust marketing mechanism and a guaranteed price for organic fertilizers, availability of low priced inferior organic fertilizer products at local markets and the high labour cost were identified as the major constraints faced by the commercial scale organic fertilizer producers in the country. Conduct training and demonstrations for organic fertilizer production, regulate the quality standards of organic fertilizer in local market, provide machineries and financial assistance, regulation of market prices of organic fertilizers and increase the farmers' awareness on organic fertilizer usage are requested by the organic fertilizer producers to expand their current fertilizer production.

Based on the findings it is concluded that there is a good potential to expand the organic fertilizer production in commercial scale and following strategies were proposed. It is suggested to formulate a long term national plan for enhance the organic fertilizer production in the country with necessary policy formulations for the production and use of organic fertilizers. Further it is suggested to initiate financial support system for organic fertilizer producers as well as introduce a well-established marketing system for organic fertilizers in the country. Initiate public private partnerships for enhance the production and use of organic fertilizers, develop laboratory facilities for quality testing of organic fertilizers with affordable prices and conducting research and training to promote latest technologies for rapid organic fertilizer production are vitally important for the expanding the commercial scale organic fertilizer production in the country.

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ABBREVIATIONS

ASC	-	Agrarian Service Center
C	-	Carbon
Ca	-	Calcium
DOA	-	Department of Agriculture
K	-	Potassium
KII	-	Key Informant Interviews
Mg	-	Magnesium
MOA	-	Ministry of Agriculture
MSW	-	Municipal Solid Waste
N	-	Nitrogen
P	-	Phosphorus
SLSI	-	Sri Lanka Standard Institute
TAMAP	-	Technical Assistance to the Modernization of Agriculture Programme in Sri Lanka

CHAPTER ONE

Introduction

1.1 Background of the Study

Nutrient management is one of the key agronomic practices to optimize productivity in agricultural lands. In agricultural lands soil nutrients are removed with harvested crops and continuous cultivation causes to decline soil fertility as a result of depletion of soil nutrient content (Scotti *et al.,* 2015). Therefore, maintaining soil fertility and nutrients is prerequisite for sustained crop growth and productivity. Organic matter in soil is an important indicator of soil fertility and plays a crucial role in maintaining sustainability as it improves soil physical, chemical and biological properties (Fageria, 2012). They provide all essential plant nutrients in readily available form and increase crop growth and yield. Hence, preservation of soil organic matter is important to ensure long term sustainability in agricultural lands and it can be achieved by adopting appropriate soil and crop management practices (Selim, 2020). In traditional farming systems generally included a fallow period in the cropping sequence to restore soil organic matter content. However, increase in global population and limited availability of lands for agriculture gradually led to reduction of fallow period until the custom of fallowing nearly disappeared (Selim, 2020). Also, organic manure has been in use as a nutrient source from the beginning of settled agriculture, but with the introduction of widespread use of chemical fertilizers organic manures were considered as a secondary source of nutrients (Geng *et al.,* 2019).

With the "Green revolution" in 1950's chemical fertilizers were identified as an essential input in agriculture, which plays a major role in soil nutrient management in current intensive farming systems. Since the introduction of chemical fertilizers to the country in late 1960's Sri Lankan farmers also adopted chemical fertilizers as a major nutrient source to increase the productivity of crop lands in commercial agriculture while neglecting other important aspects of soil fertility (Dandeniya and Dharmakeerthi, 2020). The application of chemical fertilizers can increase the soil nutrients within a short period, but they also cause soil hardness, decreased soil organic matter and pH level after a long period of application resulting in a loss of soil productivity (Sirisena *et al*., 2016). Due to excessive use of chemical fertilizers on agricultural lands soil fertility has drastically dropped over the past few decades (Silva *et al.,* 2020). Long term use of chemical fertilizers has not increased the productivity of crop lands but the cost of production (Geng *et al.,*2019). Also, excessive application of chemical fertilizer leads to food safety and quality decline issues and while giving rise to many health as well as social and environmental problems in the country (Chandrasiri *et al*., 2018; Jayasumana *et al*., 2013).

Soils in agricultural lands in Sri Lanka are inherently low in organic matter content and overall soil fertility and long term use of synthetic fertilizer further aggravated the condition (Dandeniya and Caucci., 2020). Application of organic fertilizer is deemed the best method to maintain soil organic matter content as it improves chemical, physical and biological properties of soil and contributes to enhance crop growth and productivity in those agricultural lands while facilitating environmental protection (Duran Lara *et al.,* 2020; Geng *et al.,* 2019). Studies have established that application of organic fertilizers over a long period leads to gradual improvement in soil productivity and crop performance have been observed by application of organic fertilizers over a long period of time (Sirisena *et al*., 2016).

Due to growing concerns in nutrient depletion and soil fertility decline in agricultural soils managed with synthetic fertilizers in the country, the Department of Agriculture (DOA) identified the importance of organic fertilizer in soil nutrient management. As a result, in the late 1990s compost application rates were incorporated into fertilizer recommendations of certain food crops in Sri Lanka and farmers were encouraged to use organic fertilizers in their agricultural lands. In parallel, a number of projects were initiated to expand the production of organic fertilizers, mainly compost, in different scales in the country. The scale and method of production varied from small scale at farm field or home gardens to large scale composting facilities operating at commercial scale (Dandeniya and Caucci., 2020). Commercial scale organic fertilizer producers are scattered around the country and currently range of organic fertilizers such as compost and liquid organic fertilizers are available at local markets under different commercial names.

Considering the role of organic fertilizer applications in enhancing agricultural productivity while minimizing the negative impacts caused by the use of synthetic fertilizer, a state sponsored policy came into effect to popularize the production and use of organic fertilizer. “Vistas of prosperity and splendor” the National Policy Framework of the current government emphasized the importance of organic fertilizer usage and production in the country. In effect, a ban on the import of synthetic fertilizers for agricultural purposes was imposed on May 2021. It was viewed as a move to encourage farmers to use organic fertilizers from the *Maha* season in 2021. Further a decision was reached at shifting the synthetic fertilizer subsidy to an organic fertilizer subsidy. Inevitably, a huge disparity between demand and supply of organic fertilizers occurred in the local market, compelling the government to take immediate measures to enhance the availability organic fertilizer in the country to fulfill the requirement.

Organic fertilizers can be produced with naturally available organic materials or agricultural by products at very low costs. The availability of inputs for organic fertilizer production such as green manure, animal manure, agricultural by products and rising demand assured high potential for further expansion of commercial scale organic fertilizer production in the country. Therefore, this study was conducted to find out the major issues and potentials for expansion of commercial organic fertilizer production in Sri Lanka with standard quality improvement.

1.2 Problem Statement and Justification

The development policy of the government from 2010 to 2015 targeted reducing of chemical fertilizer imports up to 15 percent by promoting organic fertilizers. As a result, different projects to promote the production and use of organic fertilizers were initiated but the target was not achieved. Organic fertilizers were commonly used in nursery management, home gardening and floriculture industry and not widely used in commercial scale cultivations of fruits, vegetables and other annual crops (Herath 2016; Dandeniya and Caucci, 2020).

However, due to the current government policy decision on ban of import of chemical fertilizer to the country from the May 2021, demand for the organic fertilizer is suddenly increased and existing production of organic fertilizers is far behind the expectations. There are huge number of small and medium scale producers in the country while limited number of large scale producers are engaged in organic fertilizer production in commercial scale (Dandeniya and Caucci, 2020). The contribution of small and medium scale producers to organic fertilizer market remains minimal mainly due to limited production capacities at household level. Expanding large scale organic fertilizer production facilities are a prerequisite to cater the demand for organic fertilizer (Hitihamu *et.al.,* 2009). The technical report of "Technical Assistance to the Modernization of Agriculture Programme in Sri Lanka (TAMAP) "Organic farming and sustainable agriculture in Sri Lanka" also revealed that elevating the organic fertilizer production to commercial scale is highly crucial in meeting the demand for organic fertilizer in the country.

On the flip side, low nutrient content and substandard organic fertilizers available in market made organic fertilizer less popular among the farmers in the country. As mentioned by the Dandeniya and Caucci, 2020, most of the farmers were not interested on organic fertilizer application as they not show yield improvement in short period as well as high cost when compared with synthetic fertilizer application. Compared to synthetic fertilizers large quantity of organic fertilizers are required to provide the nutrient requirement of cultivated crops. To maintain the quality of organic fertilizers in the country set of standards were introduced but, currently there are many organic fertilizers available at the markets without these quality standards and application of those fertilizers will not be beneficial for the plant growth as expected. The TAMAP (2020) report also highlights the importance of quality improvement in commercially available organic fertilizers in the country.

The above facts stress of the need for expanding quality organic fertilizer production in the country at commercial scale for organic farming to be successful. Many scientific studies were carried out to find out the impacts of organic fertilizer application on various crops in the country, but minimal scientific evidence is available on commercial scale organic fertilizer production. A greater understanding on the present status, constraints and potentials of commercial scale organic fertilizer production, distribution and marketing is important to further expansion of commercial organic fertilizer production sector in the country and to increase the availability of quality organic fertilizers at local markets with affordable prices for farmers. Therefore, this study was undertaken to fill those existing knowledge gaps on commercial scale organic fertilizer production sector in Sri Lanka.

1.3 Research Questions

Accordingly, this study was answered for the following questions regarding to the commercial scale organic fertilizer production in the country.

1. What is the present status of commercial scale organic fertilizer production in the country?
2. What are the constraints prevailing in the commercial scale organic fertilizer production sector?
3. What are the possible strategies to expand the organic fertilizer production at commercial scale?

1.4 Objectives of the Study

The general objective of this study was to identify the issues and potentials of commercial scale organic fertilizer production to enhance the production of quality organic fertilizer in the country.

Specific Objectives

1. To explore the present situation of commercial scale organic fertilizer production in the country
2. To examine the major constraints in organic fertilizer production at commercial scale
3. To identify possible strategies for enhancing the production of standard organic fertilizer in the country at commercial scale

1.5 Significance of the Study

Pertaining to the organic fertilizer sector in Sri Lanka, only few studies were conducted on organic fertilizer production and most are focused on compost production from Municipal Solid Wastes (MSW) in different regions in the country (Samarasinghe *et al.,*2014; Bekchanov and Mirzabaev 2018; Rashmika and Edirisinghe, 2016). However, there are issues related to the quality of compost produced with MSW as most of them contain toxic heavy metals which can be harmful for agro environmental systems (Araujo *et al.,* 2010; Smith, 2009). Hitihamu *et al.,* 2009 conducted a research to find out potentials and constraints of organic fertilizer usage in farmers in Kandy district. Also, Herath *et al.,* 2016, conducted a study on organic fertilizer production and use in the country but it is mainly focused on small scale organic fertilizer producers and compost production in municipals councils using MSW.

However, it is hard to find the literature on commercial scale organic fertilizer production using plant and animal based materials and agricultural by products which are identified as best sources to substitute synthetic fertilizers. Thus, this study is mainly focused to identify the constraints and potentials for expansion of commercial scale organic fertilizer production by use of naturally available plant and animal based materials specially from agricultural by products in the country. The study explores the status of organic fertilizer production in Sri Lanka and the findings may facilitate further research and provide focus for policy interventions to address technical and market inefficiencies prevailing in commercial organic fertilizer production, develop production technologies as well as raise awareness of all stakeholders on organic fertilizers for the success of projects and programmes aimed at organic fertilizer production.

CHAPTER TWO

Methodology

2.1 Sample Selection

In 2020, a total of 325 compost producers were registered with DOA for quality certification and based on the monthly production they were categorized in to three scales: small, medium and large scale producers (Table 2.1).

Table 2.1: Organic Fertilizer Producers Registered with DOA for Year 2020

Scale of production (tons/month)	Number of producers	Total monthly production (tons)	Monthly production as %
Large scale (> 25)	41	4552	81
Medium (5 to 25)	79	789	14
Small (< 5)	205	309	5
Total	325	5650	100

Source: DOA

The list of organic fertilizer producers available at the DOA for the year 2020 was used as the sample frame. Commercial scale organic fertilizer producers were scattered around the country and the sample was derived purposively based on the scale of production. From each scale 40 producers were selected to constitute a sample of 120 organic fertilizer producers. The distribution of sample organic fertilizer producers is presented in Table 2.2.

2.2 Type of Data and Data Collection

To achieve the objectives of the study both primary and secondary data was assessed. Primary data was collected through a questionnaire survey and Key Informant Interviews (KII). Due to the COVID 19 pandemic a questionnaire survey was conducted via telephone. Pre tested semi structured questionnaire was used to collect data from organic fertilizer producers. Data collection was carried out from August to November in 2021. KII were conducted with the relevant officers in the Ministry of Agriculture(MOA), National Fertilizer Secretariat, DOA, Department of Agrarian Development and Sri Lanka Standards Institute (SLSI) to gather information and their views on organic fertilizer production in Sri Lanka.

Secondary data was collected from journal articles, other publications and annual reports of government institutes.

Table 2.2: Distribution of Selected Organic Fertilizer Producers

District	Number of selected organic fertilizer producers		
	Large scale	Medium scale	Small scale
Colombo	3	1	2
Gampaha	4	5	9
Kalutara	3	3	3
Kegalle	-	6	2
Ratnapura	1	-	-
Anuradhapura	4	3	6
Polonnaruwa	-	3	1
Kurunegala	11	4	1
Puttalam	1	4	1
Kandy	-	1	1
Matale	2	1	2
Nuwara eliya	1	3	2
Badulla	2	-	1
Moneragala	3	1	-
Hambanthota	3	4	3
Galle	1	1	4
Matara	-	-	2
Batticloa	1	-	-
Total	40	40	40

2.3 Data Analysis

To achieve the objectives of the study, collected data was analyzed using descriptive analysis which included tables, graphs and charts. Strengths, Weaknesses, Opportunities and Threats (SWOT) assessment tool was applied for identifying the strengths, weaknesses, opportunities and threats of organic fertilizer production in the country and suggest possible strategies to promote commercial scale organic fertilizer production in the country.

CHAPTER THREE

An Overview of Organic Fertilizer Production

3.1 Organic Fertilizers

Organic fertilizers are carbon based compounds derived from organic sources such as green manure, animal manure, plant and animal by products, agricultural wastes, seaweeds and minerals (Assefa and Tadesse, 2019). Organic fertilizers contain moderate amount of plant essential nutrients as well as many trace elements. They are considered as slow releasing fertilizers and gradually release nutrient in to the soil solution and maintain nutrient balance for healthy crop growth. Also, they act as effective energy source of soil microbes which in turn improve soil structure and plant growth (Green, 2015). Organic fertilizers are mitigating several problems associated with the application of synthetic fertilizers. However, improper use of organic fertilizers leads to over fertilization or nutrient deficiency in the soil and controlled application of organic fertilizers is an effective way to overcome these impacts and maintain sustainable agriculture yield (Shaji, 2021). Organic fertilizers are produced through the processes of drying, composting, chopping, grinding, fermenting or other methods (Hammed *et al.,* 2019).

3.2 Sources for Organic Fertilizer Production and Their Nutrient Compositions

Sources of organic fertilizer in broad sense include rural and urban wastes, crop residues, agro industrial bio wastes, green manures and animal manures. Crop wastes including straw, banana leaves, sugarcane trash and any other plant material removed from agricultural lands can be used for organic fertilizer production. By products from agro industries such as oil cakes, bagasse, press mud, fruit and vegetable processing waste are good sources for organic fertilizer production. In addition, powdered rocks and minerals such as lime and rock phosphate are also used in organic fertilizer production (Kokoasse and Desmond, 2016).

The nutrient content of organic fertilizers mainly depends on the source of materials and readily biodegradable materials make better nutrient sources. Generally, Nitrogen (N) and Phosphorus (P) content are lower in organic fertilizers compared to chemical fertilizers. Moisture content is another factor that reduces or dilutes the nitrogen and phosphorous concentrations of organic fertilizers (Padilla *et al.,* 2017).
Nutrient value of animal manures is more variable than that of agricultural by products. The animal's diet, the use and type of bedding material, manure age and how it was stored are main factors that affect manure nutrient value. In contrast nutrient content of agricultural by products is less variable but can be affected by the industrial process used to produce the by product. However, it is important to analytically determine the nutrient content of organic fertilizer before application (Green, 2015).

3.3 Main Types of Organic Fertilizers

3.3.1 Compost

Compost is the most common type of organic fertilizer used around the world. Compost is a stable humus like product resulting from the biological decomposition of organic matter under controlled conditions. It is a biologically active material and typically dark brown with an earthy appearance and smell (Paul, 2019). There are different forms of compost fertilizers available as commercial products. Compost powder is the original form of end product of the composting process. It is a black to dark brown coloured powder. Compost pellets are the densified form of compost. Pellets are made by compressing compost using a machine. Compost pellets are easy to handle, transport and store. One of the other benefits of compost pelletizing is the ability of adding chemical materials to increase the nutrient quality (Papandrea *et al.,* 2021). Compost tea is a fermented water extracts of composted materials and depending on the method of production they can be further categorized in to aerated compost tea or non-aerated compost tea. Generally, compost tea is produced by mixing one volume of compost with four to ten volumes of water (Gomez *et al.,* 2015).

3.3.2 Vermicompost

Vermicompost is a type of compost produced in a non-thermophilic process involving interactions between earthworms and microorganisms leading to bio oxidation and stabilization of organic material. Earthworms consume all kinds of organic matter of which only 5 to 10 percent is used for their growth and they excrete the mucus-coated undigested matter called vermicast. These vermicast are rich in nutrients such as N, P, K, Ca, Mg, vitamins, enzymes and growth promoting substances. Earthworms can consume their own body weight per day (eg: 1kg earthworms can consume 1kg residues a day). Further warms do the turning of organic matter and no additional turning of the compost heap is required. Therefore, production of vermicompost is a cost-effective, time saving, and efficient process. Vermiwash is a kind of liquid fertilizer produced by passing water through columns of vermicompost beds (Brandon et al., 2015).

Vermicompost is ideal organic manure for better growth and yield of many plants due to various reasons. It has higher nutritional value than traditional composts mainly due to increased rate of mineralization and degree of humification by the action of earthworms. Also, it has high porosity, aeration, drainage and water holding capacity. Presence of microbiota particularly fungi, bacteria and actinomycetes makes it suitable for plant growth. Nutrients such as nitrates, phosphates, and exchangeable calcium and soluble potassium in plant-available forms are present in vermicompost. Plant growth regulators and other plant growth influencing materials produced by microorganisms are also present in vermicompost. As vermicompost is rich in microbial activity and contains antagonistic organisms to control plant pathogens it acts as an effective bio control agent (Joshi *et al.,* 2014).

3.3.3 Liquid Organic Fertilizers

Liquid organic fertilizers are produced by simple fermentation processes using organic wastes as carbon substrates such as plants and animal manure and agricultural by products. Fish wastes, cattle manure and urine are best sources for liquid organic fertilizers as they provide much needed nutrition to plants and soil. Microorganisms play an important role on the degradation of substrates in the fermentation process (Phibunwatthanawong and Riddech, 2019). They consist of essential plant nutrients and beneficial microorganisms which recycle organic matter. In addition, liquid organic fertilizers are rich with phyto hormones such as auxin and cytokinin, organic acids and plant growth promoters. Liquid organic fertilizers increase the nitrogen use efficiency when applied through a drip irrigation system known as fertigation (Martinz-Alcantara *et al*., 2016).

3.3.4 Concentrated Organic Manures

Concentrated organic manures contain higher percentages of major plant nutrients such as N, P and K, compared to bulky organic manures such as compost. They are derived from raw materials of plant or animal origin such as oilcakes, fish manure, dried blood, bone meal. Oilcakes are the residues left after oil is extracted from oil bearing seeds. Generally, edible oilcakes are used for animal feed, while non-edible oilcakes are used as manures. They contain higher amounts of N than P and K, thus these are commonly considered as organic nitrogenous fertilizers. Bone meal are made from finely ground bones obtained from cattle and other animal bones remains from the slaughter houses. It is a vital source of calcium and phosphate as well as fats and proteins. Blood meal refers to dried and powdered blood of animals especially from cattle slaughterhouses. It is usually used as organic fertilizer owing to its richness in N. Fish manure is a quick acting manure and suitable for all soils and crops. It is available as either dried fish or fish meal or powdered fish. It has high levels of calcium and some considerable amount of P together with other elements (Padilla *et al.,* 2017).

3.4 Compost Production

A compost production system is a set of distinct operations that together produce compost products from raw feed stocks. A system also includes the associated infrastructure such as buildings, equipment and utilities. Composting method is the principal part and some systems may employ two methods to accommodate different stages of composting. Supporting operations include feedstock receiving and inspection, sorting and separation, feedstock storage, grinding or size reduction, mixing, curing, odor treatment, product storage, product blending, bagging and transportation. These all operations are not necessary in all systems and depends on the composting method employed and the intended use and markets for the compost. Composting is the natural biological process of decomposition of organic matter by microorganisms under controlled conditions. Many biological transformations and products occur in the composting process, mediated by a variety of microorganisms, inhabiting diverse micro environments (Yu *et al.,* 2016). Most preferred conditions for composting are listed in Table 3.1.

Table 3.1: Preferred Conditions for Composting

Condition	Reasonable range	Preferred range
Carbon to Nitrogen (C/N)ratio	20:1 – 40:1	25:1 – 30:1
Moisture content	40 – 65%	50 – 60%
Oxygen concentration	Greater than 5%	Much greater than 5%
Particle size (diameter in mm)	3 - 13	Varies (depends on the specific materials, pile size and weather conditions
pH	5.5 – 9.0	6.5 – 8.0
Temperature (0C)	43 - 66	54 - 60

Source: Yu *et al.*, 2016

With the nature of decomposition process, composting can be divided into two categories called anaerobic and aerobic composting. Main differences in these two processes are summarized in the following Table 3.2.

Table 3.2: Differences in Composting Process

Anaerobic composting	Aerobic composting
• Decomposition occurs when oxygen is absent or in limited supply	• Decomposition occurs in the presence of ample oxygen
• Anaerobic microorganisms are dominated	• Aerobic microorganisms involved
• Develop intermediate compounds including methane, organic acids, hydrogen sulphide and these compounds accumulate and not metabolized further	• Produce carbon dioxide, ammonia, water, heat and humus
• Have strong odours	Low level of Odours
• Present phytotoxicity	• Low level of phytotoxicity
• Low temperature process	• Heat generated during the process
• Compost may contain weed seeds and pathogens	• Destroys pathogenic microorganisms and weed seeds
• Takes longer time	• Processing time is lower
• Low nutrient loss from raw materials	• More nutrient loss from raw materials and efficient in agricultural production

Source: Yu *et al.*, 2016

3.4.1 Composting Method

The composting method provides the conditions for microorganisms to convert raw feed stocks into compost. The method dictates how the composting materials are aerated, contained and moved through the system. There are numerous ways to characterize composting methods including the degree of containment (open vs in vessel), mode of aeration (passive vs forced), use of agitation (static vs turned) and the physical progression of materials through the composting process (batch vs continuous). Composting methods vary from small scale on farm traditional methods to large scale commercial production methods (Tweib *et al.,* 2011).

3.4.1.1 Small Scale Traditional Composting Methods

Traditional methods based on passive composting approach involve simply stacking the material in piles to decompose over a long period with little agitation and management (Misra *et al.,* 2003).

3.4.1.2 Commercial Scale Composting Methods

Commercial scale composting methods can be categorized in to two broad groups namely open methods and in vessel or contained systems. In open composting method the materials are composted in free standing piles or windrows. In some cases, materials are placed in simple two or three sided bins. Composting may take place outdoors or under the cover of a building. The defining feature of open composting methods is that they do not control the environment surrounding the composting materials. Common open composting methods include turned windrows, passively aerated windrow system, static piles and forced aerated static piles. In vessel composting methods refers to a group of methods that confine the composting materials within container or vessel. In vessel methods rely on a variety of forced aeration and mechanical turning techniques to accelerate the composting process. Main in vessel composting methods are bin composting, rectangular agitated beds, silos and rotating drums (Misra *et al.,* 2003).

Turned Windrow Method

Most common method used in large scale composting. This method forms raw materials into long narrow piles or windrows. To supplement passive aeration windrows are turned on a regular basis by manually or turning machines. The size of the windrow is determined by the turning method and the raw materials used for composting. Number of turnings and time between turnings varies from producer to producer. Turning mixes and blends feed stocks, homogenizes materials in the windrow, releases trapped gases and heat, distributes water, nutrients and microorganisms throughout the windrow and exchanges material from the cool oxygenated environment at the surface of the windrow with material from the warmer O_2 poor areas near the core. Depending on the feed stocks and aggressiveness of turning equipment turning also reduces particle size. Turned windrow method is a simple and flexible approach to composting. It easily accommodates a wide range of feed stocks, scales of operation, financial resources, equipment and management strategies. It is a proven successful method of composting. Disadvantages of this method are the that windrows and space for turning activities occupy a large area and therefore they are expensive to enclose within a building. Also aerobic conditions are not always maintained within windrows and create odours in the interior (Misra *et al.,* 2003).

Passively Aerated Windrow System (PAWS)
This method was first developed in Canada for composting and several modifications and variations were done over time. Under this method air is supplied to the composting materials through perforated pipes embedded in each row and thereby eliminate the need for turning. Raw materials must be mixed thoroughly before they are placed in the windrow (Misra *et al.,* 2003).

Static Pile Method
This method is a low management method which is commonly used for slowly decomposing feed stocks like farm residues and green manures. These piles are simple freestanding piles and the size usually ranges from 2 to 5m height and the width is slightly less than twice its height. Length does not affect the process and is determined by materials handling preferences and the constraints of the site.
Several feed stocks may be combined and mixed to adjust moisture, porosity, bulk density and C: N ratio, but once a pile is formed it is left undisturbed for months. Turning is not necessary in this method, but turning reduces the time required to produce compost. Due to the anaerobic conditions in static piles composting process takes long time period to complete. Sometimes it required more than a year to complete the compost production. Static pile method is a potentially economical and successful approach to composting if time and space are available and if odours are not critical. This one year composting cycle is practical for many feed stocks especially those that are generated almost entirely at a particular time of year, such as deciduous tree leaves, rice straws (Misra *et al.,* 2003).

Forced Aerated Static Pile Method
This method uses a blower to supply air to the composting materials. The blower provides direct control of the process and allows larger piles. Not turning or agitation of the materials occurs once the pile is formed. Therefore, selection and initial mixing of raw material are critical in this method. When the pile has been properly formed and of the air supply is sufficient and the distribution is uniform, the active composting period will be completed in approximately three to five weeks (Misra *et al.,* 2003).

Bin Composting
This is the simplest in vessel method. The raw materials are contained in a bin or storage building. Bin composting method operate as same as aerated static pile. Bins can eliminate weather problems, contain odours and provide better temperature control for composting process (Misra *et al.,* 2003).

Rectangular Agitated Beds
This system combines controlled aeration with periodic turning. The composting takes place between walls that from long narrow channels referred to as beds. Most commercial systems include a set of aeration pipes in the floor of the bed. The length of a bed and frequency of turning determine the composting period. Generally, commercial agitated bed systems the composting process take two to four weeks (Misra *et al.,* 2003).

Silos
In this method every day composted material is removed from the bottom of the silo and mixture of raw materials is loaded at the top. The aeration system blows air up from the base of the silo through the composting materials. Typical composting time for this method is 14 days. After leaving the silo, the compost is cured in a second aerated silo. This system minimizes the area needed for composting because the materials are stacked vertically (Misra *et al.,* 2003).

Rotating Drums
This system uses a horizontal rotary drum to mix, aerate and move the material through the system. The drum is mounted on large bearings and turned through a bull gear. In the drum the composting process starts quickly and further decomposition of materials is accomplished through a second stage of composting usually in windrows or aerated static piles (Misra *et al.,* 2003).

3.5 Vermicompost Production

Vermicomposting uses earthworms for composting organic residues. For preparation of a good quality vermicompost, a number of steps should be followed. The locally available earthworm native to a particular soil and efficient for fast composting may be used for vermicomposting. Size of the pit may be depending on the quantity of raw materials. Generally, 2 m × 1 m × 1m pit can hold 20000 to 40000 worms giving 1 ton manure per cycle. The pit should be base concreted as termite proof and ant proof through a water drain built around it. A shade of six to eight ft height is also required for cool and ambient climate for the worms.

- Preparation of vermibed: A thick layer of 15–20 cm of good loamy soil above a thin layer (5 cm) of broken bricks and sand should be made. This layer is prepared on concreted floor and made to inhabit the earthworms.
- Inoculation of earthworms: About 100 earthworms are introduced as an optimum inoculating density into a composite pit of about 2 m × 1 m × 1 m, provided with a vermibed.
- Organic layering: It is done on the vermibed with fresh cattle dung of 5–10 cm. The compost pit is then layered to about 5 cm with dry crop residues. Carbon-rich solid and dead substrates like sawdust, paper, and straw are mixed with N-rich natural components such as sewage, sludge, and biogas slurry to obtain a near optimum C/N ratio.

Mixing a variety of substances produces good-quality compost which is rich in macro, micro, and even trace nutrients. Decomposition can be accelerated by chopping raw materials into small pieces. Moisture content of the pit is maintained at 50–60% of water holding capacity. Aeration can be maintained by mixing with fibrous N-rich materials. The temperature of the piles should be around 28–30°C. After one month moist green organic waste should be spread over the pit. This practice can be repeated every three to four days as per requirement. Mixing of wastes periodically without disturbing the vermibed ensures proper vermicomposting. Wet layering with organic waste can be repeated till the compost pit is nearly full (Misra *et al.,* 2003).

In order to facilitate the separation of worms from vermicompost, the moisture content in the compost is brought down by stopping the addition of water around 7–10 days before maturation that ensures drying of compost and migration of worms into the vermibed. This forces about 80% of the worms to the bottom of the bed. The remaining worms can be removed by hand. The mature compost, a black, fine loose, granular humus rich material is removed out from the pit, dried, and packed. The pleasant earthen smell is one of the good indications of mature compost. Vermicomposting is a rapid method and low cost method and makes very attractive for practical application (Misra *et al.,* 2003).

3.6 The Way of Enriching Organic Fertilizers into Nutrient Rich Compounds

Bulky organic fertilizers like compost and farm yard manure contain very low amount of essential plant nutrient content. Therefore, production cost, storage, transport and application of these types of organic fertilizers are high. The demerits of bulky organic fertilizers can be overcome through the preparation of enriched organic fertilizers by adding nutrients such as N,P,K and micronutrients either alone or in combination (Marcelo and Sonia, 2016).

Compared to the common organic fertilizers, these enriched organic fertilizers have several advantages. Enriched organic fertilizer is more concentrated and it reduces the bulk to be handled per unit of nutrient. Also it increases nutrient use efficiency of added fertilizer and maintain soil organic carbon. Enriched organic fertilizers prevent nutrient losses due to microbial immobilization of nutrients during decomposition of organic residues and due to adsorption of cations on account of high exchange capacity of organic matter. Further, there are less problems in handling, storage and transportation of enriched organic fertilizers. Additionally, it offers a potential avenue for the efficient utilization of low grade materials such as rock phosphate. Enrichment of organic fertilizer can be done in two ways, namely physical addition of fertilizer materials during organic fertilizer production and addition of fertilizer materials by mixing with final product of organic fertilizer (Marcelo and Sonia, 2016).

3.6.1 Enrichment of Organic Fertilizers with Nitrogen

During the organic fertilizer production N fertilizers such as urea or ammonium sulphate can be added. It increases the C/N ratio and enhance the microbial mineralization and immobilization and speed up the decomposition process. Addition of nitrogen fertilizer serves as a starter. Enrichment of N during organic fertilizer production with inorganic N can be done up to 1.8 to 2.5 percent but cannot be improved beyond 2.5 percent, because of the associated losses of N includes the production of free NH_3. However, in case of ready organic fertilizers it is recommended that organic fertilizers with C/N ratio of about 20:1 should be treated with fertilizer N so as to bring the C/N ratio to <10:1 and N content >2.5 percent, thus by spraying a solution of urea on finished product of organic fertilizer followed by physical blending the N content can be increased up to 5 to 7 percent (Marcelo and Sonia, 2016).

3.6.2 Enrichment of Organic Fertilizer with Phosphorus

Phosphorus-enriched compost can be prepared by adding five percent superphosphate, dicalcium phosphate (DCP), and rock phosphate at the time of filling of the compost pits. Due to enrichment with soluble phosphate in compost, a small amount of immobilized soluble P into microbial body may be expected. But with most plant material containing sufficient P to satisfy microbial demands during decomposition, assimilation of P from external sources is seldom needed. Addition of insoluble sources of P like low-grade rock phosphate to enrich compost is a more rational and practical approach, since solubilization of sparingly soluble P occurs during composting. Besides phosphorus, it is a source of calcium and micronutrients. Early work showed that by adding rock phosphate to farm composting materials to a thickness of about 5 mm per layer, nearly 50–70% of sparingly soluble P could be converted to soluble from which is readily available to plants. Addition of soluble fertilizer P to finished compost provides a better scope for increasing the efficiency of fertilizer P as well as organic P. Thorough mixing of fertilizers with compost may reduce P-fixation. The mineralization of organic P may also be accelerated due to increased solubility of organic P in the presence of fertilizers. Amalgamation of compost with single superphosphate (SSP) could raise phosphorus content of the enriched compost up to 5% P_2O_5 (Marcelo and Sonia, 2016).

3.6.3 Enrichment of Organic Fertilizers with Potassium

To enrich the compost, potassium-bearing minerals like feldspars and mica can be added during composting. The availability of potassium can be improved due to the production of organic acids such as citric, tartaric, acetic acid, etc. Potassium can also be added to compost by incorporating plant materials, which contain appreciable amounts of potassium, viz., water hyacinth and banana skin, are rich source of potassium. Dry potato vines also contain about 1% potassium which can be incorporated to improve the K content in the compost (Marcelo and Sonia, 2016).

3.6.4 Enrichment of Organic Fertilizers with Bio inoculants

Addition of nitrogen-fixing bacteria and/or phosphate- and potassium solubilizing microorganisms is one of the possible means of improving nutrient content of the final product of organic fertilizers. Inoculation of *Azotobacter, Azospirillum, Clostridium*, etc. to the compost heap enhances N content by fixing atmospheric N_2. Phosphate-solubilizing bacteria such as *Bacillus polymyxa*, *Pseudomonas striata*, and fungi such as *Aspergillus awamori* can be introduced into the composting mass along with rock phosphate. These microorganisms help in solubilizing sparingly soluble inorganic phosphates due to the production of organic acids such as citric, tartaric, gluconic acid, etc. and thereby increasing the available P, both water-soluble and citrate soluble P, content of organic fertilizers. Some cellulolytic and lignolytic microorganisms such as *Trichoderma viride, Trichurus spiralis, Paecilomyces fusisporus*, and *Phanerochaete chrysosporium* are used as compost accelerator to expedite the process of composting (Marcelo and Sonia, 2016).

3.7 Quality of Organic Fertilizers Produced in Commercial Scale

Application of organic fertilizers improved soil fertility and nutrient content in significant manner. However, application of poor quality organic fertilizers to soil can deteriorate environmental quality and pose a threat to the safety of food. Therefore, quality certification is the most essential criteria for marketing of organic fertilizers (Mavaddati *et al.,* 2010). Quality of organic fertilizer is complex and is related to the intended use of the final product and main aspects on quality include its maturity, type, nutrient content and levels of contaminants. Quality of organic fertilizer is measured by several criteria including moisture content, nutrient content such as C: N ratio, total Nitrogen, available nitrogen, heavy metal, stability, particle size distribution, pathogen levels and product consistency over time (Shaji *et al.,* 2021).

3.8 Organic Fertilizer Production: Evidence from Other Countries

3.8.1 Vietnam

In Vietnam, organic fertilizers are produced in two ways, traditional composting and industrial production. Traditional composting methods are mainly used on farm scale based on waste materials or crop residues collected from livestock and household farming. The traditional composting procedures take as long as four to eight months to produce finished compost, by which organic residues are mixed well and mineral elements can be added and then composted into piles (Toan*, et al*., 2019).

The industrial production of organic fertilizer is production of compost in industrial scale by using rapid composting technology. Rapid composting methods offer possibilities for reducing the processing period up to some weeks. There are several composting technologies in Vietnam such as pile composting, box chamber composting, open furrow composting with turning and aeration and enclosed vessel composting with mechanical agitation and aeration. By the end of 2017, there were 180 companies permitted for producing organic fertilizer in Vietnam with the total production capacity of 2.5 million tons per year, accounting for 8.5% of total fertilizer production capacity in the country (Toan, *et al*., 2019).

By the end of 2016, there were 24 Vietnamese standards issues related to organic fertilizer, which focused mainly on testing methods to determine the density and biological activity of microorganisms in the compost enrichment inoculants and content of limiting factors in organic fertilizer. Some additional biological substances in fertilizers such as amino acids, vitamins, plant growth regulators do not have standard methods for testing and controlling fertilizer quality (Toan, *et al.,* 2019).

The main quality parameters for organic fertilizers in Vietnam are summarized in Table 3.3.

Table 3.3: Quality Requirements of Organic Fertilizer in Vietnam

Type of organic fertilizer	Quality parameters	Measured unit	Standards
Traditional organic fertilizer	Organic matter	%	>= 20.0
	C/N		<= 12.0
	Moisture	%	<=30.0
	pH H_2O		>=15.0
Bio organic fertilizer	Organic matter	%	>=15.0
	Density of beneficial microbes	CFU/g	>=1.0 *10^6
	Number of infective propagules of mycorhiza	IP/g	>=10
	Moisture	%	<=30.0
	pH H_2O		>=5.0
Biological organic fertilizer	Organic matter	%	>=20.0
	Humix acid / fulvic acid	%	>=2.0
	Moisture	%	<= 30.0
	pH H_2O		>=5.0
Organic mineral fertilizer	Organic matter	%	>= 15.0
	Content of total nitrogen available phosphorus and potassium	%	>= 8.0 <=18.0
	content of each total nitrogen available phosphorus and potassium	%	>=2.0
	Moisture	%	<=25.0
	pH H_2O		>=5.0

Source: Toan *et al., 2019*

3.8.2. China

In the last decade compost production in China has rapidly increased. Chinese government provides subsidies for composting factories and as a result price of compost in the market is reduced significantly. Therefore, farmers are willing to replace chemical fertilizers with commercial organic fertilizers. Chinese government plays a critical role in promoting the production and application of organic fertilizers by farmers. In China trough composting and windrow system are the main composting processes (Chen *et al*., 2018).

Use of spectroscopy technique for assessment of compost maturity in China

Quality of the compost is assessed by combinations of different physical chemical and biological properties. However, all these approaches are expensive and time consuming when a large number of samples are involved. China spectroscopy techniques are used for quality assessment as it has many advantages such as ease of sample preparation, rapid spectrum acquisition, nondestructive analysis and portability. Near Infrared Reflectance Spectroscopy (NIRS) has been rapidly shows (within 1 min) assess compost quality (Chen *et al*., 2018).

3.8.3 Thailand

In Thailand liquid organic fertilizers produced from agricultural residues and industrial wastes are becoming increasing popular. Liquid fish derived and soybean based fertilizer are widely used in organic vegetable production (Gerald, 2019).

3.8.4. Australia

Compost production has grown significantly in recent years in Australia. Various machineries and equipment were introduced to production of compost. Further application rates of compost for various crops are provided. The compost industry has been well served by the Australian standard for compost and related products (AS4454). Also compost Australia, the National Recycled Organics Group within the Waste Management Association of Australia (WMAA) is developing quality standards and minimum information requirements to facilitate purchase of products that are appropriate to the intended use.

CHAPTER FOUR

Government Interventions to Enhance Organic Fertilizer Production

4.1 Programmes and Projects Conducted for Promotion of Organic Fertilizer Production in the Country

Over the last 20 years government had taken several measures to promote the production and use of organic fertilizers in the country, mainly the compost production. Following are the special programmes conducted to enhance the organic fertilizer production and use in the country.

- In 1998, "*Yaya*" programme coordinated by the DOA targeted to promote the integrated use of fertilizers in paddy cultivation. Under this program, farmers were encouraged to apply straw, green manure, cow dung and poultry manure for their paddy lands. Farmers were advised to apply all paddy straws to the field after harvesting and 750kg green manure per acre, two tons of cow dung per acre and one ton of poultry manure per acre.

- In 2005, DOA conducted demonstration programmes of organic farming and organic fertilizer production in different areas in the country to promote the organic fertilizer production.

- In 2008 to 2009, a special project was conducted to promote organic fertilizer production in the country. This programme was coordinated by the MOA, DOA and the Department of Agrarian Development. Under this programme farmers and other entrepreneurs were trained and encouraged to production of organic fertilizers at commercial scale.

- From 2009 to 2013, parallel to the "A*pi wawamu rata nagamu*" programme several programmes were conducted to promote the organic fertilizer production. In 2009, Rs.2000 million was allocated for the purpose. The main target of this project was to reduce the chemical fertilizer usage by 25% in the country by promoting organic fertilizers within the next five years. Under this project following programmes and activities were conducted by the MOA, DOA and the Department of Agrarian Development and Hadabima Authority.
    - Established the "Center of Excellence for Organic Agriculture" at Makandura and provide machinery and equipment for organic fertilizer production
    - Conducted training programmes for organic fertilizer producers
    - Promotion of green manure cultivation (eg: gliricidia, sunhemp)
    - Conducted awareness programmes on organic fertilizer production via television, radio and newspaper advertisements
    - Distribution of CD with organic fertilizer production methods

  - Develop laboratory facilities for quality testing of organic fertilizers
  - Provide machinery and equipment as well as rock phosphate, polythene for small scale organic fertilizer producers free of charge
  - Facilitates bank loans for organic fertilizer production
  - Establish the quality certification process for organic fertilizers
  - Initiated 350 organic fertilizer production projects under the direct supervision of the Hadabima Authority

- In 2016, MOA conducted a special project "*Saralanka*" to promote the organic fertilizer production at a cost of Rs. 50 million for providing loans to organic fertilizer producers at 4% interest rate. The main target of this project was to upscale the small scale organic fertilizer producers to medium scale.

- In 2021 with the government policy decision on banning the imports of chemical fertilizers and convert farming systems into organic farming the demand of organic fertilizers in the country suddenly increased. To fulfill the total requirement of country's organic fertilizers the Presidential Secretariat allocated Rs.600 million to initiate the commercial scale organic fertilizer production plants in the country. This projects aims at promoting production of compost, liquid organic fertilizers as well as bio fertilizers.

4.2 Role of the "Centre of Excellence for Organic Agriculture" to Promote the Organic Fertilizer Production in the Country

The "Centre of Excellence for Organic Agriculture" is the main government body committed to Sri Lankan organic agriculture under the DOA and MOA which is established in 2013 at the DOA Makandura premises. The mission of the institute is to innovate agricultural technology required for organic agriculture in order to achieve food security of Sri Lanka and to actively contribute in the sustainable national agriculture development through conducting training programmes, seminars, workshops and field demonstrations required for the development of knowledge and skills on organic agriculture. During the last eight years this institute contributed in several ways to increase the production and use of the organic fertilizers in the country and following are the major activities.

- Conducting training programmes for organic fertilizer producers
- Conducting research programmes to identify innovative technologies for organic farming as well as organic fertilizer production
- Production and distribution of organic fertilizer inoculums among the organic fertilizer producers
- Providing quality certification for marketing of organic fertilizers
- Production of organic fertilizers to provide farmers at a subsidized price

4.3 Registration of Local Organic Fertilizer Producers

Unavailability of an updated database on the organic fertilizer producers in the country was one of the major limitation in expanding this sector. Until 2020 only 17 commercial scale organic fertilizer producers were registered with the National Fertilizer Secretariat in MOA and 325 organic fertilizer producers were registered at the Centre of Excellence for Organic Agriculture. However, with the government policy decision to enhance organic fertilizer usage in the country MOA and the Department of Agrarian Development launched a programme in July 2021 to register all organic fertilizer producers as well as entrepreneurs who are willing to engage in organic fertilizer production. Accordingly, at the end of August there were 1274 organic fertilizer producers registered in MOA.

In parallel special attention is directed to establish "All Island Organic Fertilizer Producers' Association" to ensure sustainability of the organic fertilizer production sector in the country.

4. 4 Quality Certification of Organic Fertilizers

4.4.1 Quality Certification Process in DOA

Until 2021, the quality certification for organic fertilizers produced at commercial scale was issued by the Centre of Excellence for Organic Agriculture, Regional Agriculture Research and Development Center in Makandura. The MOA initiated this quality certification process on a request made by commercial scale organic fertilizer producers in 2017. In this process, producers seek quality certificate from the DOA and the officers from the DOA visits the organic fertilizer production sites to collect fertilizer samples. Then the samples were tested for N, P, K content, sand and the moisture content. If the conditions are in an acceptable level the certificate will be issued to the producers. The total cost for quality certification for a sample was Rs.575.00. Samples were tested at laboratories in Makandura, Gannoruwa, Angunukolapallessa, Horana, Mahailluppallama and Bombuwela.

4.4.2 Quality Certification Process in the National Fertilizer Secretariat

With the recent government policy shift in organic fertilizer production and use in the country, the National Fertilizer Secretariat was declared as the authorized institute for issue of quality certification. The certification issuance process is well organized and in which the organic fertilizer samples undergo a thorough testing as per defined by the SLSI. However, unavailability of facilities in government laboratories for testing parameters such as the presence of heavy metals sample analysis takes place in the private sector laboratories. Thus, the cost for testing one sample is around Rs.45000.00. The organic fertilizers which meet the all quality standards will be provided with SLSI certification. According to the available data at the National Fertilizer Secretariat, 61 compost producers and 33 liquid organic fertilizer producers received the SLSI certification for their products at the end of October 2021.

4.4.3 Specifications for Organic Fertilizers

Sri Lanka Standard Institute (SLSI) developed specifications for solid organic fertilizers and liquid organic fertilizers to ensure the quality of organic fertilizers produced by the local producers.

Specifications for sterilized solid organic fertilizer
This standard was approved by the Sectorial Committee on Agriculture and was authorized for adoption and publication as a Sri Lanka Standard by the Council of the SLSI on 25.05.2021. This standard prescribes requirements for sterilized solid organic fertilizer that is intended to use in eco-friendly agriculture. Sterilized solid organic fertilizer shall not contain any materials hazardous to plant, animal or human health and provides plant nutrients and enhances physical, chemical and biological properties of the soil. This standard is subjected to the restrictions imposed under the Regulation of Fertilizer Act No. 69 of 1988, Fauna and Flora Protection Act No. 44 of 1964, Plant Protection Act No 35 of 1999, Food Act No. 26 of 1980, Animal Diseases Act, No. 59 of 1992, National Environmental Act No. 47 of 1980 and Quarantine and Prevention of Diseases Ordinance (Chapter 222), their amendments and the regulations framed there under and any other regulatory and statutory requirements wherever applicable.

Sterilized solid organic fertilizer is defined as any product in solid form, of plant (except byproducts from petroleum industries) or animal origin that has undergone substantial decomposition that can supply total nutrients to plants comprising N, P and K at a minimum of eight percent (8%). This shall not contain microorganisms, but shall contain naturally occurring minerals with no added chemical or inorganic fertilizer material in the finished product to affect the nutrient content. The specifications for sterilized solid organic fertilizers are given in annex 02.

Specifications for liquid organic fertilizer in Sri Lanka
This Sri Lanka Standard was approved by the Sectoral Committee on Agriculture and was authorized for adoption and publication as a Sri Lanka Standard by the council of SLSI on 24.03.2021. This Standard is subjected to the provisions under the Fertilizer Act No. 68 of 1988, the National Environmental Act No. 47 of 1980 and the regulations framed there under, and any other regulatory and statutory requirements wherever applicable. Liquid organic fertilizers are concentrated liquids that are added to water and applied to the soil and/ or foliage. Liquid organic fertilizers provide soluble and easily available nutrient to the crops. Furthermore, they provide plant nutrient in a faster-acting form than solid fertilizer. Liquid organic fertilizers consist of primary nutrient and may contain beneficial microorganisms and/or micronutrients. See annex 02 for the specifications for sterilized solid organic fertilizers.

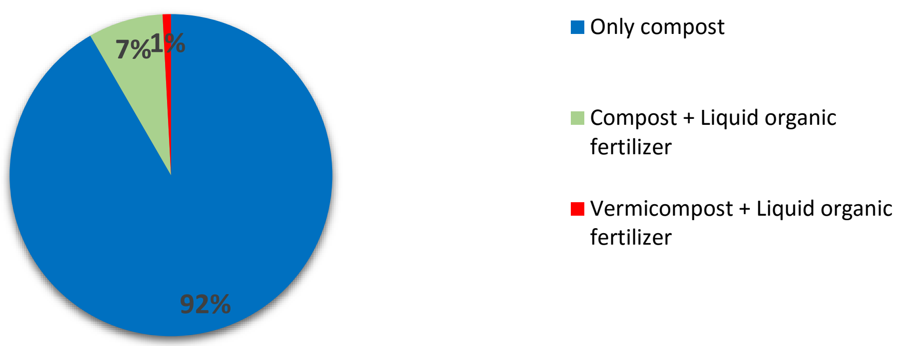
CHAPTER FIVE

Present Status of Commercial Scale Organic Fertilizer Production in the Country

Chapter Five describes the present status of organic fertilizer production in the country using the primary data collected from commercial scale organic fertilizer producers.

5.1 Types of Organic Fertilizers Produced in Commercial Scale

There are different types of organic fertilizers available at the market under different commercial names. From the selected organic fertilizer producers' majority (92 %) of the producers produce only compost as their final product. However, none of these producers made compost pellets or compost teas but all products were in the form of compost powder. Both compost and liquid organic fertilizer production accounts for seven percent and only one producer is producing vermicompost and liquid organic fertilizers (Figure 5.1).

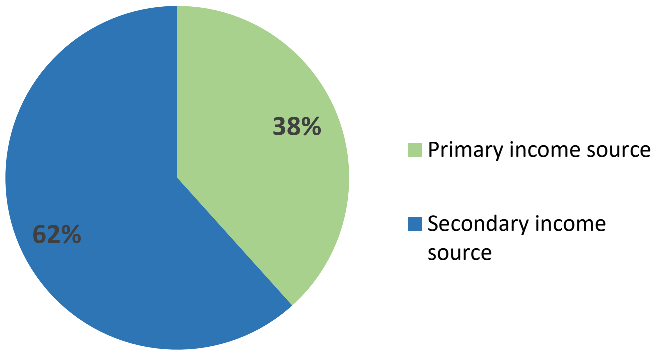


Source: Survey data, 2021

Figure 5.1: Types of Organic Fertilizers

5.2 Main Reasons for Adopting Commercial Scale Organic Fertilizer Production

Figure **5**.2 illustrates the participation of fertilizer producers in the trade as an income earning venture. Among the total number of producers in the sample 38 percent of producers engage in organic fertilizer production as their main income source and majority of the producers (62%) are engaged in the organic fertilizer production as secondary income sources.



Source: Survey data, 2021

Figure 5.2: Distribution of Fertilizer Producers (income sources wise)

As shown in Table 5.1, multiple reasons have attributed to adopting organic fertilizer production in commercial scale. Higher demand for organic fertilizers at the local market have prompted most of the producers (43%) to initiate organic fertilizer production in commercial scale. Among the total sample, 22 percent producers were engaged in this industry after received a training on organic fertilizer production. In order to have an extra income from farm waste, 21 percent producers have initiated organic fertilizer production in commercial scale. Another reason for adopting organic fertilizer production is to cultivate organic foods in their own farms (10%). It is also evident that fewer producers in the sample have had foreign and the experiences had from another country on organic fertilizer production (3%).

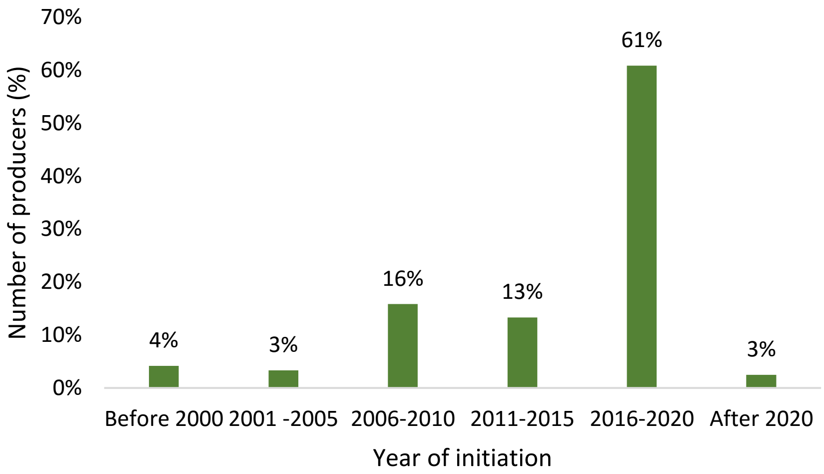
Table 5.1: Main Reasons for Adopting Organic Fertilizer Production

Main reason for engaging organic fertilizer production	Frequency	Percentage (%)
Demand for organic fertilizer in the market	52	43
Trained to produce organic fertilizer	27	22
Profit gained from the wastes of the farm	25	21
Production of organic foods in their own farms	12	10
Experience taken from another country	4	3
Total	120	100

Source: Survey data, 2021

5.3 Participation in Organic Fertilizer Production at Commercial Scale

Since 1990, government initiated several programmes to promote the organic fertilizer production and use in the country. Those programmes were mainly targeted for farm scale organic fertilizer production and promotion of commercial scale organic fertilizer production not gained an attention. However, as shown in Figure 5.3, majority of the organic fertilizer producers engaged in this industry during the 2016 to 2020 and it is 61% population of the total sample. Rapid increase in the organic farming sector and increase in the demand for organic fertilizer in the market as well as training received in organic fertilizer production may have contributed to uplift the commercial scale fertilizer production.

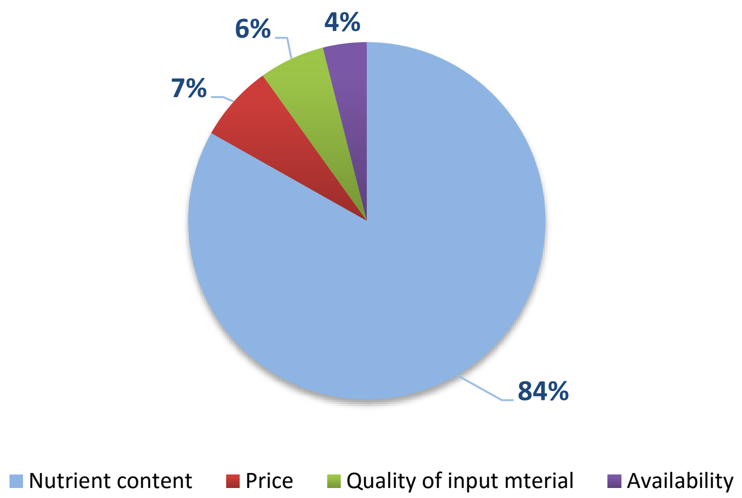


Source: Survey data, 2021

Figure 5.3: Participation in Commercial Scale Organic Fertilizer Production

5.4 Input Usage in Organic Fertilizer Production

Quantity, characteristics and composition of input materials available for organic fertilizer production vary widely with location as well as season. With regard to the major factors considered when selecting raw materials for organic fertilizer production, majority (84%) paid attention to the nutrient composition of raw materials (Figure 5.4). Producers were aware of the use of both plant materials as well as animal manures to maintain the C/N. Other factors considered for selection of raw materials are price (7%), physical quality of input material (6%) and availability of input materials (4%). Moisture content of input materials is the major factor when considered the physical quality of inputs. Majority of producers have specific input supply mechanisms such as direct linkages with dairy and poultry farms, agricultural product processing industries as well as with farmers and other contractors to collect input materials on regular basis.



Source: Survey data,2021

Figure 5.4: Factors Considered when Selecting Inputs

Input materials used for organic fertilizer production can be divided into three main groups: plant based raw materials, animal based raw materials and minerals. Cattle manure, poultry manure, goat manure, cattle urine and fish wastes are the major animal based raw materials used for organic fertilizer production. Plant based raw materials are gliricidia, paddy straw, grasses, dried plant leaves, banana leaves and trunks. Aquatic plants such as Salvinia, Japan jabara are also used for compost production. Also, by products from food processing industries such as paddy husk, molasses and fruits and vegetable debris are also used for organic fertilizer production by the sample producers. Eppawala rock phosphate and dolomite are the mineral sources used.

5.4.1 Raw Material Used for Compost Production

Different types of raw materials in use for compost production by sample producers are given in Table 5.2. In compost production majority of producers were used cattle manure as the major raw material. Among the sample producers 94 producers used the Eppawala rock phosphate for compost production to enhance the nutrient composition of final compost product.

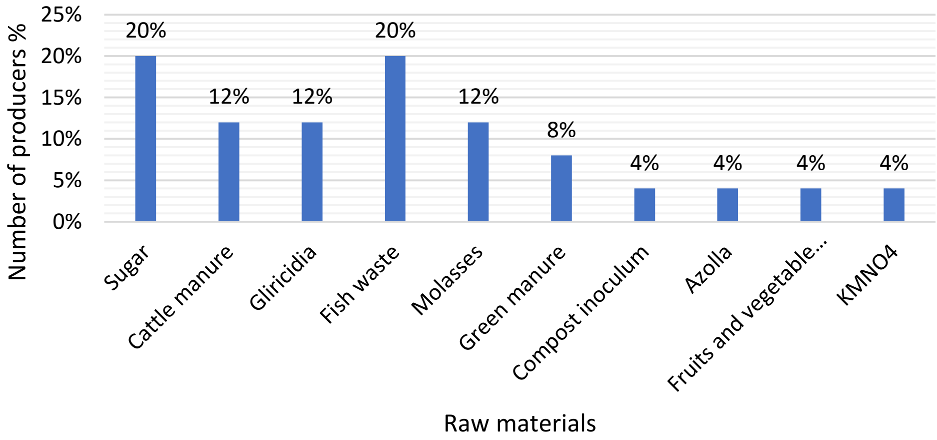
Table 5.2: Raw Materials Used in Compost Production

Raw material	Number of producers
Cattle manure	107
ERP	94
Gliricidia	91
Poultry manure	78
Other green manure	53
Straw	46
Dried plant leaves	44
Goat manure	43
Banana leaves and trunks	35
Wild grasses	28
Aquatic plants	23
Paddy husk	23
Dolamite	10
Fruit and vegetable debris	10
Feed residues in animal farms	8

Source: Survey data, 2021

5.4.2 Raw Materials Used for Liquid Organic Fertilizer Production

Figure **5**.5 illustrates the raw materials used for liquid organic fertilizers by sample producers. According to the collected data sugar and fish wastes are the major ingredients used for liquid organic fertilizer production.



Source : Survey data, 2021

Figure 5.5: Raw Materials Used for Liquid Organic Fertilizer Production

5.4.3 Raw Materials Used for Vermicompost Production

Among the total sample producers only one producer was engaged in vermicompost production. For the production mainly used cattle manure, gliricidia, wild grasses, azzolla, fruit and vegetable debris, straw and banana leaves and trunks are used.

5.5 Compost Production

5.5.1 Composting Method

Depending on the location and nature of the materials composting may be carried out outdoors, indoors or within enclosed vessels. Enclosed systems are expensive to establish but can provide maximum control over the composting process and odours. According to the survey findings, 97 percent producers used windrow method for compost production. Only one large scale producer is used passively aerated windrow method for composting and another large scale producer adopted silo method for composting. There was only one producer practiced vermicomposting. As mentioned by the producers' a major reason for adopting the windrow method is easy operation and low cost when produced in large scale.

Average time required for the compost production in the windrow method is around three months. However, aerated windrow method takes around two months and the silo method is around one month. As mentioned by the vermicompost producer average time required to vermicompost production is about two months.

5.5.2 Machinery Used in Compost Production

Machinery used for compost production ranges from raw material processing to physical turning to screening of the final product. Major types of machinery used by compost producers and their purposes are as follows. Chopper machines are used for chopping the raw materials specially the green manures used for compost production. Chopping of raw materials speeds up the decomposition rate while making it easy for turning the pit during the compost production process. Another common purpose of machinery used is the turning of the pit. Majority of the producers do the turning manually, but some of the medium and large scale producers used turning equipment attached to two wheel tractors for turning the composting pit. Large scale producers also used sieve for screening the compost and remove the undecomposed materials from the final product of compost to retain the quality of compost product. The compost producer who adopted the aerated windrow method used air blowers to provide aeration for composting pit during the compost production process. Also large scale producers used the dryers for removing the extra moisture content of final compost powder before packing.

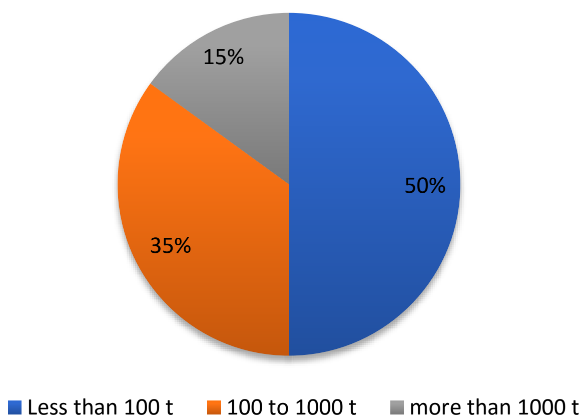
5.5.3 Measures Taken to Increase the Quality of Compost

Compost producers followed several measures to increase the quality of their product. Temperature measurement of the compost pit is performed by large scale organic fertilizer producers to find out the optimum condition for the composting process. If the temperature increased over the desired level, turning of the pit was performed immediately. Moisture content of the raw material is one of the major factor that determine the speed of the composting process. Therefore, to keep the composting process at the optimum level producers are highly concerned about the moisture level of the pit and they spray water over the pit to maintain the moisture level. Few producers added bio activators for the composting pit to accelerate the composting production rate.

5.6 Average Production of Organic Fertilizers

Producers were asked about their maximum production capacity of compost for the year. According to the recorded values, the total quantity produced in the sample in year 2020 was 659166 tons. Further, in terms of monthly production in 2020, only 37 producers in the sample produced more than 25 tons while 42 producers produced less than 5 tons and 47 producers were between 5 to 25 tons.

However, it was revealed that 57 percent of the producers were unable to maintain consistency in production as the production quantity depends on input availability and market demand. Therefore, making an annual fertilizer production estimate was infeasible.



Source: survey data, 2021

Figure 5.6: Annual Compost Production of Sample Producers

5.7 Crop Specific Organic Fertilizer Production

Nutrient requirement of crops varied by species to species. Generally, application of chemical fertilizers for crops is determined according to the main crop nutrient requirement such as N:P:K requirement and basic fertilizers are mixed and produced crop specific fertilizers mainly for paddy, fruits, vegetables, tea, coconut, rubber etc. However, no specific recommendations or instructions on prescribed quantities or nutrient compositions for organic fertilizer are available in the country. So, none of the sample producers produces crop specific organic fertilizers. However, most of the developed countries in the world currently produce crop specific organic fertilizers which contribute to optimum crop growth and productivity.

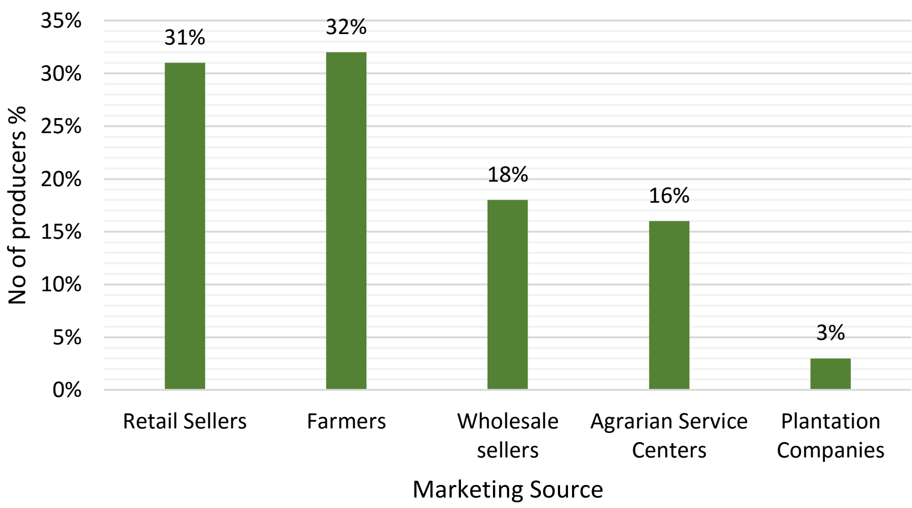
5.8 Average Cost of Production

Cost of organic fertilizer production is highly dependent on the type of input materials used for the organic fertilizer production. In general, the average cost of compost production is closely similar to all producers, which is around to Rs.18.00 to 20.00. However, the cost of liquid organic fertilizer is varying greatly among different producers and as mentioned by the sample producers, the average cost of production for 1 litre of liquid fertilizer is Rs 280.00 rupees and the price ranges from Rs100.00 to 600.00. Of the total cost of production, the highest cost component accounts for labour and input materials.

5.9 Marketing of Organic Fertilizers

Currently there are no well-established organic fertilizer marketing channels in the country. As a result, there is not guaranteed price for organic fertilizers at the local market. Average retail price of compost is about Rs 25.00 per kg and wholesale price is Rs 20.00 per kg. Average price of liquid organic fertilizers is about Rs 1000.00 per liter.

Among the sample producers, the most popular channels of selling the product is the direct sale to the farmers and direct sale to the retail fertilizer sellers. Another 18 percent producers sell their products to wholesalers and 16 percent producers sell their products for Agrarian Service Centers (ASC). Only 3 percent producers sell their products directly to the plantation companies in the country.

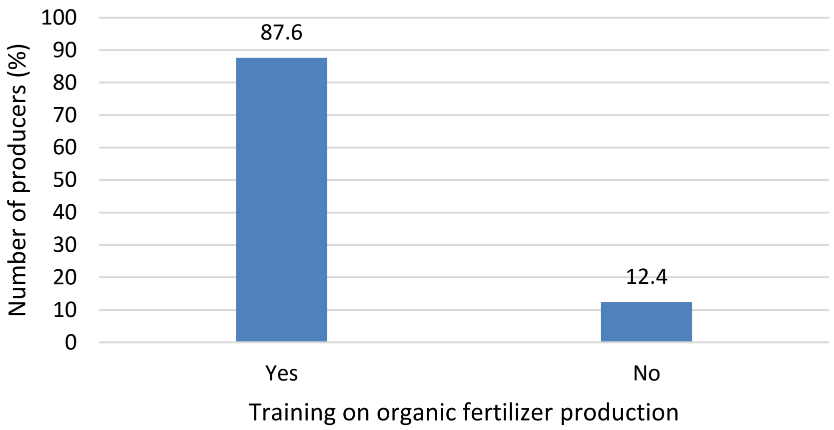


Source: Survey data, 2021

Figure 5.7: Method of Selling Organic Fertilizer

5.10 Training on Organic Fertilizer Production

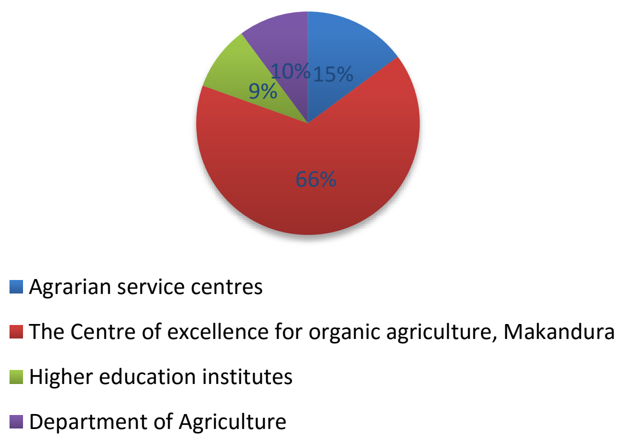
It was revealed that several training programmes including field demonstrations were conducted for organic fertilizer producers in order to promote organic fertilizer production in the country. High population in the sample has received training on organic fertilizer production. These training programmes were conducted by various government institutes focusing on methods of organic fertilizer production, use of input materials for organic fertilizer production and quality maintenance of organic fertilizer products.



Source: Survey data, 2021

Figure 5.8: Training Received on Organic Fertilizer Production

Of the trained organic fertilizer producers' the majority (66%) were trained by The Centre of Excellence for Organic Agriculture, at DOA in Makandura premises. The other training providers were ASC (15%), research institutes of DOA mainly Mahailluppallama and Gannoruwa (10%) as well as higher educational institutes such as universities and agriculture schools (9%).

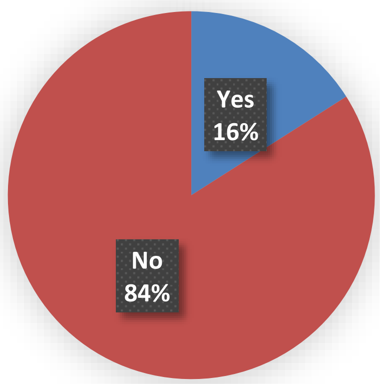


Source: survey data, 2021

Figure 5.9: Training Providers of Organic Fertilizer Production

5.11 Subsidies for Organic Fertilizer Production

Government conducted various programmes for promoting organic fertilizer production in the country mainly at farm level, providing subsidies for farmers. Thus, a very limited number of commercial scale organic fertilizer producers received subsidies for their organic fertilizer production. These subsidies included equipment and machinery for raw material processing such as choppers, materials for building huts for organic fertilizer production and storage as well as polythene for packaging the compost. The MOA, DOA and Department of Agrarian Development provided these subsidies for organic fertilizer producers under several projects and programmes.



Source: Survey data, 2021

Figure 5.10: Subsidies Received for Organic Fertilizer Production

5.12 Quality Certification of Organic Fertilizers

It is revealed that all organic fertilizer producers were aware of the importance of quality certification of their organic fertilizer products and all sample producers received the quality certification for their products from the DOA, Makandura in 2020 and only 12 producers in the sample received the SLSI certificate for the compost as well as for liquid fertilizers from MOA in 2021. However, as mentioned by all producers' though they requested quality certification for their compost products only once a year but their use of raw materials for organic fertilizer production is highly varied throughout year. Since the quality of the organic fertilizer is totally depend on the type of material used for production obtaining quality certification for each production batch of organic fertilizers is viable.

CHAPTER SIX

Constraints and Opportunities of Commercial Scale Organic Fertilizer Production in Sri Lanka

Chapter Six discusses the major constraints faced by the organic fertilizer producers, their suggestions to increase the organic fertilizer production and potential strategies to enhance the commercial scale organic fertilizer production in the country.

6.1 Constraints Faced by Commercial Scale Organic Fertilizer Producers

The organic fertilizer producers encounter a number of constraints in commercial scale organic fertilizer production.

1. Price of inputs

A major constraint for the majority of producers (35%) is the increasing price of input materials and scarcity of input materials for organic fertilizer production. As mentioned by the producers, with the government policy shift toward organic fertilizer the demand for organic fertilizer inputs specially for cattle and poultry manure has significantly increased resulting in a price escalation. Consequently, the cost of production has also risen.

2. Lack of marketing channel

The other main constraint raised by 16 percent commercial scale organic fertilizer producers is the issues related to the marketing of the organic fertilizers. Absence of a guaranteed price for organic fertilizer has created room for substandard products to thrive at low price. The cost of organic fertilizers produced according to the quality standards is invariably higher. Not having a well-established marketing channel for organic fertilizers is hence a major drawback to promote the industry.

3. Labour intensive

Majority of the organic fertilizer producers rated the labour cost as the highest cost component in organic fertilizer production and 14 percent producers were mentioned high labour cost as their major constraint in carrying out the venture. Particularly in compost production turning is an essential practice and mostly turning is performed manually, an act that demands a great deal of labour involvement. Thus, labour scarcity and cost for labour severely affects the production.

4. Lack of improved technology

Lack of machinery and equipment for organic fertilizer production was cited as another hindrance by 14 percent producers. Machineries for the chopping of raw materials and turning can reduce the labour cost as well as duration of composting process. Hence unavailability of machinery has limited the production capacity of organic fertilizer production plants.

5. Land limitations

Lack of enough land space for expand organic fertilizer production is mentioned as a major constraint by five percent producers. Generally, production of compost takes around at least two to three months and to maintain uninterrupted production throughout the year large land extent is vital.

6. Lack of infrastructure

Unavailability of infrastructure for production and storage of organic fertilizer was highlighted by another six percent. Unavailability of adequate land extent for continuous production of fertilizer throughout the year as well lack of storage facilities for final products results to limited production capacities. With regard to production of liquid organic fertilizer construction of tanks with greater capacity is also essential.

7. Quality certification process and cost

Another six percent producers were highlighted the issues of the quality certification process of organic fertilizers. As mentioned by producers the quality certification process conducted by DOA is generally a lengthy and time consuming procedure. On the other hand, the quality certification process in National Fertilizer Secretariat is speedy but costly around Rs. 45000.00.

8. Climatic factors

Only four percent producers were mentioned that adverse weather impacts mainly rainfall is negatively affected to their organic fertilizer production process.

6.2 Assistance Requested for Expanding the Organic Fertilizer Production at Commercial Scale

Organic fertilizer producers were asked about the assistance required to expand their production. Majority of the producers (35%) were requested machinery and equipment for raw material processing, turning and screening of compost production.

Another 29 percent producers requested financial support for expanding their organic fertilizer production plants. Most of them specially requested low interest rate loan facilities to purchase necessary machinery, construction of infrastructure as well as for buying land for organic fertilizer production.

Another 12 percent of sample producers requested to establish a niche market for organic fertilizers.

Lack of storage facilities was cited as the major issue affecting the organic fertilizer production and 10 percent producers requested facilities for storage of their products.

In terms of quality certification nine percent requested to facilities and technical expertise for having the own laboratories for organic fertilizer sample production. This is requested from the large-scale organic fertilizer producers.

Out of total sample producers, seven percent producers requested for training in organic fertilizer production, specifically the latest technologies of organic fertilizer production methods.

6.3 Suggestions of Producers to Uplift the Local Organic Fertilizer Production

Producers were asked to give their suggestions to enhance the local organic fertilizer production in the country. Major suggestions of producers to enhance the local organic fertilizer production are summarized in Table 6.1.

Majority of the producers (29%) suggested to formulate a long-term national level plan for organic fertilizer production, as a gesture of motivation to the organic fertilizer producers. Importance of regulating the local organic fertilizer market, with thrust on quality was highlighted by one fifth of the producers. A similar proportion suggested to conduct training and demonstrations of latest technologies on reducing the time and cost of production. Increased availability of input materials is a vital factor to enhance the production of organic fertilizers. Hence 10 percent of organic fertilizer producers suggested to set up a mechanism for increasing the production and uninterrupted supply of input materials. Another 6 percent producers highlighted the importance of establishing a robust marketing channel and set market prices for organic fertilizers while another 6 percent suggested to raise farmers awareness on organic fertilizer usage for crop production. Among the total sample producers 5 percent suggested to provide machinery to producers and financial assistance at reduced rates to enhance their production capacities to meet the country's organic fertilizer requirement.

Table 6.1 : Suggestions of Producers to Uplift the Organic Fertilizer Production

Suggestion	Frequency	Percentage
Encourage organic fertilizer producers and draft a long-term plan to invigorate the industry	78	29%
Training and demonstrations of new technologies on organic fertilizer production	54	20%
Quality standards for organic fertilizers and regulations of low quality products in the market	57	21%
Mechanism to increase input production and supply (green manure cultivation/ expansion of animal husbandry)	28	10%
Provide machinery	14	5%
Regulation of market prices and establish a marketing channel	17	6%
Raise farmer awareness on organic fertilizer usage	17	6%
Provide low interest rate loans	8	3%

6.4 Commercial Organic Fertilizer Production in Sri Lanka – A SWOT analysis

SWOT analysis was conducted to identify the present status of the commercial organic fertilizer production in Sri Lanka and identify possible strategies to enhance the quality organic fertilizer production in commercial scale. This analysis is based on the premise that such analysis helps maximize strengths and opportunities while simultaneously minimize weaknesses and threats.

Strengths	**Weakness**
• Growing demand of organic fertilizers in the country • Media is creating awareness at national level • Quality organic fertilizer application yields better results in crop production and improves crop productivity • Improves soil characteristics • Increasing demand for organically produced agricultural products in national and international market • Organic fertilizers reduce the use of synthetic fertilizers • Introduce quality standards for organic fertilizers • Availability of inputs for organic fertilizer production • Less pollution and environmental friendly production • Research and training conducted on organic fertilizer production	• Poor awareness among potential beneficiaries / farmers • Converting farm lands into organic farming is time consuming • Organic fertilizer quality certification is very costly • Lack of technology, equipment and infrastructure for large scale organic fertilizer production • Lack of long term strategy for organic fertilizer production and use in the country • Lack of an effective marketing and branding campaign • Lack of knowledge in latest technologies among producers • Obsolete technology and old equipment result in low performance and efficiency • There are no specific policies to encourage production and use of organic fertilizer
Opportunities	**Threats**
• State patronage to the producers to engage in this industry • Wide scope at national and international level • Increasing demand for organic fertilizers thus potential to upscale operations • Financial assistance from banks at low interest rates • Solutions for agricultural waste management • Creating new jobs • Cheaper compared to chemical fertilizers	• Some products in the market are of inferior quality • Changes of climatic conditions (rainy seasons are interfering with production activities) • Fluctuation of prices of inputs in the market • No guaranteed price for organic fertilizers at local market • High cost of equipment • Well established synthetic fertilizer market

Figure 6.1: SWOT Analysis of Commercial Organic Fertilizer Production in Sri Lanka

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CHAPTER SEVEN

Findings and Recommendations

7.1 Findings

- Major type of organic fertilizer produced at commercial scale is compost (92%) followed by liquid organic fertilizers (7%) and vermicompost (1%).

- Among the sample producers, 62 percent were engaged in organic fertilizer production as their secondary income source while it is the primary income source for the rest.

- Majority of sample producers (61%) initiated commercial scale organic fertilizer production during the 2016 to 2020 period.

- With regard to organic fertilizer production over 80 percent were concerned about the nutrient content of inputs. Cattle manure is the major input material used in compost, liquid organic fertilizers and vermicompost production.

- In compost production 97 percent producers adopted windrow / pit composting method. Only one producer used aerated windrow method and another one used silo method for composting. Choppers and turning equipment are the major types of machinery used in compost production.

- None of the producers manufacture crop specific organic fertilizers.

- Average compost production cost is Rs.18/kg and average cost of production of liquid organic fertilizer is Rs.280/litre. Of the total cost of production, inputs and labour account for highest.

- In the total sample 88 percent producers received training on organic fertilizer production and out of them 66 percent producers were trained from DOA, Makandura premises.

- All sample producers received quality certification from DOA, Makandura in 2020, while only 12 producers received SLSI certification for their organic fertilizer products from the National Fertilizer Secretariat, MOA. However, quality certification is not mandatory to issue the fertilizer products to market and as a result, the market is flooded with substandard organic fertilizer products.

- Escalating input prices and scarcity of input materials, lack of proper marketing channel and guaranteed price for organic fertilizers, availability of low quality organic fertilizer products in the market at low prices and high cost of labour for fertilizer production due to the lower adoption of machineries are the major constraints faced by the commercial scale organic fertilizer producers in the country.

7.2 Conclusions

Application of organic fertilizers in agricultural lands is an accepted practice worldwide to enhance the sustainability of crop production systems while aligning with green agriculture concept. With the state policy shifts towards organic farming organic fertilizers have become the major farming input, inevitably creating an unprecedented demand for organic fertilizer. However, the prevailing organic fertilizer production levels cannot cater to the demand; expanding quality organic fertilizer production using large scale commercial production facilities is a need of hour. As revealed by the findings, there is good potential to enhance the organic fertilizer production with direct government involvement at policy level. By addressing major issues in the industry such as lack of latest technology and machinery for production, quality control of local organic fertilizer products and lack of a well-established organic fertilizer market, the organic fertilizer industry in the country can be expanded. However, due to the pandemic situation that prevailed, the study's scope was confined to organic fertilizer producers; hence a detailed study on organic fertilizer production at commercial scale, examining all sub sectors related to the industry such as input suppliers, marketing agents as well as consumers of commercial organic fertilizer products to identify the prevailing issues within the industry is needed.

7.3 Recommendations

Based on the findings following strategies are recommended to enhance the commercial scale organic fertilizer production in the country.

1. Implement a long-term national level plan to enhance the organic fertilizer production with necessary policy formulations in place for the production and use of organic fertilizers using available materials from crop production, animal husbandry, food processing waste and other natural material like seaweed.
2. Initiating a financial support system for commercial scale organic fertilizer producers in the country mainly by providing loans at low interest
3. Make rules and regulations for maintaining the quality standards of commercially available organic fertilizers in the country. It is recommended to implement a mechanism for regular monitoring of the quality of organic fertilizers in the market to maintain quality supply of fertilizers to farmers. Further, it is recommended to make SLSI quality certification a prerequisite for all organic fertilizers available in the market.
4. Develop laboratory facilities in different locations in the country to facilitate quality testing of organic fertilizer at affordable price. It is suggested to provide equipment and facilities to research institutes of DOA and universities as they can act as regional centers for quality certification to cover all parts of the country.
5. Introduce a well-established market channel and guaranteed prices for organic fertilizers at the local market. As the initial step, direct involvement of

government through DOA and Department of Agrarian Development for marketing of organic fertilizers at regional level should be initiated to establish the organic fertilizer market in the country.

6. Foster public private partnerships to enhance the production and use of organic fertilizer. Currently, there are many private companies and individuals engaged in commercial scale organic fertilizer production and ones that are willing to initiate organic fertilizer production. Government should make a direct intervention in upgrading their production capacities through provision of necessary financial support and technical knowledge. Further, government should device a mechanism for marketing these products at affordable prices for farmers.
7. Advanced research should be conducted to enhance the nutrient content of organic fertilizers specially for producing crop specific fertilizers. Application of crop specific fertilizers enhances the fertilizer use efficiency while reducing the cost of fertilizers for farmers. Further, it may contribute to produce value added organic fertilizers in the country.
8. Latest organic fertilizer production technologies and machinery for commercial scale organic fertilizer production should be introduced based on raw materials availability as well as climatic factors in the country.
9. Initiate a mechanism to increase the availability of raw materials for organic fertilizer production. This can be achieved by developing the livestock industry in the country as well as by promoting the cultivation of biomass for organic fertilizer production which can contribute towards creating new income generating sources.
10. Conduct training for technology transfer to organic fertilizer producers on production technologies, quality certification, marketing and other necessary fields related to organic fertilizer production. Many countries produce organic fertilizers using highly sophisticated methods and local producers should encourage be encouraged to build international cooperation with those producers to upgrade their knowledge and skills.

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ANNEXES

Annex 01: Average nutrient content in concentrated organic manures

Product	N(%)	P2O5 (%)	K2O(%)
Plant origin			
Edible oil cakes			
Sunflower	7.9	2.2	1.9
Groundnut	7.3	1.5	1.3
Sesame	6.2	2.0	1.2
Mustard			
Nonedible oil cakes			
Neem	5.2	1.0	1.4
Castor	4.3	1.8	1.3
Cottonseed	3.9	1.8	1.6
Animal origin			
Blood meal	10-12	1.0-2.0	0.6 – 0.8
Meat meal	10 - 11	2.0 – 2.5	0.7 – 1.0
Fish meal	5 - 8	3.0 – 6.0	0.3 -1.5
Slaughterhouse waste	8–10	3.0	
Bone meal (raw)	3.0	20.0 (8% citrate soluble P2O5	
Bone meal (steamed)		22.0 (16% citrate soluble P2O5)	

Annex 02: Specifications for sterilized solid organic matter

General requirements	
Form	Granulated, pelleted or mash form
Colour	Brown to black
Keeping properties	After storage in packages/containers at room temperature for not more than 24 months from the date of production
Moisture content	Not contain more than 15% of moisture by dry mass
Odour	Free from any foul odour
Texture	Product shall be friable when moist (not applicable for pelleted forms)
Raw material	Sewage sludge (including industrial waste and human waste), or any other raw materials contaminated with sewage sludge shall not be used Properly treated animal waste can be used Municipal waste, industrial waste, clinical waste and human waste shall not be permitted as raw material and any organic fertilizer product and any other raw material shall not be contaminated with such materials
Physical requirements	
pH	6.5 to 8.5
Conductivity dSm-1, max	4.0
Foreign matter/visible contaminants	Free from visible non-biodegradable materials
Sand content, per cent by mass, on dry basis, max	5
Particle size, residue particles when passing through 4 mm sieve, percent by mass, max	2 (not applicable for pelleted forms)
Chemical requirements	
Total Nitrogen content as N, percent by dry basis, min.	5
Total Phosphate content as P_2O_5, percent by dry basis, min	1
Total Potassium content as K_2O, percent, by dry basis, min	2
Total Magnesium content, as MgO percent by dry basis, min	0.5

Total Calcium content, as CaO percent by dry basis, min	0.5
Organic Carbon as C, percent, by dry basis, min	15
Biuret	shall not be present in the product
Melamine	shall not be detected in the product when tested by electrospray ionization liquid chromatography tandem mass spectrometry (LC-MS/MS)
Living organisms	shall be free from any living organism or their viable forms
Toxic elements	
Cadmium as Cd, mg/ kg dry basis, max	1.5
Chromium as Cr, mg/ kg dry basis, max	50
Lead as Pb, mg/ kg dry basis, max	30
Mercury as Hg, mg/ kg dry basis, max	0.5
Arsenic as As, mg/ kg dry basis, max	3
Nickel as Ni, mg/ kg dry basis, max	40
Antibiotic residues	shall not contain residues of antibiotics
Organic pollutants	free from any Persistent Organic Pollutants (POP), listed substances under the Stockholm Convention
Micro plastics	not contain micro plastics or their traces
Pesticide residues	not contain any pesticides detectable under multi-residue screening methods GC-ECD/NPD, GC-MS, and LC-MS/MS
Nitrogenous residue	e free from added synthetic or manufactured nitrogen compounds
packaging	Organic fertilizer shall be packed in sound, strong and moisture proof packages or containers 5 kg or more must be packaged in polypropylene bags with an inner lining of low density polyethylene having a minimum thickness 50 µm or any other material with barrier properties superior (High Density Polyethylene) or equal to low density polyethylene of 50 µm thickness to afford

	maximum protection from normal hazard of transportation and handling 5 kg or less must be packaged in polyethylene bag with a suitable thickness. Suitable packages include polypropylene, of mass 1-50 kg. The product may also be supplied in bulk containers as agreed between the purchaser and the supplier
Marking and labelling	The package shall be legibly and indelibly have marked with the following information and shall comply with the National Fertilizer Act No. 69 of 1988 (as amended) and regulations in Sri Lanka. a. Name and type of the product b. Name and type of raw materials used c. Name and address of the manufacturer, including country of origin d. Brand name and/ or trade mark, if any e. Date of packaged f. Net mass in kilograms g. Instructions for storage and use h. Date of expiry/ date of best before i. Batch No j Total Nitrogen to total dry mass per cent by mass k Total Phosphorus as P2O5 to total dry mass per cent by dry basis m Total Potassium as K_2O to total dry mass per cent by dry basis n Total Organic Carbon as C to total dry mass per cent by dry basis q The statement “Use no hooks”

Annex 03: Specifications for liquid organic fertilizers

General requirements	Liquid form
	Biodegradable
	Not contain any artificial colours
	Not contain substances that are likely to be harmful or injurious to vegetation, animals, soil health, public health or the environment when used according to its intend use specified by the label
	Not contain any poisonous residues, when applied in amounts commonly used or as specified in the directions for use
Chemical and physical requirements	
pH	6.0 -8.5
Electrical conductivity, dS/m, max.	20.0
Total Nitrogen content as N, per cent by mass, min	1.0
Total Potassium content as K2O, per cent by mass, min	0.5
Total Phosphorus content as P2O5, per cent by mass, min	0.5
Total primary nutrient, (N+ P2O5+ K2O) per cent by mass, min	2.0
Organic carbon per cent by mass, min	5.0
Microbiological requirements	
Faecal coliform MPN, per ml	Absent
Salmonella, per 25 ml	Absent
limits of potentially toxic elements	
Arsenic, as As	0.5
Cadmium, as Cd	0.5
Chromium, as Cr	0.5
Lead, as Pb	1.0
Mercury, as Hg	0.5
Packaging	The product shall be packaged in sound and strong compatible bottles, containers or packages. Suitable packaging materials include plastic or glass or any other non-rusty materials. The product may also be supplied in bulk containers agreed upon between the purchaser and the vendor

Marking and/ or labelling	The following shall be marked or labelled legibly and indelibly on each bottle or package a) Name of the product as “Liquid Organic Fertilizers” b) Name and address of the manufacturer, packer or distributor c) Registered trade mark if any d) Batch or code number e) Net content in metric units; f) Date of manufacture g) Date of expiry j) Primary nutrient content k) Crops for which it is intended m) Dilution ratio/ Instructions for use n) Storage/disposal instructions;