



Fertigation effects on elephant foot yam (*Amorphophallus paeoniifolius*) + greengram (*Vigna radiata*) intercropping system

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ABSTRACT

An investigation was carried out during 2013–14 at the research farm of ICAR-Central Tuber Crops Research Institute, Dumuduma, Bhubaneswar, Odisha to study the effects of fertigation on elephant foot yam [*Amorphophallus paeoniifolius* (Dennst.) Nicolson]+greengram (*Vigna radiata* L.) intercropping system. The result revealed that the number of pods/plant, seed and haulm yield of greengram were greater in fertigation treatments than soil application. However, greengram responded to fertigation up to N-K₂O @80–80 kg/ha. The elephant foot yam corm yield increased with fertigation up to N-K₂O @140–140 kg/ha. The corm yield of elephant foot yam and corm equivalent yield of elephant foot yam+greengram intercropping system with fertigation of N-K₂O @100–100 kg/ha was comparable with N-K₂O @140–140 kg/ha. The fertigation of N-K₂O @100–100 kg/ha resulted in increase of 20.1–22.4% corm yield, 19.8–22.3% corm equivalent yield and 19.9–24.4% nutrient use efficiency over soil application of the same quantity of nutrients. The fertigation of elephant foot yam+greengram intercropping system with N-K₂O @100–100 kg/ha also resulted in 26.7–28.7% greater net return and higher benefit: cost ratio over soil application of the same quantity of nutrients. The study indicated that fertigation of N-K₂O @100–100 kg/ha was sufficient for obtaining optimum yield, returns and nutrient use efficiency in elephant foot yam+greengram intercropping system.

Key words: Corm yield, Dry matter production and partitioning, Gross and net return

Elephant foot yam [*Amorphophallus paeoniifolius* (Dennst.) Nicolson] is a tuberous vegetable crop. It has a crown shaped canopy which is produced on a fairly stout, single, upright pseudostem (petiole). It takes three months to fully cover the ground and that allows intercrop to grow in wider spaces. Intercropping greengram (*Vigna radiata* L.) was found suitable in elephant foot yam (Nedunchezhiyan and Byju 2005). It also improves soil fertility by fixing atmospheric nitrogen symbiotically and enriches the soil organic matter content through their leaf litter, and the haulms can be used as mulching material (Nedunchezhiyan and Byju 2005). Presence of legumes in the mixtures benefit the associated non-legumes, as the legumes provide a portion of biologically fixed nitrogen to non-legume components (Kavamahanga *et al.* 1995). Nutrients are pre-requisites for enhancing crop yield and economic returns (Achakzai *et al.* 2012). Fertigation is a method of application of fertilizers

through irrigation which enables adequate supply of water and nutrients with precise timing and uniform distribution to meet the crop requirement to get maximum yield (Chawla and Narda 2002, Nedunchezhiyan 2017). It is reported in various crops that 25–50% reduction in fertilizer use using drip irrigation system compared to surface broadcasting with no yield reduction. Drip fertigation is considered to be the most efficient in improving the yield and saving of water (Behera *et al.* 2013). In elephant foot yam, greater corm yield and fertilizer use efficiency was realized under fertigation than soil application and also saved water 4341000 l/ha (Nedunchezhiyan 2017). Elephant foot yam+greengram intercropping system is getting popular in India (Nedunchezhiyan *et al.* 2008). Though few studies on fertility management for elephant foot yam+greengram intercropping system is available and research work on fertigation management to elephant foot yam+greengram intercropping is not available. Keeping the above in view, an investigation was carried-out to find the effects of fertigation on elephant foot yam+greengram intercropping productivity, nutrient use efficiency and economics.

MATERIALS AND METHODS

A field experiment was conducted during 2013–14 at the Regional Centre of ICAR-Central Tuber Crops Research Institute (20°14' N and 85°47' E at 33 m amsl), Dumuduma, Bhubaneswar, Odisha. The soil of the experimental site was

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sandy clay loam in texture. The soil was low in organic carbon (0.42%), available nitrogen (93.5 kg/ha) and available potassium (89.4 kg/ha) and medium in available phosphorus (12.6 kg/ha) with normal soil reaction (pH 6.8). The climate condition of the area is warm and moist with hot and humid summer and mild winter. The average annual rainfall of the experimental site is 1693.5 mm out of which nearly 80% is received during June–September. The experiment elephant foot yam+greengram intercropping was laid out in randomized complete block design with four replications. The experiment consisted of six treatments, i.e. T1- Soil application of fertilizers N-K₂O @100–100 kg/ha, T2- Fertigation N-K₂O @60–60 kg/ha, T3- Fertigation N-K₂O @80–80 kg/ha, T4- Fertigation N-K₂O @100–100 kg/ha, T5- Fertigation N-K₂O @120–120 kg/ha and T6- Fertigation N-K₂O @140–140 kg/ha. The 1st season elephant foot yam crop was planted on 18th April 2013 and the 2nd season crop was planted on 16 April 2014. The elephant foot yam (var. Gajendra) seed weighing 400–500 g was planted at the spacing of 90 cm × 90 cm on the ridges below 5–10 cm depth of the soil with the help of spade. The greengram (var. Dauli) seeds were sown (5 kg/ha) continuously on single row on the top of the ridges immediately after planting of elephant foot yam. After 15 days of sowing greengram plants were thinned 15 cm apart. During the final land preparation FYM @10 t/ha was applied along with P₂O₅ @80 kg/ha as single super phosphate (SSP), borax @10 kg/ha and zinc sulphate @10 kg/ha in all the treatments. In soil application treatment the nutrient N as urea and K₂O as muriate of potash (MOP) were applied in three equal splits at 45, 75 and 105 days after planting (DAP) by band placement around elephant foot yam just after weeding followed by earthing up. In fertigation treatments the nutrient N as urea and K₂O as water soluble sulphate of potash (SOP) were applied in five equal splits at 15, 45, 75, 105 and 135 DAP along with irrigation water through drip. The required quantity of urea and sulphate of potash as per the treatments were dissolved separately in a plastic bucket and dilute it at 1:5 (w/v) proportions of fertilizer and water. The scheduled quantity of fertilizers solution was given through ventury system for each treatment separately. After complete of fertigation normal water was passing through the ventury for 5 min to avoid treatment contamination. A valve was provided at the beginning of lateral of each plot for controlled fertigation. The drippers were fixed on the laterals in such a way that each elephant foot yam plant was covered by two drippers with the spacing of 15 cm. The drip irrigation at 80% cumulative pan evaporation was applied at every three days interval during dry spells. A total of 202.8 and 213.9 mm water was applied during dry spells of 2013 and 2014, respectively.

The fully matured greengram pods were plucked at 60th and 75th day after sowing (DAS). The haulms of the greengram were left in the field and trampled them to act as mulch. The elephant foot yam crop was harvested at 8th month after planting (MAP), i.e. 17 December 2013 and 15 December 2014 of 1st and 2nd season crops, respectively.

Growth observations of greengram were recorded at 75th DAS, and yield attributes and yield at harvest. The elephant foot yam growth observations were recorded at 5th MAP, dry matter production and partitioning was carried out at 3rd, 5th and 8th MAP and yield attributes and yield at 8th MAP.

Corm equivalent yield (CEY) and nutrient use efficiency (NUE) were computed as:

$$\text{CEY (t/ha)} = \frac{\text{Corm yield of elephant foot yam (t/ha)} + \frac{\text{Seed yield of greengram (t/ha)} \times \text{Price of green gram (₹/t)}}{\text{Price of elephant foot yam (₹/t)}}}{1}$$

$$\text{NUE (kg/kg)} = \frac{\text{Corm equivalent yield (kg/ha)}}{\text{Amount of N-P}_2\text{O}_5\text{-K}_2\text{O applied (kg/ha)}}$$

The data were statistically analyzed and significance between mean differences among treatments for various parameters was analyzed using critical differences (CD) at 0.05 probability level.

RESULTS AND DISCUSSION

The fertigation levels significantly influenced the greengram plant height (Table 1). Taller plant height was noticed in fertigation treatments than soil application. Among fertigation treatments, taller plants were observed in higher levels of fertilizer application. The number of pods per plant, seed and haulm yield were greater in fertigation treatments than soil application (Table 1). Among the fertigation levels, greater number of pods per plant, seed yield and haulm yield were recorded with treatment T3. This might be due to optimum available of nutrients in this treatment. It also indicated that greengram is not utilizing fertilizers if applied in higher level. Soil application of N-K₂O resulted in lower number of pods per plant, seed yield and haulm yield. This might be due to lesser amount of nutrients available to greengram.

In elephant foot yam + greengram intercropping system, the fertigation treatments did not influence growth parameters of elephant foot yam at 5th MAP (Table 1). However, the treatments T5 and T4 resulted in greater number of pseudostems per heap, pseudostem height and pseudostem collar girth. No definite trend in canopy spread and number of leaflets per heap was noticed among the treatments (Table 1). Elephant foot yam reaches maximum vegetative growth at 5th MAP after that the growth is negligible and decline/ senescence (Nedunchezhiyan *et al.* 2017). In the present experiment, the treatments T5 and T4 received more nutrients and utilized efficiently at 5th MAP to put forth maximum vegetative growth.

The dry matter production and partitioning into shoot and corm of elephant foot yam at 3rd, 5th and 8th MAP is presented in the Fig 1. The dry matter accumulation in the corm was greater than the shoot at 3rd, 5th and 8th MAP. At 3rd MAP, the treatment T5 resulted in greater shoot and corm dry matter accumulation during 2013–14. At 5th and 8th MAP, the treatment T5 resulted in greater dry matter accumulation in the shoot during 2013 but during 2014, the treatment T6 resulted in greater dry matter accumulation in

Table 1 Fertigation effects on growth and yield attributes of green gram and elephant foot yam in elephant foot yam+green gram intercropping

Treatment	Plant height (cm)		Number of pods per plant		Seed yield (kg/ha)		Haulm yield (kg/ha)		Number of pseudo stems per heap		Pseudo stem height (cm)		Pseudo stem collar girth (cm)		Canopy spread (cm)		Number of leaflets per heap	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
T1	25.3	25.8	25.8	24.8	0.40	0.36	1.76	1.60	2.8	2.8	72.0	71.3	18.0	17.3	83.3	85.3	236.5	236.3
T2	26.7	26.6	29.5	28.5	0.45	0.42	1.98	1.88	2.8	2.8	72.3	73.3	18.3	18.8	83.7	86.0	261.5	260.8
T3	27.5	27.4	31.5	31.0	0.47	0.48	2.10	2.13	2.5	2.5	77.8	77.3	17.8	18.5	85.0	86.3	248.5	249.5
T4	27.9	27.6	29.8	30.0	0.46	0.47	2.03	2.07	3.0	3.0	80.3	80.8	18.8	20.5	85.3	84.8	199.5	224.8
T5	28.7	26.9	25.8	28.3	0.43	0.41	1.90	1.83	3.0	3.0	80.3	80.0	19.8	20.8	83.3	84.0	228.0	227.5
T6	28.3	27.0	28.8	28.8	0.44	0.44	1.97	1.96	2.5	2.5	80.0	80.3	19.3	19.3	95.3	94.5	205.0	206.3
CD (P=0.05)	1.0	0.7	NS	3.4	NS	0.06	NS	0.29	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

the shoot. The treatment T6 resulted in greater dry matter accumulation in the corm at 5th and 8th MAP during both the years. Higher dry matter accumulation in the shoot as well as corm in the treatments T6 and T5 might be due to more nutrients were available to the plants compared to other treatments. Further, growth attributes in these treatments were also higher (Table 1). The treatment T1 resulted in lower dry matter accumulation in the shoot and corm during both the years. Nedunchezhiyan *et al.* (2017) reported that elephant foot yam produced more dry matter when greater amount of nutrients were available to the plants.

The treatment T6 resulted in significantly higher corm diameter, average corm weight and corm yield (Table 2). The treatments T6, T5, T4 and T3 resulted in 23.1, 22.4, 20.1 and 16.0% and 24.4, 24.0, 22.4 and 19.3% higher corm yield over T1 (Soil application of N-K₂O @100–100 kg/ha) during 2013 and 2014, respectively. The higher corm yield in these treatments was due to greater growth (Table 1) and yield attributes (Table 2). The increased application of major nutrients under fertigation increased the corm yield as reported by Manickasundaram *et al.* (2002), Sahoo *et al.* (2014) and Venkatesan *et al.* (2014). In this investigation, fertigation of N-K₂O @100–100 kg/ha (T4) resulted in 20.1–22.4% increase in corm yield over soil application of the same quantity of nutrients (T2). Nedunchezhiyan *et al.* (2016) also reported 15–21% greater corm yield under fertigation. Further, it also indicated that fertigation of N-K₂O @100–100 kg/ha was sufficient for obtaining

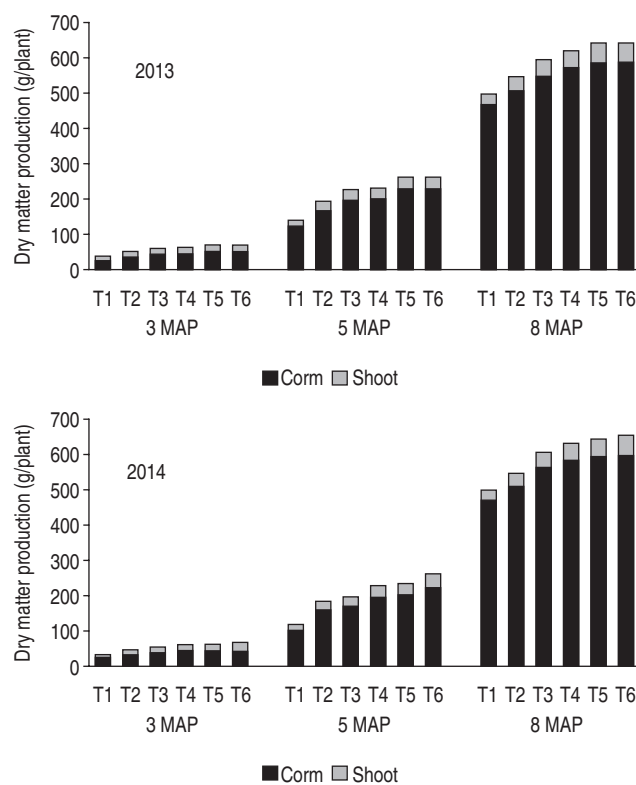


Fig 1 Dry matter production and partitioning at 3rd, 5th and 8th MAP in elephant foot yam as influenced by fertigation of elephant foot yam+greengram intercropping system.

Table 2 Fertigation effects on yield, nutrient use efficiency and economics of elephant foot yam+greengram intercropping

Treatment	Corm diameter (cm)		Average corm weight (kg)		Corm yield (t/ha)		Corm equivalent yield (t/ha)		Nutrient use efficiency (kg/kg)		Total cost ($\times 10^5$ ₹/ha)		Gross return ($\times 10^5$ ₹/ha)		Net return ($\times 10^5$ ₹/ha)		B: C ratio	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
T1	18.6	18.8	2.2	2.4	29.4	29.5	29.8	30.0	106.3	107.2	1.71	1.71	4.56	4.57	2.85	2.86	1.7	1.7
T2	21.2	22.0	2.5	2.5	32.3	32.7	32.7	33.4	163.6	166.8	1.81	1.81	5.02	5.07	3.21	3.27	1.8	1.8
T3	23.0	24.5	2.8	2.8	34.1	35.2	34.5	36.0	143.8	150.1	1.82	1.82	5.30	5.47	3.48	3.65	1.9	2.0
T4	24.5	25.3	3.0	2.9	35.3	36.1	35.7	36.7	127.5	133.4	1.86	1.86	5.47	5.57	3.61	3.68	1.9	1.9
T5	24.8	25.4	3.1	3.2	36.0	36.6	36.4	37.4	113.7	114.6	1.89	1.89	5.56	5.67	3.67	3.81	1.9	2.0
T6	25.4	25.8	3.7	3.6	36.2	36.7	36.6	37.4	101.7	104.0	1.92	1.92	5.60	5.69	3.68	3.77	1.9	2.0
CD (P=0.05)	1.0	1.9	0.3	0.3	1.1	1.9	1.1	1.9	3.8	7.2	0.09	0.09	0.17	0.29	0.17	0.29	0.1	0.2

optimum corm yield in elephant foot yam. Nedunchezhiyan *et al.* (2016) also concluded that fertigation of N-K₂O @100–100 kg/ha were optimum for obtaining economic production of elephant foot yam corm. Lower corm yield in the treatments T1 and T2 was due to lower growth (pseudostem height and collar diameter) and yield attributes (corm diameter and average corm weight). The plants were not utilizing the applied nutrients (N and K) efficiently in this treatment. This might be due to various losses of soil applied nutrients (N and K).

The corm equivalent yield (Table 2) revealed that the treatment T6 resulted in greater corm equivalent yield. The treatments T6, T5, T4 and T3 resulted in 22.8, 22.1, 19.8 and 15.8%, and 24.7, 24.7, 22.3 and 20.0% higher corm equivalent yield over T1 (Soil application of N-K₂O @100–100 kg/ha) during 2013 and 2014, respectively. The fertigation of elephant foot yam+greengram intercropping system with N-K₂O @100–100 kg/ha (T4) resulted in 19.8–22.3% increase in corm equivalent yield over soil application of the same quantity of nutrients (T1). Lower corm equivalent yield in the treatment T1 was due to lower greengram and elephant foot yam yields.

The nutrient use efficiency was significantly influenced by the fertigation levels in elephant foot yam+greengram intercropping system (Table 2). The nutrient use efficiency was declined with the increasing levels of fertigation owing to higher rate of fertilizer use. Significantly higher nutrient use efficiency was observed in the treatment T2 and it was followed by T3, T4 and T5. In these treatments though the corm yield increased, successive increase of fertigation level reduced the nutrient use efficiency. Nedunchezhiyan (2017) reported that incremental increase of fertigation level did not increase nutrients use efficiency linearly in elephant foot yam. In treatment T2, elephant foot yam crop utilized applied minimum quantity of nutrients (N-K₂O @100–100 kg/ha) efficiently. The fertigation of elephant foot yam+greengram intercropping system with N-K₂O @100–100 kg/ha (T4) resulted in 19.9–24.4% increase in nutrient use efficiency over soil application of the same quantity of nutrients (T1). Nedunchezhiyan (2017) reported an increase of 9% nutrient use efficiency under fertigation than soil application. Significantly lower nutrient use efficiency was noticed in the treatment T6 followed by T1 (Table 2). In the former case lower nutrient use efficiency was due to higher fertigation level, in the latter case it was due to lower corm yield.

In elephant foot yam+greengram intercropping system, the treatment T1 recorded lower cost of cultivation than all other treatments (Table 2). This was due to involvement of additional cost of drip irrigation system accessories (pipes, laterals, drippers, ventury system etc.) in fertigation treatments. The cost of cultivation increased with the increase in the levels of fertigation. This was due to higher level of fertilizer cost. The greater gross and net returns were noticed in the treatment T6 (Table 2) due to greater corm equivalent yield. The treatments T6, T5, T4 and T3 resulted in 29.1, 28.8, 26.7 and 22.1%, and 31.8, 32.2, 28.7 and

27.6% higher net return over T1 (Soil application of N-K₂O @100–100 kg/ha) during 2013 and 2014, respectively. All the fertigation treatments recorded greater benefit cost ratio (B:C ratio) than soil application of fertilizer (T1) (Table 2).

It can be concluded that the fertigation of N-K₂O @100–100 kg/ha resulted in increase of 20.1–22.4% corm yield, 19.8–22.3% corm equivalent yield and 19.9–24.4% nutrient use efficiency, and 26.7–28.7% greater net return over soil application of the same quantity of nutrients. Thus, for elephant foot yam+green gram intercropping system, fertigation of water soluble fertilizer N-K₂O @100–100 kg/ha may be recommended for greater yield, nutrient use efficiency and economics.

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