# Yield and quality attributes of elephant foot yam [*Amorphophallus paeoniifolius* (Dennst) Nicolson] as influenced by corm size and integrated nutrient management practices

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## ABSTRACT

A field experiment was conducted to evaluate the effect of size of minisett corm and integrated nutrient management (INM) practices on yield and quality attributes of elephant foot yam at the instructional farm of College of Agriculture, Vellayani, Thiruvananthapuram, Kerala over two seasons during April-November 2018 and April-November 2019. The treatments consisted of three minisett corm sizes ($S_1$: 200 g, $S_2$: 300 g and $S_3$: 400 g) and five INM practices ($I_1$: 100% NPK, $I_2$: 75% NPK with 50% N substitution through coir pith compost, $I_3$: 75% NPK with 50% N substitution through coir pith compost + PGPR mix-I + AMF, $I_4$: 50% NPK with 50% N substitution through coir pith compost, $I_5$: 50% NPK with 50% N substitution through coir pith compost + PGPR mix-I + AMF) and a control (1 kg). The results indicated that the minisett corm size 400 g ($S_3$) recorded the highest corm yield per ha. Among different INM practices, application of 75 per cent NPK with 50 per cent N substitution through coir pith compost + PGPR mix-I + AMF recorded higher corm yield per hectare and among all the treatments, application of 100 per cent NPK ($I_1$) as chemical fertilizers recorded significantly the highest corm yield per hectare. The lowest oxalate content was recorded in the application of 50 per cent NPK with 50 per cent N substitution through coir pith compost with or without biofertilizers. The highest content of oxalic acid was found in $I_1$ wherein 100 per cent NPK was applied as chemical fertilizer.

**Keywords:** Elephant foot yam; minisett; INM; total sugar; crude protein; crude fibre; oxalic acid

## INTRODUCTION

Elephant foot yam [*Amorphophallus paeoniifolius* (Dennst) Nicolson] which is regarded as the king of tuber crops, is basically an important tuber crop of the tropical and sub-tropical countries, which belongs to Araceae family. Due to its higher yield potential, biological efficiency, culinary properties, medicinal uses and therapeutic values, it is raised as a cash crop with good acceptance throughout the world. The economic part of elephant foot yam is corm which is an underground modified stem and is rich in carbohydrates, minerals, vitamins, protein as well as starch.

Size of seed corm has been found to be a growth determining factor for tuber crops as it decides the amount of stored food for the next crop. The relation between planting material size and corm yield has been reported by Ravi et al (2011). Elephant foot yam requires fairly high amount of nutrients as it has high economic yield and high dry matter production. Continuous and imbalanced use of chemical fertilizers has been proven repeatedly to deteriorate soil health and ecological balance resulting in conjunction to decrease in nutrient uptake efficiency of applied nutrients (Saravaiya et al 2010). Therefore, there is a need for integrating chemical fertilizers with organic sources and biofertilizers so as to have a cost effective and eco-friendly recommendation for the farming community. In this context, integrated nutrient management (INM) offers a great way to meet the growing nutrient demands and maintain high levels of crop productivity. Hence, in the present study, the effect of seed corm size and INM practices on yield and quality of elephant foot yam was investigated.

## MATERIAL and METHODS

The investigations were carried out at the instructional farm of the College of Agriculture, Vellayani, Thiruvananthapuram, Kerala during April-November 2018 and April-November 2019. The experiment was a two factorial arrangement laid out in RBD with 15 treatment combinations and a control, replicated three times. The treatments included three corm sizes and five integrated nutrient management practices. The healthy seed corms of three sizes viz $S_1$ (200 g), $S_2$ (300 g) and $S_3$ (400 g) at a spacing of 60 cm x 60 cm and a control of 1 kg at a spacing of 90 cm x 90 cm of elephant foot yam var Gajendra were planted. The nutrient management practices included $I_1$ (100% NPK), $I_2$ (75% NPK with 50% N substitution through coir pith compost), $I_3$ [75% NPK with 50% N substitution through coir pith compost + PGPR (plant growth-promoting rhizobacteria) mix-I + AMF (arbuscular mycorrhizal fungi)], $I_4$ (50% NPK with 50% N substitution through coir pith compost) and $I_5$ (50% NPK with 50% N substitution through coir pith compost + PGPR mix-I + AMF). Recommended dose of N, P and K for elephant foot yam is 100:50:150 kg NPK/ha which was modified based on soil test data. A uniform dose of farmyard manure @ 2 kg per pit was given at the time of land preparation. Coir pith compost was used as the organic source in the study and was substituted on N equivalent basis as per the treatments. P and K were given through chemical sources. Full dose of P and half dose of N and K were applied 45 days after planting. The N substituted through organic source was applied in full quantity at 45 days after planting. The second dose of N and K was applied one month after first application. Corm treatment with 5 per cent suspension of PGPR mix-I (consortium of *Azospirillum lipoferum*, *Azotobacter chroococcum*, *Bacillus megaterium* and *B sporothermodurans*) followed by soil application of PGPR enriched cow dung @ 10 g per pit (mixture of dry cow dung and PGPR mix-I in 50:1 proportion) was done at planting and 2 months after planting in treatments $I_3$ and $I_5$. AMF was applied @ 10 g per pit at the time of planting in $I_3$ and $I_5$. Green manure cowpea was raised in the interspaces in all the treatments and incorporated 50 days after planting.

Oxalic acid content of corm was estimated by the method suggested by Day and Underwood (1986), total sugar and crude fibre were analyzed with the procedure given by Sadasivam and Manickam (1996) and the nitrogen content of corm was multiplied with a factor 6.25 to get the crude protein content (Simpson et al 1965).

## RESULTS and DISCUSSION

### Corm yield

The size of minisett corm, INM practices and their interaction had significant influence on the corm yield (Tables 1a, 1b). The minisett corm, $S_3$ (400 g) produced significantly the highest corm yield/ha during first year (48.81 tonnes) as well as during second year (50.57 tonnes). Pooled analysis revealed the same trend recording the highest corm yield of 49.69 tonnes/ha with $S_3$. Yield per hectare is determined by the size of planting material and spacing adopted. Sethi et al (2002), Bairagi and Singh (2014) and Pathak et al (2018) reported maximum seed corm yield of elephant foot yam with the largest sett size. Among different INM practices, $I_3$ (75% NPK with 50% N substitution through coir pith compost + PGPR mix-I + AMF) recorded significantly higher corm yield (38.26 tonnes/ha) during first year and was on par with $I_2$ (75% NPK with 50% N substitution through coir pith compost) which produced a yield of 37.31 tonnes/ha. During second year, $I_3$ (45.37 tonnes/ha) recorded significantly higher corm yield on par with $I_5$ (50% NPK with 50% N substitution through coir pith compost + PGPR mix-I + AMF) which recorded a yield of 43.61 tonnes/ha. Pooled data indicate that among INM practices, $I_3$ had significantly higher pooled mean yield of 41.82 tonnes/ha. The superiority of $I_3$ among different INM practices may be due to the higher level of nutrients and the combined favourable effect of inorganic and organic sources with biofertilizers. Increase in fertilizer level leads to increase in corm weight and the highest was obtained with higher NPK level (Nath et al 2007). The organic matter acts as an energy source for soil microflora and they convert inorganic nutrients held in soil or applied through inorganic fertilizers into a form that can be readily assimilated by plants. The increased availability of nitrogen and phosphorus due to combined application of PGPR mix-I and AMF might have increased the yield. As reported by Gopi et al (2020), the PGPR mix-I is a microbial consortium of *Azospirillum lipoferum, Azotobacter chroococcum, Bacillus megaterium* and *B sporothermodurans* for

Table 1a. Effect of size of minisett corm and integrated nutrient management on corm yield

| Treatment | Corm yield (tonnes)/ha | | |
|---|---|---|---|
| | I year | II year | Pooled mean |
| **Size of minisett corms (S)** | | | |
| $S_1$- 200 g | 26.86 | 37.83 | 32.35 |
| $S_2$- 300 g | 33.41 | 43.39 | 38.40 |
| $S_3$- 400 g | 48.81 | 50.57 | 49.69 |
| SEm(±) | 0.367 | 0.500 | 0.341 |
| $CD_{0.05}$ | 1.064 | 1.450 | 0.987 |
| **Integrated nutrient management (I)** | | | |
| $I_1$- 100% NPK | 42.09 | 50.00 | 46.05 |
| $I_2$- 75 % NPK with 50% N substitution through coir pith compost | 37.31 | 41.30 | 39.31 |
| $I_3$- 75% NPK with 50% N substitution through coir pith compost + PGPR mix-I + AMF | 38.26 | 45.37 | 41.82 |
| $I_4$- 50% NPK with 50% N substitution through coir pith compost | 28.92 | 39.38 | 34.15 |
| $I_5$- 50% NPK with 50% N substitution through coir pith compost + PGPR mix-I + AMF | 35.21 | 43.61 | 39.41 |
| SEm(±) | 0.474 | 0.646 | 0.44 |
| $CD_{0.05}$ | 1.374 | 1.872 | 1.275 |

PGPR = Plant growth promoting rhizobacteria, AMF = Arbuscular mycorrhizal fungi

Table 1b. Interaction effect of size of minisett corms and integrated nutrient management on corm yield

| Interaction (s x i) | Corm yield (tonnes)/ha | | |
|---|---|---|---|
| | I year | II year | Pooled mean |
| $S_1I_1$ | 30.50 | 40.28 | 35.39 |
| $S_1I_2$ | 26.65 | 37.22 | 31.94 |
| $S_1I_3$ | 27.50 | 38.89 | 33.19 |
| $S_1I_4$ | 21.33 | 35.00 | 28.17 |
| $S_1I_5$ | 28.32 | 37.78 | 33.05 |
| $S_2I_1$ | 38.75 | 46.11* | 42.43* |
| $S_2I_2$ | 35.58 | 42.22 | 38.90* |
| $S_2I_3$ | 37.50 | 44.44* | 40.97* |
| $S_2I_4$ | 24.58 | 40.00 | 32.29 |
| $S_2I_5$ | 30.63 | 44.17* | 37.40 |
| $S_3I_1$ | 57.03 | 63.61 | 60.32 |
| $S_3I_2$ | 49.71 | 44.44* | 47.08 |
| $S_3I_3$ | 49.79 | 52.78* | 51.29 |
| $S_3I_4$ | 40.85 | 43.15 | 42.00* |
| $S_3I_5$ | 46.69 | 48.89* | 47.79 |
| SEm(±) | 0.821 | 1.119 | 0.762 |
| $CD_{0.05}$ | 2.379 | 3.242 | 2.207 |
| Treatment mean | 36.36 | 43.93 | 40.15 |
| Control | 35.61 | 48.27 | 41.94 |
| Treatment vs Control | NS | S | S |

*On par with control; $S_1$: 200 g, $S_2$: 300 g, $S_3$: 400 g, Control: 1 kg corm + 100% NPK, $I_1$: 100% NPK, $I_2$: 75% NPK with 50% N substitution through coir pith compost), $I_3$: 75% NPK with 50% N substitution through coir pith compost + PGPR (plant growth-promoting rhizobacteria) mix-I + AMF (arbuscular mycorrhizal fungi)], $I_4$: 50% NPK with 50% N substitution through coir pith compost, $I_5$: 50% NPK with 50% N substitution through coir pith compost + PGPR mix-I + AMF supplementing all the major nutrients. PGPR is reported to produce nutrients and enzymes that are biologically active, such as vitamins, nicotinic acid, indole acetic acid, and gibberellin (Ranjan et al 2013) in inoculated plants having growth promoting effects which in turn increase yield. Patel et al (2010) reported maximum corm yield with the application of 75 per cent RDF (inorganic source) + 25 per cent RDF (organic source) + AMF @ 5 kg/ha + *Azospirillum* @ 5 kg/ha. Thus the combination of inorganic and organic nutrients, therefore, made it possible for plants to produce more yield (Saravaiya et al 2010, Bairagi and Singh 2013). However, among all the treatments, $I_1$ in which 100 per cent NPK was applied as chemical fertilizers recorded significantly the highest corm yield during both the years and showed same trend in the pooled analysis. The S x I interaction, $S_3I_3$ (400 g + 75% NPK with 50% N substitution through coir pith compost + PGPR mix-I + AMF) recorded significantly higher corm yield (49.79 tonnes/ha) which was on par with $S_3I_2$ (400 g + 75% NPK with 50% N substitution through coir pith compost) (49.71 tonnes/ha) during first year. Significantly higher corm yield of 52.78 tonnes/ha during second year was recorded with $S_3I_3$. The data on pooled mean also reveal a similar trend with $S_3I_3$ producing higher corm yield of 51.29 tonnes/ha. However, significantly highest corm yield was obtained in the combination $S_3I_1$ (400 g + 100% NPK as chemical fertilizers) in first year (57.03 tonnes/ha), in second year (63.61 tonnes/ha) as well as in pooled analysis (60.32 tonnes/ha). Comparing the treatments (combination of minisett corm planted at 60 cm x 60 cm + integrated nutrient management) with control (1 kg corm planted at 90 cm x 90 cm + 100% NPK as chemical fertilizers), there was significant variation between the corm yield per hectare of minisett corms and control corm in second year. During first year, the treatments and control were on par, however, the combinations $S_2I_1$, $S_2I_3$, $S_3I_1$, $S_3I_2$, $S_3I_3$, $S_3I_4$ and $S_3I_5$ produced higher yield/ha than control. In second year, the combinations $S_2I_1$, $S_2I_3$, $S_2I_5$, $S_3I_2$, $S_3I_3$ and $S_3I_5$ were on par with control and $S_3I_1$ produced superior results than control. All other treatments

Table 2a. Effect of size of minisett corms and integrated nutrient management on total sugar, crude protein, crude fibre and oxalic acid content of corm

| Treatment | Content (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Total sugar | | Crude protein | | Crude fibre | | Oxalic acid | |
| | I year | II year | I year | II year | I year | II year | I year | II year |
| **Size of minisett corm (S)** | | | | | | | | |
| $S_1$- 200 g | 2.00 | 2.49 | 12.45 | 13.44 | 1.24 | 1.40 | 0.227 | 0.229 |
| $S_2$- 300 g | 2.12 | 2.78 | 11.46 | 13.26 | 1.24 | 1.46 | 0.219 | 0.225 |
| $S_3$- 400 g | 2.33 | 2.61 | 12.80 | 12.97 | 1.26 | 1.50 | 0.215 | 0.236 |
| SEm(±) | 0.266 | 0.230 | 0.491 | 0.331 | 0.026 | 0.033 | 0.008 | 0.006 |
| $CD_{0.05}$ | NS | NS | NS | NS | NS | NS | NS | NS |
| **Integrated nutrient management (I)** | | | | | | | | |
| $I_1$- 100% NPK | 2.14 | 2.86 | 13.50 | 13.77 | 1.30 | 1.48 | 0.252 | 0.258 |
| $I_2$- 75 % NPK with 50% N substitution through coir pith compost | 2.01 | 2.43 | 12.13 | 13.46 | 1.23 | 1.39 | 0.231 | 0.244 |
| $I_3$- 75% NPK with 50% N substitution through coir pith compost + PGPR mix-I + AMF | 2.30 | 2.66 | 11.26 | 13.01 | 1.28 | 1.50 | 0.226 | 0.238 |
| $I_4$- 50% NPK with 50% N substitution through coir pith compost | 2.12 | 2.52 | 12.07 | 12.95 | 1.19 | 1.43 | 0.197 | 0.207 |
| $I_5$- 50% NPK with 50% N substitution through coir pith compost + PGPR mix-I + AMF | 2.19 | 2.67 | 12.21 | 12.90 | 1.22 | 1.47 | 0.197 | 0.203 |
| SEm(±) | 0.344 | 0.297 | 0.633 | 0.427 | 0.034 | 0.042 | 0.011 | 0.008 |
| $CD_{0.05}$ | NS | NS | NS | NS | NS | NS | 0.031 | 0.023 |

PGPR = Plant growth-promoting rhizobacteria, AMF = Arbuscular mycorrhizal fungi

Table 2b. Interaction effect of size of minisett corms and integrated nutrient management on total sugar, crude protein, crude fibre and oxalic acid content of corms

| Interaction (s x i) | Content (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Total sugar | | Crude protein | | Crude fibre | | Oxalic acid content | |
| | I year | II year | I year | II year | I year | II year | I year | II year |
| $S_1I_1$ | 2.17 | 2.99 | 14.47 | 14.00 | 1.25 | 1.45 | 0.250 | 0.260 |
| $S_1I_2$ | 1.88 | 2.26 | 12.72 | 13.31 | 1.27 | 1.47 | 0.243 | 0.243 |
| $S_1I_3$ | 1.72 | 2.06 | 11.38 | 13.63 | 1.35 | 1.49 | 0.243 | 0.243 |
| $S_1I_4$ | 2.00 | 2.42 | 10.73 | 12.62 | 1.18 | 1.35 | 0.200 | 0.200 |
| $S_1I_5$ | 2.24 | 2.74 | 12.95 | 13.63 | 1.14 | 1.25 | 0.200 | 0.200 |
| $S_2I_1$ | 1.75 | 2.96 | 13.30 | 13.68 | 1.25 | 1.49 | 0.253 | 0.253 |
| $S_2I_2$ | 1.97 | 2.40 | 11.43 | 13.76 | 1.25 | 1.35 | 0.220 | 0.240 |
| $S_2I_3$ | 2.46 | 2.95 | 9.33 | 13.15 | 1.32 | 1.44 | 0.220 | 0.230 |
| $S_2I_4$ | 2.27 | 2.99 | 13.07 | 13.43 | 1.19 | 1.46 | 0.200 | 0.200 |
| $S_2I_5$ | 2.14 | 2.60 | 10.15 | 12.25 | 1.18 | 1.58 | 0.200 | 0.200 |
| $S_3I_1$ | 2.50 | 2.64 | 12.72 | 13.63 | 1.41 | 1.51 | 0.253 | 0.260 |
| $S_3I_2$ | 2.17 | 2.64 | 12.25 | 13.31 | 1.18 | 1.35 | 0.230 | 0.250 |
| $S_3I_3$ | 2.71 | 2.95 | 13.07 | 12.25 | 1.18 | 1.58 | 0.213 | 0.240 |
| $S_3I_4$ | 2.09 | 2.13 | 12.43 | 12.82 | 1.20 | 1.49 | 0.190 | 0.220 |
| $S_3I_5$ | 2.19 | 2.68 | 13.53 | 12.82 | 1.35 | 1.58 | 0.190 | 0.210 |
| SEm(±) | 0.596 | 0.515 | 1.097 | 0.74 | 0.059 | 0.073 | 0.019 | 0.014 |
| $CD_{0.05}$ | NS | NS | NS | NS | NS | NS | NS | NS |
| Treatment mean | 2.15 | 2.63 | 12.24 | 13.22 | 1.25 | 1.45 | 0.220 | 0.229 |
| Control | 2.32 | 2.40 | 10.97 | 14.68 | 1.25 | 1.41 | 0.231 | 0.237 |
| Treatment vs Control | NS | NS | NS | NS | NS | NS | NS | NS |

$S_1$: 200 g, $S_2$: 300 g, $S_3$: 400 g, Control: 1 kg corm + 100% NPK, $I_1$: 100% NPK, $I_2$: 75% NPK with 50% N substitution through coir pith compost), $I_3$: 75% NPK with 50% N substitution through coir pith compost + PGPR (plant growth-promoting rhizobacteria) mix-I + AMF (arbuscular mycorrhizal fungi)], $I_4$: 50% NPK with 50% N substitution through coir pith compost, $I_5$: 50% NPK with 50% N substitution through coir pith compost + PGPR mix-I + AMF

produced significantly lower corm yield/ha than control. Pooled analysis of corm yield/ha indicated that $S_2I_1$, $S_2I_2$, $S_2I_3$ and $S_3I_4$ were on par with control and $S_3I_1$, $S_3I_2$, $S_3I_3$ and $S_3I_5$ were superior to control. Closer spacing accommodating more number of plants in minisett cultivation might be the reason for higher yield compared to wider spacing in control. Mondal and Sen (2004) reported that closer planting distances lead to higher yields of whole seed corms while a wider planting distance lead to increased average weight of seed corm. Isaac et al (2012) reported higher per plant yield of elephant foot yam in conventional sett of 1 kg planted at a spacing of 90 cm x 90 cm but the highest corm yield per ha was obtained from 100 g minisett planted at a spacing of 60 cm x 45 cm.

**Quality attributes**

Different sizes of minisett corm and INM practices had no significant effect on corm quality attributes like total sugar, crude protein and crude fibre content of corm (Tables 2a, 2b). The quality of the produce is determined by various factors like variety, genetic makeup, location, fertilization and weather conditions during crop growth (Suja et al 2020). Regardless of the source, plants absorb nutrients as inorganic ions and after absorption, the nutrients are re-synthesized into compounds that determine the quality of the produce which is mainly governed by the genetic makeup of the plants (Chhonkar 2008). Nedunchezhiyan et al (2017) also reported that quality attributes like starch and total sugar content were not influenced by source of nutrients. Irrespective of different nutrient sources (inorganic, organic and biofertilizers), there were no significant variations in starch and total sugar content of sweet potato as reported by Sheth et al (2018).

Different sizes of minisett corm had no significant effect on oxalic acid content of corm while it was influenced by different INM practices (Tables 2a, 2b) and the lowest oxalate content was recorded in $I_5$ (50% NPK with 50% N substitution through coir pith compost + PGPR mix-I + AMF) and $I_4$ (50% NPK with 50% N substitution through coir pith compost) during both the years. The highest content of oxalic acid was found in $I_1$ wherein 100 per cent NPK was applied as chemical fertilizers. The form of nitrogen is considered to have a role in deciding the oxalic acid content of plants and increase in the N content supplied through the inorganic fertilizers results in the accumulation of more oxalates. Zhang et al (2005) reported that oxalate accumulation was positively correlated with increase in N levels especially $NO_3^-$N in spinach. The low oxalic acid content reported in INM treatments involving 50 per cent substitution of coir pith compost may be due to lesser quantity of nitrate N supplied by these treatments in comparison with 100 per cent NPK as chemical fertilizers treatment or its 75 per cent substitution with coir pith compost. Similar findings of higher oxalate content in 100 per cent RDF (as inorganic) NPK and lowest in control where no inorganic fertilizers were applied, were pointed out by Annepu (2011). Lower oxalate content in corms due to organic source of nutrients was previously reported by Suja (2013) and Nedunchezhiyan et al (2017). The reduction in oxalate in relation with application of organic manures might also be due to increased availability of micronutrients influencing metabolism of oxalates in different biochemical products as reported by Singh et al (2016).

## CONCLUSION

The highest corm yield per ha was obtained with 400 g minisett corm compared to 300 and 200 g minisett corms. Among INM practices, application of 75 per cent NPK with 50 per cent N substitution through coir pith compost + PGPR mix-I + AMF and among all the treatments, application of 100 per cent NPK as chemical fertilizers recorded superior corm yield per hectare in elephant foot yam. The lowest oxalic acid content among all the treatments was observed with 50 per cent NPK with 50 per cent N substitution through coir pith compost with or without biofertilizers and the highest in 100 per cent NPK as chemical fertilizers.

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