Post Harvest Processing of Moringa and Socio-Economic Appraisal of Moringa Orchards in Tamil Nadu

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Abstract The word Moringa is Magic to Many of the consumers both in India and many other countries. Because of the nutritional and medicinal importance of Moringa, the demand for Moringa and its value added products are increasing which in turn permits enhanced area under Moringa from the supply side and hence a study has been taken up in the Western and Southern Part of Tamil Nadu to analyze the reasons for taking up Moringa plantations in a large scale and their economics. This paper has identified few factors which are influencing the cultivation of Moringa and the factors governing the profitability of Moringa. The Economic appraisal tools have revealed that the Moringa cultivation is profitable and hence the detailed analysis of costs and their return is presented and discussed. Besides, the nutritional and medicinal importance coupled with the steps involved in post harvest processing are also discussed for the benefit of Processors.

Keywords Moringa; Varieties of Moringa; Processing of Moringa; Socio-Economic Appraisal; Cost of Production; Costs and Returns

1 Introduction

Moringa (Moringa oleifera Lam.) belongs to the family ‘Moringaceae’ is a fast growing multipurpose medicinal tree extensively grown in tropics and subtropics of India and Africa. It is also widely distributed in India, Egypt, Philippines, Sri Lanka, Thailand, Malaysia, Burma, Pakistan, Singapore, West Indies, Cuba, Jamaica and Nigeria. In eastern and southern regions of India, Moringa is widely used as vegetable and grown commercially for its edible pods and leaves. Moringa oleifera is an important food commodity which has had enormous attention as the ‘Natural Nutrition of the Tropics’. Almost all the parts of this plant: root, bark, gum, leaf, fruit (pods), flowers, seed and seed oil have been used for various ailments in the indigenous medicine of South Asia, including the treatment of inflammation and infectious diseases along with cardiovascular, gastrointestinal, haematological and hepatorenal disorders. Its popularity is increasing steadily because of its nutritional, medicinal value and for its sweetness in curry and slurry preparation along with red gram dhal. From that one could understand the importance of Moringa (D’Souza and Kulkarni, 1993; Anwar and Bhanger, 2003; Anwar et al., 2005).

2 Moringa in India

India is the prime producer of Moringa (Drumstick) with an annual production of 2.2 to 2.4 million tonnes of tender fruits from an area of 43600 ha leading to the productivity of around 50 tonnes per ha. Among the different states, Andhra Pradesh leads in both area and production (15,665 ha) followed by Karnataka (10,280 ha) and Tamil Nadu (13250 ha). In other states, it occupies an area of 4,613 ha. Tamil Nadu is the pioneering state as it has varied genotypes from diversified geographical areas, as well as introductions from Sri Lanka.

3 Moringa Cultivation in Tamil Nadu

3.1 The perennial Eco-types of Moringa

The cultivation of Moringa in India occurs mainly in the southern states of Tamil Nadu, Karnataka, Kerala, and Andhra Pradesh. Principally perennial types have been known for cultivation for a very long time. However, perennial types are beset with many production constraints, such as a relatively long pre-fruit bearing period, non
availability of planting materials (stem cuttings), requirement of a greater number of rainy days in regions where water is scarce, and vulnerability to pests and diseases. Important varieties of Moringa are Moolanur Moringa, Valayapatti Moringa, Chavakacheri Moringa, Chemmurungai, Jaffna Type, Kattu Moringa, Kodikkal Moringa, Palmurungai, Punamurungai, Palamedu Moringa.

3.1.1 Moolanur Moringa
Farmers in and around Moolanur, Karur, Dharapuram areas of Tamil Nadu, predominantly cultivate perennial Moringa which has a pod length of 45-50 cm, pod weight of 120 g and an yield of 200 kg/tree. Trees are maintained up to 15 years without pruning.

3.1.2 Valayapatti Moringa
Another perennial type cultivated in and around Usilampatti, Aundipatti areas is Valayapatti Moringa. The pods are around 65 cm long, and weigh about 120 g. Yield is reported to be 1000-1200 pods per tree.

3.1.3 Chavakacheri Moringa
An ecotype of Jaffna Moringa, it bears pods as long as 90-120 cm. It is also cultivated in Tamil Nadu.

3.1.4 Chemmurungai
Another ecotype of Jaffna Moringa, it flowers and fruits throughout the year, yielding a heavy crop. The tips of the pods are red. The tree is medium sized and bearing long pods.

3.1.5 Jaffna Type
A Yazhphanam type Moringa introduced from Sri Lanka. Its fruits are 60-90 cm long with soft flesh and good taste. This type yields around 40 pods from the second year of planting which increases up to 600 pods/tree from the third year onwards. It is cultivated commercially in Tirunelveli and Tuticorin districts of Tamil Nadu.

3.1.6 Kattumurungai
A wild form of Moringa, _M. concanensis_ found in the forest of Tamil Nadu.

3.1.7 Kodikkal murungai
It is cultivated predominantly in the betel vine gardens of Tiruchirapalli district of Tamil Nadu. The pods are shorter (20-25 cm long) and are thick fleshed. The pods and leaves are very tasty. Trees are short statured with smaller leaves.

3.1.8 Palmurungai
It is preferred for its thick pulp and tasty pods.

3.1.9 Punamurungai
It is grown in home gardens of Tirunelveli and Kanyakumari districts.

3.1.10 Palamedu Moringa
The pods are 60 cm long, with a pod weight of 95-100 g and an yield of 100 pods/tree.

3.2 Annual Moringa varieties
The Horticultural College and Research Institute of Tamil Nadu Agricultural University, Periyakulam, had an assemblage of 85 Moringa accessions. The germplasm collection block contains perennial and annual Moringa accessions with heavy fruit-bearing, cluster bearing, drought tolerance, dwarfing stature and pest and disease resistance. Scientists at the Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam have succeeded in developing seed-propagated Moringa types, which has revolutionized the Moringa cultivation in the country. By judicious breeding programs, including introduction of elite mother plants, evaluation, selection and hybridization, The Horticultural College and Research Institute of Tamil Nadu Agricultural University has released two improved annual Moringa varieties (PKM-1, PKM-2) within a span of 10 years, for commercial cultivation. These varieties have developed up well in many traditional and non-traditional areas (Sadashathi, 1995).
3.2.1 PKM - 1 Annual Moringa
It is a pure line selection developed by continuous selfing for six generations, collected from Eppothumvendran village of Thoothukkudi region. In each generation, only long pods and desirable characters are selected and advanced. It was released in the year 1989. The fruits are fleshy and tasty. It comes to flowering within 5-6 months of sowing and comes to harvest in 7-8 months. The peak harvest is during March-August. The plants grow to a height of 4-6 m in a year and produce 6-12 primary branches. The pinnate leaves are about 40 cm long with small leaflets which are dark green on the upper side and pale green on the lower side. Though the flowers are in clusters of 25-150/cluster, only one pod develops usually and rarely 2-4 develop per cluster. The pods are 75 cm long with a girth of 6.3 cm and weigh 150 g with 70 per cent flesh. The average yield is 220 fruits/tree. The estimated yield is around 52 t/ha. The pods attain edible maturity 65 days after flowering. The leaves can be used as a nutritive green. Ratoon crops can be maintained for 3-4 years. After every year the trees have to be cut back to 1 m from ground level. This variety can be grown as intercrop in coconut orchards during the early period. Chilli, onion and groundnut can be grown as intercrop in Moringa fields (V. Ponnusamy, 2012).

3.2.2 PKM - 2 Annual Moringa
It is a hybrid derivative of a cross between MP 31 (Eppothum vendran local) and MP 28 (Arasaradi local). It can be propagated through seeds. The tree comes to bearing six months after planting and is suitable for growing in different cropping systems. The pods are 126 cm long, with a girth of 8.3 cm and individual fruit weight of 280 g with 70 per cent flesh. The pods are less seeded and delicious. The average number of pods per tree is 220/tree/year. It yields 98 tonnes/ha. Ratoon crop can also be taken up for three years. It is suitable for growing in Tamil Nadu and is adapted to most soil types varying from sandy loam to clay loam with good drainage (V. Ponnusamy, 2012).

In Moolanur block, Moringa is established as an intercrop on field scale and their allies were cropped with vegetables and Sorghum. This system evolved as Moringa based cropping systems offered some protection to alley crops from drying winds during summer and Moringa provided some additional income. With the migration of people from south to north India, and elsewhere in the world, the demand for Moringa picked up and hence area under Moringa is also found to be increasing.

Farmers found that growing Moringa crops during summer season was remunerative. Thus, Moringa gained a foothold as a summer vegetable. Its unique flavor and aroma became very popular. For South Indian any meal without Moringa and pulses is considered incomplete. The demand for the Moringa pod also increased due to increased urban settlements and migration of people to urban colonies.

4 Objectives of the Study
Any Production activity needs clarity on economics. On realizing the economic benefits that accrue from the production process, either the entrepreneur or the producer of any activity will give his consent in establishing the production unit. In Horticulture, Moringa production is one of the principal activity that is gaining importance across the world and many farmers have resorted their willingness to establish Moringa orchards in their farm lands for maximizing their profits. Many of the small and marginal farmers are unaware on the economics but they continue their activity of producing the crops. Whatever the output that comes to them, they get satisfied. But the enterprising farmers are showing much interest in learning the economics out of Moringa and hence a study has been initiated in the western and southern zone of Tamil Nadu to quantify the exact income generation possibilities out of Moringa.

5 Methodology
Among the 31 Districts of Tamil Nadu, only 6 districts have the notable area under Moringa cultivation. Among the 6 Districts, the traditional Moringa growers were belonged to Tiruppur and Thoothukkudi Districts. In these two districts, area expansion under Moringa is dismal while other districts take a lead in cultivation of Moringa and hence a study has been initiated to assess the reasons for the same and hence the Tiruppur and Thoothukkudi Districts were purposively chosen in the First Stage.
Table 1 revealed that the total area under Moringa is distributed only in two taluks to the tune of 98 per cent in Thoothukkudi District. Among the two taluks, Sathankulam found to have 73 per cent of the total area under Moringa. In respect of Tiruppur District, around 80 per cent of the total area under Moringa is vested with Dharapuram Taluk and hence the Sathankulam Taluk of Thoothukkudi District and Dharapuram Taluk of Tiruppur District were chosen purposely in the Second Stage.

Table 1 Area under Moringa in Thoothukkudi and Tiruppur Districts (2015-16)

| Sl. No | Name of the Taluk  | Name of the District | Area under Moringa in Ha | % to Total Area under Crops in the District |
|--------|--------------------|---------------------|--------------------------|---------------------------------------------|
| 01     | Sathankulam        | Thoothukkudi        | 1062.86                  | 72.55                                       |
| 02     | Tiruchendur        | Thoothukkudi        | 367.81                   | 25.11                                       |
| 03     | Others             | Thoothukkudi        | 34.33                    | 2.34                                        |
|        | Total Area under Moringa in Thoothukkudi District | 1465.00 | 100.00 |
| 03     | Dharapuram         | Tiruppur            | 956.25                   | 80.24                                       |
| 04     | Kangeyam           | Tiruppur            | 182.61                   | 15.32                                       |
|        | Total Area under Moringa in Tiruppur District | 1191.74 | 95.56 |

Note: G-Return (2015-16)

In the Third Stage, the villages where the highest area under Moringa available were enlisted after getting the list of farmers from the Department of Horticulture and Plantation Crops of Government of Tamil Nadu and in each village 10 sample farmers were randomly selected following a Three Stage Random Sampling Technique for the Study.

Table 2 revealed that the samples selected in respect of Moringa are accounted for 50 samples from Thoothukkudi District and another 50 samples were drawn from Tiruppur District. Put together, One hundred samples were selected for the study from these two districts. From the sample farmers, the details of land use, crop management for its production and productivity, Post harvest processing methods, Cost of production of Moringa and the constraints involved are assessed using the structured and pretested questionnaire exclusively designed for the purpose and the same were analyzed and documented in this study by adopting a descriptive statistics like mean and percentage analysis.

Table 2 Details of Samples Selected for the Study

| Sl. No | Name of the Villages Selected in Sathankulam Taluk | No. of Samples | Name of Villages Selected in Dharapuram Taluk | No. of Samples |
|--------|---------------------------------------------------|----------------|-----------------------------------------------|----------------|
| 01     | Sasthavinallur                                    | 10             | Kilangundal                                   | 10             |
| 02     | Nadavakkurichi                                    | 10             | Komarapalayam                                 | 10             |
| 03     | Mudhalur                                          | 10             | Mulayampooondi                                | 10             |
| 04     | Arasoor                                           | 10             | Moolanur                                      | 10             |
| 05     | Thatchamoozhi                                     | 10             | Puduppai                                      | 10             |
|        | Total Samples in Thoothukkudi District             | 50             | Total Samples in Tiruppur District            | 50             |

6 Results and Discussion
The results of the study were presented here for better understanding of the stakeholders under the following heads. They are

- Factors influencing Moringa Plantations
- Costs and Returns from Moringa Orchards
- Yield and Income Generation Possibilities from Moringa
- Economics of Moringa Cultivation in Tamil Nadu

6.1 Factors Influencing Moringa Plantations
The increasing area under Moringa necessarily called for analyzing the influencing factors for establishing the Moringa Plantations in their farm holdings. Few of the factors may be positively influencing and some are negatively influencing. In this respect, these are analyzed and the results are presented in Table 3.
Table 3 Factors Influencing Moringa Cultivation

| S. No. | Factors in Favor of Moringa                                      | No. of Farmers Reported |
|--------|------------------------------------------------------------------|-------------------------|
|        |                                                                  | Thoothukkudi             | Tiruppur                |
| 1.     | Higher Return from Moringa Orchard                               | 16 (32.00)              | 18 (36.00)              |
| 2.     | Availability of Land and Water Resources                         | 08 (16.00)              | 03 (6.00)               |
| 3.     | Minimal Pest Problems                                            | 02 (4.00)               | 05 (10.00)              |
| 4.     | Sustainable Income Generation                                    | 18 (36.00)              | 16 (32.00)              |
| 5.     | Good Market Demand for Moringa Produce                           | 06 (12.00)              | 08 (16.00)              |
| Total  |                                                                  | 50 (100.00)             | 50 (100.00)             |

Note: Field Survey (Figures in Parentheses indicate Percentage to Total)

Table 3 revealed that the factors are positively influencing to the farmers in the study area. The influencing factors are delineated as follows:

- Higher Return from Moringa
- Sustainable Income Generation
- Availability of Land and Water Resources for Establishing Moringa
- Good Market Demand for Moringa Products in the National and International markets
- Minimal Pest Problems and able to control the same through organic way

Among these factors, the Thoothukkudi farmers were of the opinion that the Sustainable Income generation possibilities are available with Moringa and hence they prefer the crop maximum followed by Higher return from Moringa. These two are the most influencing factors to the farmers of Thoothukkudi District. Whereas, Higher returns from Moringa followed by Sustainable income generation are the factors dearer to the people of Tiruppur District. Though these factors are very closely related to income realization, the farmers are much interested in Moringa plantations owing to heavy market demand that exists in the National and International Markets. The factor of ‘Good Market Demand’ is being ranked by them to the fourth rank and indirectly supporting the farmers to enter into higher area under Moringa cultivation. How much income over the costs are being generated by the farmers is important in this context and hence the details on economic incentives are analyzed and details are discussed elsewhere.

6.2. Costs and Returns in Moringa Plantations

A developing country like India needs not only food on quantitative terms but also the food must be qualitative and should possess the nutrient requirements of the body which is not available to many in the rural and urban settings. Moringa is one of the best alternative which could serve the nutritious food. Hence in the daily diet of an individual, one should take Moringa products daily to lead a healthy and energetic life. Production of the Moringa as vegetables and conversion of the vegetables into value added products depends on the supply of quality output from the farm. Ensuring the regular supply not only promotes healthy life but also promotes economy and hence one should analyze whether the Moringa plantation and its establishment is dearer to the farm community so that they could ensure sustainable supply. In this respect, the economic incentives associated with Moringa cultivation is discussed under the following heads:

- Establishment Cost for Perennial Moringa Plantations
- Details of Maintenance Cost involved in Perennial Moringa Plantations
- Yield and Income Potentials of Perennial Moringa Plantations
- Cost of Production of Annual Moringa
- Economics of Moringa Plantations

6.2.1 Establishment Cost for Perennial Moringa Plantations

The establishment cost or the cost incurred in the zero time period comprise rental value of land, cost of plant material, cost of farm houses, expenditure on farm equipments, fencing etc assumes greater importance and hence the details of establishment cost incurred by the sample farmers are analyzed and the results are presented in Table 4.
Table 4 Establishment Cost for Perennial Moringa Plantations

| Sl. No | Cost Components                          | Thoothukkudi          | Tiruppur           |
|--------|----------------------------------------|-----------------------|--------------------|
| 01.    | Ploughing and Preparation of Land       | 3230.98               | 3705.00            |
| 02.    | Digging of Pits                         | 3140.49               | 3250.00            |
| 03.    | Fencing Charges                         | 19450.50              | 18466.91           |
| 04.    | Formation of Irrigation Channels        | 950.00                | 850.00             |
| 05.    | Cost of Plant Material including Transportation | 6350.00               | 6446.09            |
| 06.    | Cost of Manure                          | 2242.00               | 2346.21            |
| 07.    | Cost of Filling of Pits, Manuring and Planting | 1438.56              | 1533.83            |
| 08.    | Cost of Irrigation including Labour     | 3235.60               | 3483.34            |
| 09.    | Plant Protection Charges while Planting of | 428.90                | 386.77             |
| 10.    | Rental Value of Land                    | 22530.58              | 19302.30           |
| 11.    | Land Cess and Taxes                     | 60.00                 | 60.00              |
| 12.    | Total Establishment Cost                | 63057.61              | 59830.45           |

Table 4 revealed that the establishment cost incurred for Moringa in Tiruppur District has commanded low cost when compared to Thoothukkudi District. Among the different constituent costs under establishment, the rental value of land and the fencing charges have commanded more than 60 per cent to the total establishment cost.

The total establishment cost of Moringa in Thoothukkudi District is arrived at Rs 63058 and Rs 59830 in respect of Tiruppur District. The cost of plant material alone accounted for around 10 per cent to the total establishment cost in both of the districts. From that one could infer that the rental value of land, fencing charges and planting material cost are the major items under establishment cost. The cost of irrigation arrangements during the initial period is accounted for around 5 per cent to the total establishment cost.

6.2.2 Annual Maintenance Cost involved in Moringa Plantations

After incurring the initial investment on establishing the Moringa plantations, the farmer is required to make some of the following investments until the tree reaches the bearing stage. Such costs are known as operational or maintenance costs and are mainly incurred for land preparation, fertilizer application, pesticide spraying, irrigation and manuring the plantations with farm yard manure etc. The analysis of the collected data from the samples revealed that the total investment on the Moringa plantations until getting the yield was averaged and are presented as average maintenance cost up to 3 years; average maintenance cost up to 7 years and average maintenance cost up to the 10th year of maintenance and designated as maturing phase, yielding phase, and economically yielding phase respectively. Similar approach was practiced by Ritambhara Singh et al. during 2017. The details are analyzed and presented in Table 5.

Table 5 revealed that annual maintenance cost during different phases of Moringa plantation is found to be 59 per cent and the total annual harvesting cost is arrived at 41 per cent to the total maintenance cost. It revealed that the farmers in Thoothukkudi region is capable of applying same input cost and it did not differ between the maturing phase, yielding phase and the economically yielding phase leaving absolute difference. The absolute difference in the maintenance cost is comparatively higher in the initial stages of maintenance and during the economically yielding stages. It might be due to the healthy establishment of the plantation during the initial stages will withstand some environmental distress like drought and disease. During the economically yielding stage, the increase in cost is visible due to the interest of getting the continuous yield increase in respect of Moringa fresh vegetable pods. In this respect, the annual maintenance cost that are incurred by the farmers of Tiruppur District is much important and the details are analyzed and the results are presented in Table 6.
Table 5 Average Maintenance Cost of Moringa Plantations in Thoothukkudi District

| Sl. No | Particulars of Cost          | Economically Yielding Phase (10 Years) | Yielding Phase (7 Years Average) | Maturing Phase (3 Years Average) |
|--------|------------------------------|----------------------------------------|---------------------------------|----------------------------------|
| 01     | Manures and Manuring         | 6896.01                                | 6077.02                         | 8806.98                          |
| 02     | Fertilizer Application       | 7645.38                                | 6910.62                         | 9359.80                          |
| 03     | Plant Protection             | 1359.04                                | 1228.43                         | 1663.80                          |
| 04     | Weeding                      | 4549.69                                | 4112.44                         | 5569.92                          |
| 05     | Earthing up and Basin Formation | 2413.51                          | 2181.56                         | 2954.72                          |
| 06     | Pruning of Tips              | 1089.63                                | 960.22                          | 1391.58                          |
| 07     | Irrigation                   | 6924.83                                | 6240.74                         | 8521.04                          |
| 08     | Miscellaneous Charges        | 1901.28                                | 1758.22                         | 2235.11                          |
| 09     | Land Cess and Tax            | 74.63                                  | 65.77                           | 95.31                            |
|        | **Total Annual Operational Cost** | **32854.00 (58.79)** | **29535.02 (58.66)** | **40598.26 (59.01)** |

Harvesting and Distribution Cost of Moringa

| Sl. No | Particulars of Cost          | Economically Yielding Phase (10 Years) | Yielding Phase (7 Years Average) | Maturing Phase (3 Years Average) |
|--------|------------------------------|----------------------------------------|---------------------------------|----------------------------------|
| 10     | Harvesting Charges           | 14558.92                               | 13159.74                        | 17823.66                        |
| 11     | Packing and Grading          | 6098.63                                | 5512.52                         | 7466.21                          |
| 12     | Transportation Charges       | 856.41                                 | 774.10                          | 1048.45                          |
| 13     | Loading and Unloading        | 2491.37                                | 2251.94                         | 3050.57                          |
|        | **Total Annual Harvesting Cost** | **23032.14 (41.21)** | **20818.63 (41.34)** | **28196.94 (40.99)** |

Total Annual Maintenance Cost

| Sl. No | Particulars of Cost          | Economically Yielding Phase (10 Years) | Yielding Phase (7 Years Average) | Maturing Phase (3 Years Average) |
|--------|------------------------------|----------------------------------------|---------------------------------|----------------------------------|
| 01     | Manures and Manuring         | 7276.63                                | 6412.44                         | 9293.08                          |
| 02     | Fertilizer Application       | 8423.93                                | 7614.35                         | 10312.94                         |
| 03     | Plant Protection             | 1538.42                                | 1390.57                         | 1883.40                          |
| 04     | Weeding                      | 4949.64                                | 4473.96                         | 6059.57                          |
| 05     | Earthing up and Basin Formation | 2491.37                          | 2251.94                         | 3050.57                          |
| 06     | Pruning of Tips              | 796.39                                 | 701.81                          | 1017.08                          |
| 07     | Irrigation                   | 7474.10                                | 6755.80                         | 9150.11                          |
| 08     | Miscellaneous Charges        | 1946.38                                | 1759.32                         | 2382.84                          |
| 09     | Land Cess and Tax            | 74.63                                  | 65.77                           | 95.31                            |
|        | **Total Annual Operational Cost** | **34971.49 (58.90)** | **31425.96 (58.76)** | **43244.37 (59.14)** |

Harvesting and Distribution Cost of Moringa

| Sl. No | Particulars of Cost          | Economically Yielding Phase (10 Years) | Yielding Phase (7 Years Average) | Maturing Phase (3 Years Average) |
|--------|------------------------------|----------------------------------------|---------------------------------|----------------------------------|
| 10     | Harvesting Charges           | 14948.19                               | 13511.61                        | 18300.23                        |
| 11     | Packing and Grading          | 6332.19                                | 5723.64                         | 7752.15                          |
| 12     | Transportation Charges       | 934.26                                 | 844.48                          | 1143.76                          |
| 13     | Loading and Unloading        | 2188.59                                | 1978.25                         | 2679.36                          |
|        | **Total Annual Harvesting Cost** | **24403.23 (41.10)** | **22057.98 (41.24)** | **29875.50 (40.86)** |

Total Annual Maintenance Cost

Note: Figures in Parentheses indicate Percentage to Total

Table 6 Average Maintenance Cost of Moringa Plantations in Tiruppur District

| Sl. No | Particulars of Cost          | Economically Yielding Phase (10 Years) | Yielding Phase (7 Years Average) | Maturing Phase (3 Years Average) |
|--------|------------------------------|----------------------------------------|---------------------------------|----------------------------------|
| 01     | Manures and Manuring         | 7276.63                                | 6412.44                         | 9293.08                          |
| 02     | Fertilizer Application       | 8423.93                                | 7614.35                         | 10312.94                         |
| 03     | Plant Protection             | 1538.42                                | 1390.57                         | 1883.40                          |
| 04     | Weeding                      | 4949.64                                | 4473.96                         | 6059.57                          |
| 05     | Earthing up and Basin Formation | 2491.37                          | 2251.94                         | 3050.57                          |
| 06     | Pruning of Tips              | 796.39                                 | 701.81                          | 1017.08                          |
| 07     | Irrigation                   | 7474.10                                | 6755.80                         | 9150.11                          |
| 08     | Miscellaneous Charges        | 1946.38                                | 1759.32                         | 2382.84                          |
| 09     | Land Cess and Tax            | 74.63                                  | 65.77                           | 95.31                            |
|        | **Total Annual Operational Cost** | **34971.49 (58.90)** | **31425.96 (58.76)** | **43244.37 (59.14)** |

Harvesting and Distribution Cost of Moringa

| Sl. No | Particulars of Cost          | Economically Yielding Phase (10 Years) | Yielding Phase (7 Years Average) | Maturing Phase (3 Years Average) |
|--------|------------------------------|----------------------------------------|---------------------------------|----------------------------------|
| 10     | Harvesting Charges           | 14948.19                               | 13511.61                        | 18300.23                        |
| 11     | Packing and Grading          | 6332.19                                | 5723.64                         | 7752.15                          |
| 12     | Transportation Charges       | 934.26                                 | 844.48                          | 1143.76                          |
| 13     | Loading and Unloading        | 2188.59                                | 1978.25                         | 2679.36                          |
|        | **Total Annual Harvesting Cost** | **24403.23 (41.10)** | **22057.98 (41.24)** | **29875.50 (40.86)** |

Total Annual Maintenance Cost

Note: Figures in Parentheses indicate Percentage to Total

Table 6 revealed that the Tiruppur District also had the similar cost use pattern in respect of operational and harvesting related cost. Only the absolute difference is visible between the average cost incurred during different phases.

The early stages of maintenance alone attracted higher operational cost as visible in Thoothukkudi District. In this circumstance, one has to analyze the yield and income realized by the farmers from Moringa plantations after incurring heavy investment and hence these data are analyzed and the results are presented in Table 7. Though
the Moringa plantations are capable of yielding up to 30 years of its life, the yield calculation was made only up to 10 years of establishment due to errors in recollection of data and limited to 10 years.

### 6.3 Yield and Income Potentials from Moringa Plantations

The drier environment is preferable to Moringa plantations. Fearing the drought, the Moringa plants will tend to promote their flowering profusely and capable of producing more number of fresh pods to deliver their offspring to the environment. In this respect, if one could maintain optimum needs of water for their survival coupled with fertigation arrangements, it could yield higher and hence these details are analyzed and the results are presented in Table 7. in respect of sample farms.

#### Table 7 Yield and Income Realized from Moringa Plantations

| Year | Yield of Moringa Pod in Tonnes per Ha | Gross Income Realized per Ha |
|------|--------------------------------------|-------------------------------|
|      | Thoothukkudi District | Tiruppur District | Thoothukkudi District | Tiruppur District |
| 01   | 07.20                  | 08.10                        | 75600.00                  | 102465.00           |
| 02   | 12.60                  | 14.40                        | 132300.00                 | 182160.00           |
| 03   | 26.55                  | 27.90                        | 278775.00                 | 352935.00           |
| 04   | 28.35                  | 29.25                        | 297675.00                 | 370012.50           |
| 05   | 30.15                  | 31.05                        | 316575.00                 | 392782.50           |
| 06   | 31.05                  | 32.85                        | 326025.00                 | 415552.50           |
| 07   | 33.75                  | 35.10                        | 354375.00                 | 444015.00           |
| 08   | 36.00                  | 36.45                        | 378000.00                 | 461092.50           |
| 09   | 36.45                  | 37.80                        | 382725.00                 | 478170.00           |
| 10   | 37.80                  | 39.60                        | 396900.00                 | 500940.00           |
| Total| 27.99                  | 29.25                        | 2938950.00                | 3700125.00           |

**Note:** Primary Survey

Table 7 revealed the details of yield and income realization over years from the Moringa plantations. The average yield of fresh Moringa pod is arrived at 28 tonnes in respect of Thoothukkudi District. Whereas, Tiruppur District was capable of realizing 29 tonnes per ha. On examining the yield difference between the Thoothukkudi District and the Tiruppur District, the much difference is invisible, but only marginal when comparing the mean yield. The yield potential of Moringa in Tamil Nadu is good. On an average, Tamil Nadu could be able to produce around 2.81 lakh tonnes of Moringa pods per annum with the average productivity of 21 tonnes per ha. Whereas, the national productivity of Moringa is found to be 51 tonnes and Tamil Nadu has to take much initiative to achieve that level. In this circumstance, whether the Moringa plantations are economically viable or not has to be analyzed and hence the details are analyzed and the results are presented elsewhere.

#### 6.3.1 Cost of Production of Annual Moringa

So far, the discussions were made in favor of perennial Moringa. Very few households particularly in Tiruppur and Thoothukkudi Districts had raised Annual Moringa (PKM-1 and PKM-2). Before analyzing the cost of production of annual Moringa, the discussion on how many farm households are in practice with establishing annual Moringa is analyzed and the details are presented in Table 8.

#### Table 8 Number of Households Practicing Annual Moringa

| Sl. No | Particulars of Annual Moringa | Number of Households in Thoothukkudi District | Tiruppur District |
|--------|-------------------------------|-----------------------------------------------|-------------------|
| 01     | Perennial Moringa             | 47 (94.00)                                     | 42 (84.00)        |
| 02     | Annual Moringa – PKM - 1      | 02 (04.00)                                     | 05 (10.00)        |
| 03     | Annual Moringa – PKM - 2      | 01 (02.00)                                     | 03 (06.00)        |
| Total  |                               | 50 (100.00)                                    | 50 (100.00)       |

**Note:** Primary Survey; Figures in Parentheses indicate Percentage to Total

Table 8 revealed that the perennial Moringa is cultivated by 94 per cent of the farm households in Thoothukkudi District. Whereas, only 84 per cent of the farm households have raised Perennial Moringa in Tiruppur District.
Only 6 per cent of the farm households are having the practice of cultivating annual Moringa in Thoothukkudi District. But 16 per cent of the farm households are having the practice of establishing annual Moringa in their farms of Tiruppur District. Among the annual Moringa varieties, the PKM – 1 variety found to dominate both in Thoothukkudi District and Tiruppur District because the fresh Moringa Pods are in optimum size which facilitates transportation to different consuming centers. Whereas, the PKM – 2 variety pods are fleshy and lengthy which has bit difficulties in transportation. Sometimes, breakage is also visible in PKM – 2 and hence it is less preferred among the farmers. However, the cost of production of annual Moringa is important and hence these details are analyzed and the results are presented in Table 9.

Table 9 Costs and Return from Annual Moringa Plantations

| Sl. No | Particulars of Cost                  | Number of Units | Cost per Unit in Rs | Total Cost in Rs per Acre | Total Cost in Rs per Ha |
|--------|-------------------------------------|-----------------|---------------------|---------------------------|-------------------------|
|        | Operational Cost                    |                 |                     |                           |                         |
| 01     | Preparatory Cultivation and Tillage | 03              | 700.00              | 2100.00                   | 5187.00                 |
| 02     | Cost of Farm Yard Manure            | 12              | 400.00              | 4800.00                   | 11856.00                |
| 03     | Application of Farm Yard Manure     | 24              | 25.00               | 600.00                    | 1482.00                 |
| 04     | Cost of Seed and Planting Charges   | 0.50 Kgs        | 2400               | 1200.00                   | 2964.00                 |
| 05     | Weeding Cost                        | 54              | 25.00               | 1350.00                   | 3334.50                 |
| 06     | Hiring Cost of Sprayers and its Operation | 04          | 260.00              | 1040.00                   | 2568.80                 |
| 07     | Cost of Pesticides and Fungicides   |                 |                     |                           |                         |
| 08     | Cost of Neem Cake                   | 150 Kgs         | 23.00               | 3450.00                   | 8521.50                 |
| 09     | Cost of Urea                        | 275 Kgs         | 06.00               | 1650.00                   | 4075.50                 |
| 10     | Cost of Super Phosphate             | 100 Kgs         | 07.75               | 775.00                    | 1914.25                 |
| 11     | Cost of Potash Fertilizer           | 130 Kgs         | 17.00               | 2210.00                   | 5458.70                 |
| 12     | Cost of Harvesting (Men Hours)      | 68 Hours         | 60.00               | 4080.00                   | 10077.60                |
| 13     | Cost of Harvesting (Women Hours)    | 50 Hours         | 25.00               | 1250.00                   | 3087.50                 |
|        | Total Operational Cost (I)          |                 |                     |                           |                         |
|        |                                    |                 |                     | 27005.00                  | 66702.35(77.47)         |
|        | Annual Fixed Cost                   |                 |                     |                           |                         |
| 14     | Rental Value of Land                | 01 Acre         | 7720               | 7720.00                   | 19302.30                |
| 15     | Land Tax, Cess, etc                 | 01 Acre         | 95.00              | 95.00                     | 100.00                  |
|        |                                    |                 |                     |                           |                         |
|        | Total Annual Fixed Cost             |                 |                     | 7815.00                   | 19402.30(22.53)         |
|        | Total Cost of Cultivation           |                 |                     | 34820.00                  | 86104.65(100.00)        |
|        |                                     |                 |                     |                           |                         |
|        | Gross Income                        |                 |                     |                           |                         |
|        | Income from Main Product (Drumstick)| 14605 Kgs      | 12.65              | 184753.00                | 456340.53               |
|        | Income from Bi-Product (Leaves)     | 9100 Kgs        | 05.00               | 45500.00                  | 112385.00               |
|        | Total Income from Moringa           |                 |                     | 230253.00                 | 568725.53               |
| IV     | Cost of Production per Kg of Main Product | 02.38         |                     | 0.238                     |                         |
| V      | Output – Input Ratio                |                 |                     | 06.62                     | 06.62                   |

Note: Primary Survey; Figures in Parentheses indicate Percentage to Total

Table 9 revealed that the total operational cost incurred in respect of establishing annual Moringa is arrived at Rs. 66702/ per ha which is accounted for 77.47 per cent to the total cost of cultivation of annual Moringa. Whereas, the annual fixed cost incurred was arrived at Rs 19402/ which is accounted for 22.53 per cent. The total cost of establishing the annual Moringa per ha was arrived at Rs 86104/ . The gross income realized by the farmer per ha was arrived at 5.69 lakhs in which the revenue earned from main product was accounted for 80 per cent and the bi-product accounted for only 20 per cent. The bi-product harvested was green leaves for local sales. Put together, the cost of production of fresh Moringa pod per kg was arrived at Rs 2.38 per kg. The cost of production per ton was arrived at rupees 2380/ . However, the sale of fresh Moringa pods per ton was arrived at Rs 11750/ which has indicated that the cultivation of annual Moringa is highly profitable as there exists good market for the produce. Hence, the farmers can take up annual Moringa cultivation in their farm lands in general. But, specifically, as the perennial Moringa is enriched with much of nutritional and pharmaceutical importance, the cultivation of Perennial Moringa in the sample farm households are predominant.
6.3.2 Factors Governing Profitability of Moringa

The profitability of Moringa is influenced by certain factors. Though certain farmers are not conversant and has clarity on which parameter mostly influences the profitability, the researcher has given highlights on certain factors and then the farmer could say something about the factors and hence those factors have been analyzed and the details are presented in the Table 10.

Table 10 Factors Governing the Profitability of Moringa

| S. No. | Factors Governing the Profitability of Moringa                           | No. of Farmers Reported |
|--------|-------------------------------------------------------------------------|-------------------------|
|        |                                                                         | Thoothukkudi | Tiruppur |
| 1.     | Selection and Adoption of High Yielding Varieties of Moringa            | 24 (48.00)   | 14 (28.00) |
| 2.     | Sowing of Moringa in Appropriate Season                                | 03 (06.00)   | 05 (10.00) |
| 3.     | Moringa Variety that should have Greater Consumer Acceptance          | 09 (18.00)   | 08 (16.00) |
| 4.     | Adoption and Management of Ratoon Crop in Moringa                     | 04 (08.00)   | 11 (22.00) |
| 5.     | Adoption of Appropriate Post Harvest Management Practices            | 10 (20.00)   | 12 (24.00) |
|        | Total                                                                   | 50 (100.00)  | 50 (100.00) |

Table 10 revealed a different response in respect of sample farms drawn from Thoothukkudi and Tiruppur Districts in respect of Profitability aspects of Moringa. In respect of sample farms from Thoothukkudi District, they were of the opinion that the Selection and Adoption of High Yielding varieties of Moringa is one of the Principal factor that decides profitability. But it is not that much reflected in respect of farms from Tiruppur District. It might be due to the expertise developed in this regard in raising both perennial types and high yielding varieties of Moringa. The higher percentage of respondents from Thoothukkudi reported that the high yielding varieties of Moringa could enhance the profitability.

The Moringa variety practiced should have greater consumer acceptance with regard to taste of the vegetable as well as marketability specifically the size of Moringa. Higher the length of the Moringa vegetable or pod is not much preferred by the consumers and producers. The response of the farmers with regard to this factor is almost equal and hence the breeders who are involved in making new varieties for release should take care of this sensitive factor.

The most important factor is “Adoption of Appropriate Post Harvest Management Practices” which is also contributing to the profitability as reported by the sample farmers of Thoothukkudi and Tiruppur Districts which are also almost equal and ranked as second important factor that decides the profitability. The post harvest measures included are harvesting methods, transportation methods, processing methods like drying and value addition. Around 20 to 24 per cent of the sample farms have expressed this as a most important factor and hence immediately after harvest of Moringa pods or Moringa leaves, the post harvest management issue should be properly looked into and one should see that the aspects are being implemented properly or sequentially or not. Hence those who are planning to establish the Moringa orchards, these factors must also be given a fillip to earn higher profitability.

6.3.3 Steps involved in Post Harvest Practices for Moringa Leaves

Various steps are involved in processing of Moringa leaves and Pods for manufacturing various products like Moringa leaf Powder, Moringa Leaf Tablets, Moringa Capsules, Moringa Chips etc. The steps involved are arranged orderly and sequentially and the details are presented in Table 11.

While doing labeling the following points must be taken into account. They are

- Name of the Product
- Net Content in Grams or Mg
- Name and Address of the Producer or the Manufacturer
- Country of Origin
- Lot Number or Code
- Instructions for Use
The above aspects of post harvest and value addition measures if practiced scrupulously, the product quality could be ensured and it fetches higher consumer acceptance both in the regional, national and international markets.

Table 11 Steps Involved in Post Harvest Processing of Moringa Leaves

| Steps | Sequence of Operations |
|-------|------------------------|
| 01    | Cut Big Branches of Moringa Tree |
| 02    | Strip the Leaves off the Branches before Transporting to the Processing Centre |
| 03    | Freshly Harvested Leaves should be Transported to the Processing Centre as Quickly as Possible |
| 04    | Wash the Leaflets in Troughs using Clean Potable Water to remove dirt and impure materials |
| 05    | Wash the Leaves again in One per cent saline solution for 3-5 Minutes to remove Microbial load if any |
| 06    | Drain Each Trough after Wash |
| 07    | Spread the Leaflets on Trays made with food grade mesh and leave to drain for 15 Minutes before taking them to the Dryer |
| 08    | Try to Use Solar Drying or Room Drying. Do not expose the leaflets to sun drying. Use electric or gas hot –air dryers. Drying temperatures should range between 50 degree Celsius to 55 degree Celsius |
| 09    | Dry the leaves and see that the Moisture level is less than 10 Per cent. |
| 10    | Ensure the Chlorophyll Content to the level of 6 to 7 Per cent. Higher the Chlorophyll Content of leaves will have higher acceptability in Export Markets. |
| 11    | Mill dry leaves using a stainless steel hammer Mill. |
| 12    | Sieve the leaf powder if needed. Recommended particle Sizes are Coarse (1.0 MM to 1.50 MM); Fine (0.50 MM to 1.00 MM) and Very Fine Powder (0.2 MM to 0.50 MM) |
| 13    | Dry the Leaf Powder immediately after Milling. The Drying may be performed at 50 degree Celsius for 30 Minutes to reduce Moisture content to the level below of 7.50 per cent. |
| 14    | Do Packing and Store the produce free from Bacteria and Fungi as it could attract these two. |
| 15    | Maintain Personal Hygiene by wearing Head Caps, Nose Masks, Disposable Gloves etc. |
| 16    | Do Labeling and Branding of the Value Added Produce |
| 17    | Get the FSSAI Certification from Government of Tamil Nadu |
| 18    | Get HALAL certification to highlight the vegetable origin. |
| 19    | Get Good Management Practices Certification also from the technical firm nearby to build the confidence among the consumers |

6.3.4 Composition of Nutrients in Moringa Produce

The Moringa leaves or greens of Moringa, the pods of Moringa contain high levels of energy contributing Vitamins, Minerals, Proteins and Carbohydrates. The people who are regularly taking Moringa in their diet were of the opinion of energy gaining as reported by Ponnuswami during the year 2012. The details of energy contributing Vitamins and Minerals are delineated in Table 12.

Table 12 outlined that the Moringa leaves contain high level of energy contributing vitamins and minerals. In that Vitamin – A acts as a shield against eye disease to the human, skin disease, heart ailments, diarrhea and many other diseases. Similarly Vitamin – C is capable of fighting a host of illness including Colds and Flu. The Calcium which is present in the Moringa is able to build Strong bones and teeth and helps prevent Osteoporosis.

Potassium is an essential element for the functioning of Brain and Nerve cells (Ponnuswami, 2012) and the Proteins, the building blocks of all our body cells and hence every consumer must take the produce of Moringa in either as a juice or side dish or as main dish or soup and or in Capsule or tablet forms. Those who are in the urban fringes may not be able to get the Moringa greens and hence they can go for consuming Moringa Tablets and or the Moringa Capsules which are available in Palamudhir Nilayam and in Big Retail Formats.
6.4 Economics of Moringa Plantations in Tamil Nadu

To work out the economics of Moringa production, the year wise and operation wise costs incurred over the years were analyzed and the results are presented elsewhere. In a nutshell, the plantations are economically viable or not has to be discussed and hence the data have been analyzed using the economic appraisal tools which are presented in Table 13.

Table 12 Composition of Nutrients from Moringa Leaves and Pods

| Sl. No | Available Nutrients per 100 Gram of Intake | Units | Moringa Leaves | Moringa Pods |
|-------|--------------------------------------------|-------|----------------|--------------|
| 01    | Edible Protein                             | Percent | 75.00         | 83.00        |
| 02    | Moisture Content                           | Percent | 75.00         | 86.90        |
| 03    | Protein                                    | Grams   | 06.70          | 02.50        |
| 04    | Fats                                       | Grams   | 01.70          | 00.10        |
| 05    | Carbohydrate                               | Grams   | 13.40          | 03.70        |
| 06    | Minerals                                   | Grams   | 02.30          | 02.00        |
| 07    | Fibre                                      | Grams   | 00.90          | 04.80        |
| 08    | Calories                                   | --      | 92.00          | 26.00        |
| 09    | Calcium                                    | Mg      | 440.00         | 30.00        |
| 10    | Magnesium                                  | Mg      | 24.00          | 24.00        |
| 11    | Oxalic Acid                                | Mg      | 101.00         | 101.00       |
| 12    | Phosphorous                                | Mg      | 70.00          | 110.00       |
| 13    | Potassium                                  | Mg      | 259.00         | 259.00       |
| 14    | Copper                                     | Mg/Gram | 01.10        | 03.10        |
| 15    | Iron                                       | Mg      | 07.00          | 05.30        |
| 16    | Sulphur                                    | Mg      | 137.00         | 137.00       |
| 17    | Vitamin - A                                | IU      | 11300          | 184.00       |
| 18    | Choline                                    | Mg      | 423.00         | 423.00       |
| 19    | Thiamine                                   | Mg      | 00.06          | 00.05        |
| 20    | Riboflavin                                  | Mg      | 00.05          | 00.07        |
| 21    | Nicotinic Acid                             | Mg      | 00.80          | 00.20        |
| 22    | Vitamin - C                                | Mg      | 220.00         | 120.00       |

Table 13 Economics of Moringa Plantations

| Sl. No | Tools of Appraisal | Units per Ha | Thoothukkudi District | Tiruppur District |
|-------|--------------------|--------------|-----------------------|-------------------|
| I     | Perennial Moringa  |              |                       |                   |
| 01    | Gross Income       | Rupees       | 293895.00             | 370013.00         |
| 02    | Net Income         | Rupees       | 231703.00             | 304660.00         |
| 03    | Net Present Value @ 12% | Rupees   | 1128756.00           | 1507024.00        |
| 04    | Benefit Cost Ratio | Ratio        | 04.17                 | 05.07             |
| 05    | Internal Rate of Return | Per Cent | >100                 | >100              |
| II    | Annual Moringa     |              |                       |                   |
| 01    | Gross Income       | Rupees       | 568725.53             |                   |
| 02    | Net Income         | Rupees       | 482620.88             |                   |
| 03    | Cost of Production / Ton | Rupees | 2380.000            |                   |
| 04    | Output – Input Ratio | Ratio       | 06.62               |                   |
| 05    | Return on Investment |             | 05.60               |                   |

Table 13 revealed that the perennial Moringa is capable of generating a net income of Rs 2.31 lakhs in Thoothukkudi District. But the same perennial Moringa is able to provide 3.05 lakhs per annum as its net income per ha. This is comparatively more because Tiruppur farm households able to receive an average price of Rs 12.65 per kg of Moringa pods. Whereas, the farm households at Thoothukkudi District is able to receive an average price of Rs 10.50 per kg of Moringa vegetables. It is mainly due to the export competitiveness available.
in Tiruppur and the demanding firms are checking the quality of the produce and offer best price. The Tiruppur produce naturally commands best price due to its taste because of its cultivation made in calcium rich soils.

On discounting the values of income and investment over years using 12 per cent discount rate, the Thoothukkudi farm households are able to generate the Net Present Value of Rs 11.39 lakhs while the Tiruppur counterparts are able to secure net present value of Rs 15.07 lakhs. The Benefit Cost Ratio was arrived at 4.17 and 5.07 in respect of Thoothukkudi farm households and Tiruppur farm households revealed that the farmers respectively could earn a profit of Rs 4.17 and 5.07 for a rupee of investment in the establishment and maintenance activities of Moringa. The study conducted by Ritambhara Singh during the year 2017 in Gujarat State has arrived the Benefit Cost Ratio to the tune of 10.76 for a rupee of investment and the NPV under normal cost and return was arrived at Rs 25.24 lakhs per ha and the IRR was estimated at 95.53 per cent. In this study, the returns are valued at lower price per unit of the produce. None other enterprises are able to provide such returns and hence the area under horticulture particularly Moringa can best be encouraged by the extension functionaries in their respective districts.

On analyzing the economic worthiness of annual Moringa, the annual Moringa established by the farm households could generate a net income of Rs 4.83 lakhs per annum with the cost of production of Rs 2380 per ton of Moringa vegetables. On an undiscounted term, the Output-Input ratio is arrived at 6.62 revealed that the farmers are able to generate a gross income of Rs 6.62 per rupee of investment. The Return on Investment figure revealed that the farm households whom are capable of establishing the annual Moringa in their farms, could generate 5.60 as their profit per unit of investment.

7 Summary and Conclusions
Economic analysis of Moringa orchards revealed that the plantations are capable of generating higher return per unit of the produce. This was proved with the data provided by the Benefit Cost Ratio, Net Present Value and Internal Rate of Return. The Benefit Cost Ratio was arrived at 4.17 and 5.07 in respect of Thoothukkudi farm households and Tiruppur farm households revealed that the farmers respectively could earn a profit of Rs 4.17 and 5.07 for a rupee of investment in the establishment and maintenance activities of Moringa. None other enterprises are able to provide such returns and hence the area under horticulture particularly Moringa can best be encouraged by the extension functionaries in their respective districts by infusing technology to the farm households and the area expansion could be achieved which is one of the focal area of National Mission on Horticulture. With regard to Post Harvest Management practices, the steps involved in processing of Moringa leaves to protect the Chlorophyll content and the appearance of the leaf powder is also discussed.

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