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# On Farm Validation of Organic Farming Technology in Elephant foot yam [*Amorphophallus paeoniifolius* (Dennst.) Nicolson]

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## Abstract

Currently alternative agricultural systems, like organic farming, that are less chemical intensive, less exploitative and that can conserve the environment are gaining popularity. Tuber crops, especially aroids, like elephant foot yam, respond well to organic manures and offer scope for organic production. However, lack of package of practices recommendations hinders the promotion of this viable alternative farming practice. Hence, the organic farming technology for elephant foot yam developed at CTCRI was validated through on farm trials under State Horticulture Mission funded programme. Demonstration trials were conducted during 2008-2009 in 10 farmers' sites to cover an area of 5 ha in Kollam and Pathanamthitta districts of Kerala to compare the yield, quality, economics and soil nutrient status under the organic management practices with the existing farmers' practice and conventional practice (present Package of Practices Recommendations) in elephant foot yam. Organic farming resulted in higher corm yield (34.60 t $ha^{-1}$) and additional income (Rs. 43,651 $ha^{-1}$) over conventional farming. Organically produced corms had significantly higher dry matter and Mg contents and significantly lower oxalate content. The chemical properties of the soil, especially K, were also seen favoured under organic farming. The organic farming technology standardized for elephant foot yam includes the application of farmyard manure ( FYM) @ 36 t $ha^{-1}$, green manuring with cowpea to generate 20-25 t $ha^{-1}$ of green matter in 45-60 days, neem cake @ 1 t $ha^{-1}$ and ash @ 3 t $ha^{-1}$. FYM and neem cake are to be applied in pits at the time of planting. Ash may be applied at the time of incorporation of green manure at 45-60 days after planting.

**Key words**: *Amorphophallus paeoniifolius*, organic farming, conventional farming, on farm trial, corm yield, quality, economics, available N, P and K

## Introduction

Global awareness of health and environmental issues is spreading fast in recent years. Presently there is considerable interest among farmers, researchers, government and non-government agencies and environment conservation groups in investigating and adopting eco-friendly farming strategies like organic farming in view of the growing demand for safe and healthy food and concerns of environmental pollution associated with the indiscriminate use of agro-chemicals. Though the use of chemical inputs is inevitable to meet the growing demand for food in India, there are opportunities in selected crops and niche areas where organic production could be encouraged to tap the domestic and export markets and ultimately protect soil health, human health and the environment.

Elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson) is an important tropical tuber crop gaining popularity not only as a food security crop but also as a remunerative cash crop. It has high production potential and is popular as a vegetable having high nutritive value, good taste and cooking quality besides

medicinal values. The crop responds well to organic manures and can be grown with lesser chemical inputs, using the organic wastes available in home gardens. Thus there is ample scope for organic production as well as for export to the middle east, Europe and USA.

The results of the on station experimentation at Central Tuber Crops Research Institute (CTCRI), Sreekariyam, Thiruvananthapuram, have indicated that organic farming is a viable strategy in elephant foot yam for getting high yield of good quality corms besides maintaining soil fertility (Suja *et al.*, 2006; Suja *et al.*, 2008; Suja and Sundaresan, 2008). However, further confirmation about the feasibility of the organic farming technology (developed on station) is necessary for recommendation of package of practices for organic farming and promotion of organic farming in this crop. Hence a project funded by the State Horticulture Mission was taken up for further validation and popularisation of the organic farming technology developed in elephant foot yam at CTCRI. An attempt has been made in this paper to compare yield, quality, economics and soil nutrient status under the organic management practices with the existing farmers' practice and conventional practice in elephant foot yam and thereby validate the organic farming technology developed for elephant foot yam.

## Materials and Methods

The project envisaged validation and popularization of organic farming technology in elephant foot yam developed at CTCRI in an area of 5 ha in Kollam and Pathanamthitta districts (2.5 ha each).

The Principal Agricultural Officers of the two districts viz., Kollam and Pathanamthitta were contacted and from about 30 farmers' fields identified by the Agricultural Officers of the various Krishi Bhavans, 10 most appropriate and suitable farmers' sites were selected to cover a total area of 5.2 ha (13 acres; @ 2.6 ha in each district) for laying out demonstration trials.

Before laying out the on farm trials, soil samples were collected and analyzed for organic C, available P and K status by standard analytical procedures for calculating the quantity of organic manures and chemical fertilizers to be applied in the various treatments. The nutrient status of the soil before the commencement of the on farm trials is given in Table 1. In general, organic C status was medium to high, except in the sandy tracts of Karunagappally, Kulasekharapuram areas, where it was low, as expected. Available P content was high and available K content was medium to high.

Thirty five tons of seed corms of elephant foot yam of a local variety were procured from Swasraya Karshaka Samithi- Elanadu, Kunnumpuram, Elanadu P.O., Palakkad district (authorized farmer market established by Vegetable and Fruit Promotion Council Keralam) and distributed to the farmer beneficiaries in various panchayats of Kollam and Pathanamthitta districts.

Table 1. Initial nutrient status of the soil in various on farm locations

| Location | Area (ha) | Conditions | Organic C (%) | Available P (kg $ha^{-1}$) | Available K (kg $ha^{-1}$) |
|---|---|---|---|---|---|
| Kollam district | | | | | |
| Shakthikulangara | 1.2 | upland | 0.46 | 58.91 | 191.14 |
| Karunagapally | 0.4 | upland | 0.24 | 55.08 | 165.76 |
| Karunagapally | 0.4 | upland | 0.33 | 77.41 | 172.48 |
| Kulasekhara Puram | 0.4 | upland | 0.30 | 47.92 | 174.72 |
| Chadayamangalam | 0.2 | upland | 1.17 | 71.55 | 217.28 |
| Anchal | 0.4 | lowland | 1.29 | 133.35 | 439.04 |
| Pathanamthitta district | | | | | |
| Kadampanad | 1.0 | lowland | 1.74 | 47.70 | 248.64 |
| Thumpamon | 0.2 | upland | 0.78 | 69.17 | 259.84 |
| Omallur | 0.4 | upland | 0.84 | 90.85 | 327.04 |
| Omallur | 0.6 | lowland | 2.25 | 394.63 | 179.20 |
| Total | 5.2 | | | | |

The validation trial was laid out in randomised block design (RBD) with 3 treatments replicated 10 times (10 locations). The area of each farmer was demarcated into 3 for imposing the following treatments viz., conventional practice (present Package of Practices Recommendations (POP): FYM @ 25 t $ha^{-1}$ + NPK @ 100: 50: 150 kg $ha^{-1}$), traditional (farmer's practice) and organic practices (strict use of organic manures). Cut pieces of corms of 500-750 g were used for planting in almost all locations. In conventional practice, full P, half N and K were applied within a week after sprouting of elephant foot yam and the remaining dose 1 month after the first application. In traditional practice, FYM, ash, neem cake and chemical fertilizers were used, the quantity varied with farmers and locations. In general, application of FYM @ 3 kg, neem cake @ 200 g and ash @ 250 g per pit and chemical fertilizers to supply NPK @ 80:75:90 kg $ha^{-1}$ was the farmer's practice. Chemical fertilizers were applied in 2-3 splits after sprouting. In the organic practice, the seed corms were treated with cow dung-neem cake-*Trichoderma harzianum* slurry and dried under shade before planting. In the organic plots, FYM@ 36 t $ha^{-1}$ (3 kg per pit), green manuring with cowpea (to generate 20-25 t $ha^{-1}$ of green matter), neem cake @1 t $ha^{-1}$ (100 g per pit) and ash @ 3 t $ha^{-1}$ (250 g per plant) were the organic manures used. Farmyard manure and neem cake were applied in pits at the time of planting. For producing sufficient quantity of green manure in the organic plots, cowpea seeds were sown (@ 20-25 kg $ha^{-1}$) in between elephant foot yam pits immediately after planting elephant foot yam and incorporated after 45-60 days. Ash was applied at the time of incorporation of green manure. The farmers were educated about the importance of the various treatments and were cautioned not to use any chemical fertilizers/ inputs in the organic plots. All the trials were planted during the second fortnight of May (May 15-30 2008), the crop was rainfed and harvested by January-February 2009. All these field operations were carried out strictly as per the directions of the investigators and supervised by the technical staff of CTCRI.

Corms from the 3 treatments were harvested and fresh weights were recorded and corm yield was expressed in t $ha^{-1}$. Proximate analyses of corms for dry matter, starch, total sugar, reducing sugar, crude protein, oxalates and total phenols were also done using standard procedures. Dry matter, crude protein and oxalates were determined by the method of AOAC (1980). The starch was converted to sugars by acid hydrolysis and estimated by the method of Dubois et al. (1956). Total sugars were also determined by this method. Reducing sugars was estimated by the method of Nelson (1944) and total

Table 2. Corm yield of elephant foot yam at different sites as influenced by three production systems

| Location | Conventional practice | | Farmers' practice | | Organic practice | |
|---|---|---|---|---|---|---|
| | (kg $plant^{-1}$) | (t $ha^{-1}$) | (kg $plant^{-1}$) | (t $ha^{-1}$) | (kg $plant^{-1}$) | (t $ha^{-1}$) |
| Kollam district | | | | | | |
| Shakthikulangara | 2.43 | 29.20 | 1.82 | 21.78 | 3.30 | 39.71 |
| Karunagapally | 2.03 | 24.41 | 2.00 | 24.10 | 2.56 | 30.72 |
| Karunagapally | 1.31 | 15.77 | 1.09 | 13.06 | 1.77 | 21.25 |
| Kulasekharapuram | 1.53 | 18.30 | 1.35 | 16.20 | 1.75 | 21.00 |
| Chadayamangalam | 4.20 | 25.20 | 5.00 | 30.00 | 3.92 | 23.53 |
| Anchal | 3.12 | 18.72 | 3.85 | 23.10 | 4.33 | 25.98 |
| Pathanamthitta district | | | | | | |
| Kadampanad | 2.58 | 30.97 | 2.47 | 29.65 | 3.53 | 42.30 |
| Thumpamon | 4.42 | 26.52 | 4.80 | 28.80 | 5.42 | 32.52 |
| Omallur | 1.82 | 21.85 | 1.33 | 15.98 | 5.31 | 63.74 |
| Omallur | 2.87 | 34.40 | 1.62 | 19.38 | 3.76 | 45.10 |
| Mean | 2.63 | 24.50 | 2.53 | 22.20 | 3.57 | 34.60 |
| S.Em ± | 0.229 | 2.61 | | | | |
| CD ( 0.05) | 0.680 | 7.75 | | | | |

phenols by the method of Swain and Hillis (1955). Mineral composition of corms viz., P, K, Ca, Mg, Cu, Zn, Mn and Fe contents were determined by standard analytical procedures (Piper, 1970). Soil chemical properties such as pH, organic C, available N, P and K contents of the soil were determined by standard analytical procedures (Jackson, 1973). Total cost of cultivation and gross returns were calculated from the average input cost and average market price of the produce during the period of investigation. Based on these, the net income and benefit: cost ratio was computed as follows:

Net return (Rs. $ha^{-1}$) = Gross income - cost of cultivation

Benefit: cost (B: C) ratio = Gross income/cost of cultivation

The analysis of variance of data was done using GenStat by applying analysis of variance technique (ANOVA) for randomised block design with 3 treatments and 10 replications (locations).

## Results and Discussion

### Corm yield

The corm yield of elephant foot yam at different locations as influenced by the 3 production systems is given in Table 2. Organic farming proved significantly superior at all locations (34.60 t $ha^{-1}$), which may be due to the overall improvement in soil physico-chemical properties under the influence of organic manures. Conventional practice and traditional practice remained on a par. Similar results were reported by Mahapatra et al. (2006a) in Basmati rice and Mahapatra et al. (2006b) in lentil, chick pea and wheat. The on farm trials proves beyond doubt that for a highly nutrient exhausting crop like elephant foot yam, satisfactory yield can be obtained by organic farming by proper supplementation of nutrients based on soil testing through cheaper and on farm generated organic manures like green manures, ash etc.

### Corm quality

Cooking quality of corms from the 3 farming practices was equally good. Among the biochemical parameters, dry matter, oxalate and total phenol contents were significantly influenced by the management practices (Table 3). Dry matter content was significantly higher and oxalate content significantly lower in organically produced corms than in conventionally produced corms. Rembialkowska (2007) reported that organically grown crops contain more dry matter than conventionally grown crops. However, the total phenol content of conventionally produced corms was significantly higher in this study. The contents of starch, crude protein, reducing sugar and total sugars remained unaffected due to the various practices.

### Mineral composition of corms

The mineral content of corms viz., P, K, Ca, Zn, Mn and Fe did not vary significantly due to the various management practices (Table 4). This is in accordance with the report of Radhakrishnan et al. (2006) that quality parameters of made tea manufactured from different farming systems, including organic system, did not vary significantly. However, Mg content of organic corms was significantly higher in this study.

### Soil chemical properties

Among the chemical parameters, available K was appreciably higher in organic plots (Table 5). Higher content of K in the organic manures, especially green

Table 3. Bio-chemical composition of corms as influenced by three production systems in elephant foot yam

| Production systems | Dry matter (%) | Starch* (%) | Crude protein* (%) | Oxalate** (%) | Total phenols* (mg 100 $g^{-1}$) | Reducing sugar* (%) | Total sugars* (%) |
|---|---|---|---|---|---|---|---|
| Conventional | 19.29 | 15.58 | 1.761 | 0.221 | 133.7 | 1.233 | 2.496 |
| Traditional | 20.00 | 15.48 | 1.960 | 0.218 | 114.0 | 1.186 | 2.432 |
| Organic | 21.00 | 16.66 | 2.138 | 0.191 | 116.2 | 1.212 | 2.414 |
| S.Em ± | 0.391 | 0.427 | 0.1212 | 0.0026 | 5.02 | 0.0184 | 0.0268 |
| CD ( 0.05) | 1.162 | NS | NS | 0.0076 | 14.93 | NS | NS |

*Fresh weight basis of corm ** Dry weight basis of corm

Table 4. Mineral composition of corms as influenced by three production systems in elephant foot yam

| Production systems | P | K | Ca | Mg | Zn | Mn | Fe |
|---|---|---|---|---|---|---|---|
| | | | (mg 100 $g^{-1}$ DW basis) | | | | |
| Conventional | 282.4 | 969.0 | 100.0 | 91.9 | 4.23 | 3.56 | 4.96 |
| Traditional | 272.6 | 924.0 | 88.0 | 91.8 | 4.17 | 3.58 | 4.65 |
| Organic | 299.0 | 1006.0 | 93.6 | 95.3 | 4.40 | 3.86 | 4.83 |
| S.Em ± | 8.27 | 23.7 | 4.75 | 0.688 | 0.1049 | 0.1069 | 0.0916 |
| CD ( 0.05) | NS | NS | NS | 2.045 | NS | NS | NS |

Table 5. Soil chemical properties as influenced by three production systems in elephant foot yam

| Production systems | pH | Organic C (%) | Available N ( kg $ha^{-1}$) | Available P ( kg $ha^{-1}$) | Available K ( kg $ha^{-1}$) |
|---|---|---|---|---|---|
| Conventional | 5.43 | 0.602 | 164 | 75.8 | 98.8 |
| Traditional | 5.39 | 0.561 | 171 | 90.5 | 88.7 |
| Organic | 5.54 | 0.629 | 167 | 84.9 | 142.7 |
| S.Em ± | 0.1067 | 0.0701 | 30 | 9.83 | 13.47 |
| CD ( 0.05) | NS | NS | NS | NS | 40.02 |

manure and ash (FYM: 0.28%, green manure cowpea: 2.02%, neem cake: 1.2%, ash: 7.11%), K mining effect from the sub surface layers by the extensive root system of green manure crop of cowpea, organic acid dissolution of the rather inaccessible K minerals in the soil during green manure decomposition might have contributed to higher content of available K in organic plots. The pH, organic C, available N and P contents were almost the same in different plots, though these were slightly higher in organic plots than in conventional plots. Increase in soil organic matter, soil pH, available P and K have been measured in some organic systems (Scow et al., 1994; Clark et al., 1998). Similar results have been reported in other crops under Indian conditions as well (Srivastava et al., 2006; Mahapatra et al., 2006b).

### Economic analysis

Organic farming generated higher net income of Rs. 1,13,720 $ha^{-1}$ and benefit:cost ratio of 1.49 as against Rs. 70,069 $ha^{-1}$ and 1.40 respectively under the conventional system (Table 6). Organic farming generated additional income of Rs. 43,651 $ha^{-1}$ over conventional practice obviously due to higher yield.

## Conclusion

Organic farming produced higher yield of quality corms and returns over conventional farming practice. Organic corms had significantly higher dry matter and Mg contents and significantly lower oxalate content. The chemical properties of soil, especially K, were also seen favoured under organic farming. The practice of green manuring with cowpea is a cost effective practice that should form an inevitable component of any organic farming program. The organic farming technology package standardized for elephant foot yam includes the application of farmyard manure @ 36 t $ha^{-1}$, green manuring with cowpea to generate 20-25 t $ha^{-1}$ of green matter in 45-60 days, neem cake @ 1 t $ha^{-1}$ and ash @

Table 6. Economic analysis of three production systems in elephant foot yam

| Production systems | Yield (t $ha^{-1}$) | Gross income (Rs $ha^{-1}$) | Total costs (Rs $ha^{-1}$) | | Gross costs (Rs $ha^{-1}$) | Net income (Rs $ha^{-1}$) | B:C ratio |
|---|---|---|---|---|---|---|---|
| | | | Materials | Labour | | | |
| Conventional | 24.500 | 245000 | 98681 | 76250 | 174931 | 70069 | 1.40 |
| Traditional | 22.200 | 222000 | 108825 | 71250 | 180075 | 41925 | 1.23 |
| Organic | 34.600 | 346000 | 149780 | 82500 | 232280 | 113720 | 1.49 |

3 t $ha^{-1}$. FYM and neem cake are to be applied in pits at the time of planting. Ash may be applied at the time of incorporation of green manure at 45-60 days after planting.

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