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Effect of fertigation on growth, yield and nutrient uptake in elephant foot yam *Amorphophallus paeoniflorins* (Dennest.) Nicolson

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Abstract
The field experiment was conducted to elicit information on the yield and nutrient uptake of elephant foot yam [*Amorphophallus paeoniflorins* (Dennest.) Nicolson] under fertigation at orchard, Department of Vegetable Crops, TNAU, Coimbatore during the year 2012-2013. The experiment was laid out in randomized block design with three replications. The growth attributes of elephant foot yam *viz.*, plant height, canopy spread, leaf area, and pseudo stem girth were found to be the highest in T_5 receiving 75% RDF through
(50 % straight fertilizers + 50% water soluble fertilizers) under fertigation. The yield attributes are corm weight, corm diameter, number of cornels, root number, root length and root diameter were also recorded highest in treatment T_5 [75% RDF through (50% straight fertilizers + 50% water soluble fertilizers) followed by T_4 which receives 100% RDF through (50% straight fertilizers + 50% water soluble fertilizers) under fertigation. Increased nutrient content and nutrient uptake in corms were observed in fertigation with 75% RDF through (50% straight fertilizers + 50% water soluble fertilizers) (T_5) followed by fertigation with 100% RDF through (50 % straight fertilizers + 50% water soluble fertilizers) (T_4). The BC ratio was found to be higher in T_5 [fertigation with 75% RDF through (50% straight fertilizers + 50% water soluble fertilizers)] with 3.96.

Keywords: Fertigation, elephant foot yam, nutrient, nitrogen

Introduction

Amorphophallus paeoniflorins (Dennest.) Nicolson is a herbaceous perennial crop belongs to the family Arcae, commonly known as elephant yam, elephant foot yam, Suren, Sweet Yam (Hetterscheid and Ittenbach, 1996) [6]. It is basically a crop of Southeast Asian origin. It has long been used as a staple food in many countries such as Philippines, Java, Indonesia, Sumatra, Malaysia, Bangladesh, India, China and Southeastern countries (Sugiyama and Santosa, 2008) [28]. Generally, elephant foot yam is considered only as famine food in the Pacific Islands (Thaman, 1984) [29]. It is commercially cultivated due to its productivity and popularity as a vegetable in various Indian cuisines. In India, it is cultivated in Andhra Pradesh, West Bengal, Gujarat, Kerala, Tamil Nadu, Uttar Pradesh, Maharashtra and Jharkhand whereas in Northeastern states, wild, local cultivars grown are being generally used for making vegetable pickles and medicine preparations for various ailments.

Elephant foot yam is a rich source of carbohydrate (18.4 %), calcium (500 mg g^{-1}), phosphorus (34 mg g^{-1}) and vitamin A (260 IU g^{-1}). The leaves are used as vegetable by local tribes in India because they contain high concentration of vitamin A. The corms are usually eaten as vegetables after boiling or by baking. It is a remunerative crop because of its high production potential as well as high market price.

The crop is also cultivated as an intercrop along with turmeric and under coconut or banana. Elephant foot yam is propagated by daughter corms (cornels) as such or by cut corm having a part of apical meristem. Sen *et al*., (1991) [24] suggested that 500g of seed corn was the most beneficial considering the total seed corm requirement and per cent increase in corm yield. It is cultivated in an area of about 2.5 million hectares in the world producing about 23.5 million tons of tubers. Africa alone produces about 90% of the tubers and covers about 95% of the area.

In India though it is cultivated in almost all the states, especially in Tamil Nadu, commercially it is cultivated in Erode, Salem, Tiruvannamalai, Tirunelveli, Thoothukudi and Thanjavur districts in an area of about 807 ha and with a production of 20,175 t.

Considering the soil and crop constraints, fertilizers should be applied in synchrony with crop demand in smaller quantities during the growing season. It is challenged to manage water and nutrients in such a way that production benefits are maximized, while adverse environmental effects are minimized. The right combination of water and nutrients is a prerequisite for higher yield and good quality produce. The method of fertilizer application is also important in improving the use efficiency of nutrients. Fertigation enables adequate supply of water and nutrients with precise timing and uniform distribution to meet the crop demand (Patel and Rajput, 2000; Chawla and Narda, 2002) [19, 2]. The ever-increasing population scenario of our country warrants more production of vegetables to bring down the gap between the per capita availability and the consumption. This can be achieved by increasing the productivity per unit area, which is indirectly related to proper management of the crop. Manuring and fertilizer application are the management practices that can increase the growth and yield of elephant foot yam. Among the plant nutrients, Nitrogen (N), Phosphorus (P) and Potassium (K) are the most important, which play vital role in the nutrition of the tuber crop. Therefore, it is necessary to undertake studies on the fertigation, soil reaction, as well as uptake pattern of the crop under fertigation. The information available is scanty on this and there is a need for standardising the optimum dose of N, P and K on growth and yield of this crop.

Materials and methods

The field experiment was conducted during 2012-2013 at the College Orchard, Horticultural College and Research Institute, Tamil Nadu Agricultural College, Coimbatore (11° N latitude and 77° E longitude and 426.76 m above the Mean Sea Level). The soil at the experimental site had 1.92 dsm^{-1} electrical conductivity, 7.92 pH, 130 kg available N/ha, 20 kg available P/hand 660 kg available K/ha.

The experiment was laid out in Randomized Block Design (RBD) with eight treatments and three replications *viz.* T_1 - Fertigation with 100% of RDF through straight fertilizers, T_2 - Fertigation with 75% of RDF through straight fertilizers, T_3 - Fertigation with 50% of RDF through straight fertilizers, T_4 - Fertigation with 100% of RDF (50% straight fertilizers+ 50% water soluble fertilizers), T_5 - Fertigation with 75% of RDF (50% straight fertilizers+ 50% water soluble fertilizers), T_6- Fertigation with 50% of RDF (50% straight fertilizers+ 50% water soluble fertilizers), T_7- Recommended dose (150:60:150 kg NPK/ha) through straight fertilizers by soil application and flood irrigation and T_8- Absolute control. N, P and K fertilizers are provided through straight fertilizers (Urea, Single Super Phosphate and Muriate of Potash) and water-soluble fertilizers through fertigation [Polyfused (19: 19: 19), MAP (12: 61: 0) and Multi K (13:0:46)].

The field was ploughed once and tilled twice and Pits of 30×30×30 cm^3 size were dug out at 90×90 cm spacing. Each pit was applied with 2.5 kg of FYM except the absolute control. The seed corms were planted at uniform depth in the pits in such a way that the eye of the cut piece facing upward. Then they were covered with topsoil and the plots were leveled and irrigated immediately. Fertigation was done twice a week starting from ten days after planting as per the treatments. First irrigation was given immediately after planting and subsequent irrigations were given weekly twice. Light irrigation was given to avoid rotting of corms. The crop was harvested at maturity after a crop duration of eight months (after the senescence of aerial portion). Observations on plant height, canopy spread, pseudo stem girth from 10 cm above the ground, leaf area, tuberous roots, root length and root diameter, corm characters viz. corm yield per plant, corm yield per plot, number of cornels per plant, corm diameter and dry matter content of corms was recorded.The soil samples were collected twice and analyzed for the following nutrients before planting and after harvest. The collected soil samples were air dried in shade and passed through two mm sieve and used for the analysis. The available nitrogen in soil was estimated by Alkaline Permanganate method (Subbiah and Asija., 1956) [27] and expressed in kg ha ^{1}. The available phosphorus was estimated by using Klatt Summer son Colorimeter using red filter (Olsen *et al.*, 1954) [18] and expressed in kg ha-^{1}. The available potassium was estimated by Flame Photometry method and the values were expressed in kg ha^{-1} (Hanway and Heidal, 1952) [5].

The corms after harvest were cleaned well, dried under shade for 10 days and then oven dried at 70°C for two days. The dried samples were powdered in a grinding Wiley mill and stored for chemical analysis. The nitrogen content of corm was estimated by Microkjeldahl method (Humphries., 1956) [7] and expressed in percent. The phosphorus content in corm was estimated by adopting Vanadomalayaite phosphoric yellow color method (Jackson, 1973) [9]. The potassium content in corm was estimated by the flame photometric method as suggested by Jackson (1973) [9].

The nitrogen, phosphorus and potassium uptake by corms were computed by using its N, P and K concentrations and dry matter yield and expressed in kg ha ^{1}. The expenditure incurred from field preparation to harvest was worked out and expressed as Rs. ha ^{1}. The corm yield was computed per hectare and the total income was worked out at the rate of Rs.10 per kg.Net returns were obtained by subtracting the cost of cultivation from gross return for each treatment. The benefit cost ratio was worked out in terms of total expenditure. The total return was arrived at based on realized yield and BC ratio was calculated.

$$BCR = \frac{\text{Gross return (Rs. ha}^{1})}{\text{Total cost of cultivation (Rs. ha}^{1})}$$

Statistical analysis was performed on all the data by using AGRESS software package. Analysis of variance (ANOVA) was used to evaluate the statistical difference of treatment means. The level of significance was set $P<0.05$.

Results

Growth and yield characters

The data pertaining to the performance of elephant foot yam for growth and yield parameters by different levels of nitrogen, phosphorus and potassium under fertigation is depicted in table 1, 2 and 3. The analysis of variance showed a wide range of variation and significant differences for growth and yield parameters. The plant height at 3rd, 5th, and 7th, months after planting was significantly influenced by different levels of nitrogen, phosphorus and potassium under fertigation. The plant height was the highest in T_5 (35.76, 99.90 and 144.30 cm) and lowest in T_8 (29.30, 69.30, 103.20 cm)at 3rd, 5th, and 7th months after planting respectively. The different levels of fertilizers under fertigation had significant effect on the girth of the plant at various growth stages. The pseudo stem girth was maximum in

T_5 (14.30 cm, 16.19 and 25.80 cm) and minimum in T_8(10.64 cm, 11.77 and 18.50 cm) at 3rd, 5th, and 7th month after planting respectively. Significant differences in the leaf area of the plant were noticed by the application of different levels of fertilizers under fertigation. A rapid increase in leaf area was observed between 3rd and 5th month and after that, the increase was very less and at the time of harvest leaf area got reduced. The leaf area was minimum in T_8 (5583.06, 7653.90, 7438.60 cm^2) and it was maximum in T_5 (6786.10 cm^2, 12225.35 cm^2 and 11176.80 cm^2) at 3rd, 5th and 7th months after planting respectively. The increased dose of fertilizers increased the leaf area. The treatment with soil application T_7 gave the lowest leaf area registering 6023.77, 8532.55 and 8201.20 cm^2at 3rd, 5th and 7th month after planting respectively. There was progressive increase in spread of the plant from 3rd month to the maturity. Various treatments had a favorable influence in enhancing the canopy spread. Increasing the level of the fertilizer significantly increased the canopmmaturity$_5$ was recorded high canopy spread (93.5, 115.75, 150.6 cm) and T_8 was found to be low (72.20, 98.65 and 137.50 cm) at 3rd, 5th, and 7th months after planting respectively. Number of roots at different levels of fertigation exhibited significant differences at all the stages of growth. The number of roots produced per plant was high in T_5 at 3rd, 5th and 7th month after planting (84.10, 144.60 and45.80)

Table 1: Effect of fertigation on growth characters at different growing stages in elephant foot yam

Treatments	Plant height (cm)			Pseudo stem girth (cm)			leaf area (cm^2)		
	3rd MAP	5th MAP	7th MAP	3rd MAP	5th MAP	7th MAP	3rd MAP	5th MAP	7th MAP
T_1	33.32	89.50	130.30	13.30	14.52	22.4	6250.50	9290.94	8963.47
T_2	30.80	74.50	114.80	11.82	12.58	19.00	5659.02	8032.60	7864.71
T_3	32.90	82.13	125.40	12.68	13.37	20.60	6132.86	8989.52	8565.30
T_4	33.45	91.20	136.70	13.56	15.81	23.60	6556.38	10253.89	9983.58
T_5	35.76	99.90	144.30	14.30	16.19	25.80	6786.10	12225.35	11176.80
T_6	32.95	84.10	128.00	13.13	13.72	21.10	6173.30	9194.41	8675.32
T_7	30.65	78.22	120.60	11.50	12.29	19.30	6023.77	8532.55	8201.20
T_8	29.30	69.30	103.20	10.64	11.77	18.50	5583.06	7653.90	7438.60
SE(d)	0.296	1.430	1.858	0.158	0.235	0.366	59.14	209.01	175.52
CD (0.05)	0.635	3.067	3.986	0.340	0.505	0.785	126.87	448.35	376.50
CV	1.16	2.17	1.88	1.61	2.17	2.18	1.22	2.86	2.51

Table 2: Effect of fertigation on growth characters at different growing stages in elephant foot yam

Treatments	Canopy spread (cm)			Tuberous roots plant ^{1}			Root length (cm)			Root diameter (cm)		
	3rd MAP	5th MAP	7th MAP	3rd MAP	5th MAP	7th MAP	3rd MAP	5th MAP	7th MAP	3rd MAP	5th MAP	7th MAP
T_1	86.90	111.55	143.70	79.65	135.00	41.00	19.60	35.55	47.2	0.80	1.76	2.63
T_2	73.80	101.08	139.10	71.00	115.30	20.80	13.50	27.60	35.00	0.35	0.97	1.50
T_3	76.10	105.55	141.30	75.40	126.10	32.30	16.30	30.65	43.10	0.60	1.45	2.30
T_4	87.90	112.34	146.50	81.00	138.60	41.50	20.20	38.20	48.00	1.00	1.85	2.70
T_5	93.50	115.75	150.60	84.10	144.60	45.80	22.30	39.85	48.30	1.20	2.05	3.20
T_6	78.76	109.05	142.00	77.20	130.30	36.80	18.00	32.35	45.80	0.73	1.63	2.50
T_7	75.30	103.30	140.30	72.65	120.40	31.20	14.20	29.50	38.30	0.40	1.00	1.60
T_8	72.20	98.65	137.40	69.35	110.10	28.30	12.80	25.90	31.20	0.30	0.80	1.32
SE(d)	0.983	0.869	0.619	0.748	1.723	1.108	0.476	0.726	0.946	0.047	0.067	0.098
CD (0.05)	2.109	1.864	1.328	1.605	3.696	2.377	1.021	1.558	2.031	0.100	0.144	0.211
CV	1.56	1.03	0.55	1.25	1.71	4.10	3.56	2.84	2.85	8.87	5.95	5.63

Table 3: Effect of fertigation on yield characters at different growing stages in elephant foot yam

Treatments	Corm diameter (cm)			Number of cornels			fresh corm weight (kg)			Corm yield (kg/plant)	Yield (kg/ plot)	Yield (t/ha)
	3rd MAP	5th MAP	7th MAP	3rd MAP	5th MAP	7th MAP	3rd MAP	5th MAP	7th MAP			
T_1	10.68	15.53	20.10	5.10	7.80	11.30	0.56	1.86	2.53	2.53	75.90	25.30
T_2	8.10	12.30	17.74	2.70	4.60	7.25	0.28	0.90	1.50	1.50	45.00	15.00
T_3	9.30	13.21	18.79	3.10	5.50	8.60	0.36	1.61	2.04	2.04	61.20	20.40
T_4	12.32	17.65	20.68	4.30	6.90	10.98	0.63	1.90	2.86	2.86	85.80	28.60
T_5	14.65	18.83	21.60	2.50	4.00	6.50	0.72	2.25	3.30	3.30	99.00	33.00
T_6	9.63	13.86	19.35	3.60	5.98	9.30	0.48	1.82	2.38	2.38	71.40	23.80
T_7	8.38	12.78	18.22	3.00	5.40	7.70	0.30	1.36	1.83	1.83	54.90	18.30
T_8	7.60	10.60	17.21	3.70	6.50	10.00	0.25	0.86	1.35	1.35	40.50	13.50
SE(d)	0.34	0.40	0.21	0.12	0.17	0.25	0.02	0.07	0.09	0.09	2.92	0.97
CD (0.05)	0.74	0.86	0.47	0.27	0.38	0.54	0.05	0.15	0.21	0.21	6.28	2.09
CV	4.36	3.58	1.45	4.64	3.89	3.60	6.93	5.84	5.59	5.59	5.57	5.57

The number of roots showed a decreasing trend towards maturity and with the lower levels of fertilizers. The number of roots was very less in T_8 recorded with 69.35, 110.10 and 28.30at 3rd, 5th and 7th month after planting respectively. Different levels of fertilizers were found to influence the length of roots significantly in all the growth stages. In all the cases, the plants applied with T_5- 75% RDF (50% SF + 50% WSF) level of fertilizer showed increased length of 22.30, 39.85 and 48.30 command lowest in T_8(12.80, 25.90 and 31.20 cm) at 3rd, 5th, and 7th months after planting respectively Among different levels of nitrogen, phosphorus and potassium compared, T_5-75% RDF (50% SF + 50% WSF) was found to be the best and it recorded a root diameter of 1.20, 2.05 and 3.20 cm and lowest in T_8 (0.30s, 0.80, 1.32 cm) at 3rd, 5th and 7th month after planting respectively.

It was clear that the different levels nitrogen, phosphorus and potassium under fertigation influenced the average corm diameter. Among different fertigation levels compared, T_5 receiving 75% RDF (50% SF + 50% WSF) was found to be the best and highest corm diameter was registered in T_5 (14.65, 18.83, and 21.60 cm)and lowest was in T_8(7.60, 10.60 and 17.21cm)at 3rd, 5th and 7th month after planting respectively.

The number cornels produced per plant was more in plant fertilized with T_1-Fertigation with 100% of RDF through straight fertilizers (5.10, 7.80 and 11.30)and less in T_8(3.70, 6.50 and 10.00)at 3rd, 5th and 7th month after planting respectively. After planting the mother corms, initiation of new corms was observed during 70 to 75 days of growth. The mother corm supplied the daughter plant with nutrients. Mother corm seemed to supply food up to 100 days of planting and then shriveled leading to death. Newly initiated daughter corms started to grow rapidly. The data on the fresh weight of corms showed an increasing trend towards harvest. In all the growth stages, the higher level of fertigation increased the fresh weight of corms. Among different treatments, T_5 was found to give the highest fresh corm weight (0.72, 2.25, and 3.30 kg per plant at 3rd, 5th and 7th month after planting respectively) and lowest in T_8(1.35 kg per plant at harvest). The plot yield was maximum 99.00 kg plot^{-1} in $T_5$and lowest in T_8 (control) which marked 40.50 kg plot^{-1}. The yield per hectare was computed from the plot yield and hence the trend was similar to that of yield per plot. It showed a significant difference in the yield of corms per hectare due to different levels of fertilizers under fertigation. The yield of corms showed an increasing trend till harvest. The treatment T_5 recorded the highest yield of 33.00 t ha^{-1} whereas, the yield was low in T_7 which registered 18.30 t ha^{-1}. The percentage of dry matter of the corm after harvest varied significantly. Among different levels of fertigation, T_5 recorded the highest percentage of dry matter of 13760.51 kg ha^{-1}and lowest in T_8 (5539.96 kg ha^{-1}).

Nutrient content in corms

The nitrogen content in corms increased steadily with different fertigation levels of nitrogen, phosphorus and potassium (from T_1 to T_8 level). The highest nitrogen content was registered in T_5 (2.41%) and lowest in T_8 (1.93 per cent). The phosphorus content of the corms was found to increase with different fertigation levels of nitrogen, phosphorus and potassium. The treatment T_5recorded higher phosphorus content (0.87%) and lowest in T_8 (0.20%). The highest potassium content was registered (2.88 per cent) in $T_5$and found to be lowest in T_8(2.04%)

Nutrient uptake

Highly significant differences in the uptake of nitrogen, phosphorus and potassium had been noticed due to the application of different doses of fertilizers under fertigation at different times. The highest N, P, and K uptake was found in T_5 and recorded 125.23, 45.08 and 149.28 in corms and the uptake of N, P, and K was less in T_8 (36.36, 8.18 and 38.36 kg ha^{-1}) respectively.

Fertility status of the soil after harvest

Different doses of nitrogen, phosphorus and potassium under fertigation had significantly influenced the fertility status of the soil after harvest (Table 4). The available nitrogen, phosphorus and potassium in soil were found to be high in T_5 receiving 75% RDF under SF+WSF recorded 250, 21.5 and 713 kg ha^{-1} of N, P and K and low in T_8 and which registered 120, 12.5 and 487 kg ha^{-1} N, P and K respectively.

Table 4: Effect of fertigation on nutrient content of corms, uptake of nutrients in corms and fertility status of soil at harvest in elephant foot yam

Treatments	Nutrient content of corms			Uptake of nutrients in corms			Fertility status of soil		
	N (%)	P (%)	K (%)	N (Kg ha^{-1})	P (Kg ha^{-1})	K (Kg ha^{-1})	N (Kg ha^{-1})	P (Kg ha^{-1})	K (Kg ha^{-1})
T_1	2.12	0.24	2.66	75.22	8.55	94.36	186	17.3	650
T_2	1.93	0.43	2.33	62.01	6.51	74.72	130	14.8	537
T_3	2.22	0.19	2.38	66.94	5.82	71.89	147	15.1	550
T_4	2.32	0.35	2.76	104.31	15.65	124.31	225	20.0	672
T_5	2.41	0.87	2.88	125.23	45.08	149.28	250	21.5	713
T_6	2.12	0.23	2.59	69.13	7.54	84.21	155	16.5	600
T_7	2.03	0.19	2.33	44.89	4.27	51.51	126	13.2	512
T_8	1.93	0.20	2.04	36.36	8.18	38.36	120	12.5	487
SE(d)	0.024	0.034	0.040	5.02	1.17	6.33	7.03	0.457	11.86
CD (0.05)	0.053	0.074	0.085	10.77	2.52	13.59	15.09	0.981	25.45
CV	1.48	13.08	2.03	6.98	10.68	7.31	5.34	3.55	2.55

Economics

Significant differences existed in gross return, net return and BC ratio (Table 5). Among the different doses of fertilizers, gross return was the highest in T_5 (Rs.147333). The cost of cultivation was high in T_5 (Rs. 37192), whereas the net return and BC ratio was high in T_5 (Rs. 110141 and 3.96) and the lowest gross return was at T_8 (Rs. 77331), whereas net return was Rs. 46956. The cost of cultivation and BC ratio was Rs. 30375 and 2.21 respectively.

Table 5: Effect of fertigation on cost economics in elephant foot yam

Treatments	Gross return (Rs)	Cost of cultivation (Rs)	Net return (Rs)	BC ratio
T_1- 100% RDF under SF	254300	85862	340162	3.28
T_2- 75% RDF under SF	150000	76958	226958	2.25
T_3-50% RDF under SF	204000	75057	279057	2.86
T_4-100% RDF under (50% SF+ 50% WSF)	286000	73154	359154	3.69
T_5-75% RDF under (50% SF+ 50% WSF)	330000	71250	401250	3.96
T_6-50% RDF under (50% SF+ 50% WSF)	238000	124672	362672	3.04
T_7-100% RDF as soil application and flood irrigation	183000	113220	296220	2.54
T_8- Absolute control	135000	101771	236771	2.21

Discussion

Different levels of fertigation had significant influence on growth parameters.

In the present investigation, plant height, canopy spread, pseudo stem girth, leaf area, root length and number of roots were significantly increased with application of 75 per cent RDF through water soluble fertilizers and straight fertilizers (T_5). The increased growth parameters might be due to better absorption of nitrogen under fertigation, which is useful for better carbohydrate and protein synthesis that are essential for building of new cells besides it accelerates synthesis of chlorophyll and amino acids, leading to improvement in vegetative growth. Similar finding was reported by Brahma *et al*. (2010). The combination of straight and water-soluble fertilizers at 75 % RDF (T5) recorded the highest plant height of 144.3 cm. This indicated that for obtaining growth and development in elephant foot yam, the critical stages of growth for fertilizer application might be 3rd month after planting. This was in line with the findings of Nair and Mohan Kumar (1991) [15]. Under drip fertigation, fertilizers were applied at frequent intervals. This might have resulted in higher availability and uptake by the corms which ultimately would have favored better growth and yield. The enhancement of growth parameters might be due to the restricted wetting area and root zone application of nutrients through drip system coupled with constant and continuous availability of optimum soil moisture, which would have facilitated the plants to absorb more nutrients (Patil, 1999). In the case of soil application of fertilizers with furrow irrigation, fertilizers were applied on a wider area, which had resulted in faster depletion of nutrients from the rhizosphere. Further, the faster rate of infiltration in furrow irrigation resulted in water deficit, which might have led to many changes in plant anatomy such as decrease in cell size and intercellular spaces and limiting cell division and elongation, reflecting its effect on plant growth (Guinn *et al*., 1981). The increase in the fertigation level positively increased the plant height, canopy spread, pseudo stem girth and leaf area per plant. This result corroborated with the findings of Odubanjo *et al*. (2011) [17]. The increase in plant height at higher levels of nitrogen in taro was also reported by Rahman and Rashid (1983) [22]. The increase in plant height might be due to better synthesis of assimilates in large photosynthetic area and optimum supply of nourishments to the meristematic tissues. According to Singh *et al*. (1997) [26], nitrogen is associated with synthesis of amino acid, which would have increased the meristematic activities at faster rate under fertigation and caused better growth. The pseudo stem girth was increased due to the combination of straight and water-soluble fertilizers, whereas the control and other treatments showed reduced girth of the plant. The result confirmed the findings of Odubanjo*et al.* (2011) [17]. The leaf area of photosynthetically active leaves is a fundamental determinant of the rate of photosynthesis by the plant. The largest leaf area development aids in the effective interception of light leading to higher dry matter accumulation. There was an increase in leaf area up to 6th MAP and then it declined towards harvest. Since the crop at this stage reflects lesser vegetative activity with corm production already started, the lack of response in terms of leaf area at this stage was in the expected direction. The decline in leaf area might be due to the transport of assimilates from the leaves to the developing sink after cessation of vegetative growth, which later caused senescence of leaves.

The results revealed that leaf area index was found to increase when the nitrogen level was increased. This is in accordance with the report of Lawlor *et al*. (2001) [11].

Root length and number of roots were observed to be more at 3rd and 5th MAP and afterwards the value started declining. It revealed that maximum absorption of nutrients might have taken place at that period to put forth better vegetative growth. Nair *et al*. (1990) [16] concluded that maximum radial root length was observed during 3rd month.

The fertigation level tends to increase the root number as well as root length. This led to better vegetative growth due to higher uptake of nutrients.

The corm diameter of elephant foot yam was significantly influenced by the fertilizer combinations with straight and water-soluble fertilizers. The treatment T_5 gave positive and better results than the other treatments. Elvin Roman and David (2012) [3] reported that in cassava, the mean root number, root weight and girth were significantly influenced by fertigation. The favorable effect of nitrogen on growth of corm could be attributed to the nitrogen requirement of plant during cell division and enlargement phase of growth. The poor development of corm in T_8 might be due to inadequate supply of nutrients (absolute control). The obvious reason for the corm diameter being very less at 3rd and 5th months might be that the food material that the plant synthesized would have been utilized for the development of aerial parts until the compensation point was reached when the production of leaves was almost complete by this stage. After this point, translocation of nutrients might take place towards the corm. That might be the reason for the decreased corm size recorded up to 6th month. A similar finding was found to be recorded by Mohamed Amanullah *et al*. (2007).

The highest fresh weight of corms was recorded due to the application of WSF and SF in the treatment T_5. Nitrogen through its direct participation in protein synthesis has a direct effect on yield. Potassium is the activator of many enzymes and concerned in CO_2 and nitrogen assimilation favoring formation of nitrogen compounds of higher molecular weight. Hence, it is absolutely necessary to pay due attention to the optimum nutrient balance, especially the ratio between the major nutrients to obtain maximum yield at higher efficiency. The result is in line with the findings of Shivalinga swamy and Misra (1999) [25]

The method of application of fertilizers also influenced the yield of corm significantly and the response was more pronounced when the fertilizers were applied in split doses through fertigation. However, fertilizers applied in equal splits gave the highest corm yield. Nair *et al*. (1990) [16] reported that tuber bulking rate increased steeply due to split doses of fertilizers under fertigation. Being a long duration of the crop, it exhibits distinct phasic requirements of nutrients. Fertigation with the combination of water soluble and straight fertilizers application increased the yield of corm since the plants can afford the major nutrients in a readily available form. The corm bulking was at a rapid rate even after leaf growth had dropped due to senescence. Even at maturity stage the leaves remaining at the last stage still had enough photosynthetic efficiency to channel substantial amounts of assimilates for tuber bulking and hence the high rate of corm growth (Muthusamy, 1983) [14].

The NPK content in corms gradually increased with fertigation at 75 per cent RDF through the combination of water soluble and straight fertilizers. The higher nitrogen content was noticed in the treatment T_5, which is in accordance with Law Ogbomo and Remison (2009) [9]. The nitrogen content of corms showed an increasing trend and the highest values of nitrogen, phosphorus and potassium were noticed during harvest (Muthusamy, 1983) [14]. The highest NPK content in corms might be due to the translocation and accumulation of nutrients from pseudo stem, leaves and roots at later stages of growth.

The synergistic effect of nitrogen, phosphorus and potassium uptake had been well pointed out by Pushpadas and Iyer (1976) [21] and Rajendran *et al*. (1976) [23] in cassava. The increase in uptake of nitrogen might probably be due to the fact that the plant dry matter production also followed a similar trend. The nutrient uptake of corm was higher at T_5. Muthusamy (1983) [14] reported that combination of higher level of nitrogen, phosphorus and potassium application recorded the highest uptake of nutrients at all stages of crop growth. Igbokwe and Ogbannaya (1980) [8] reported similar trend in cocoyam. It clearly indicated that rapidly developing tissues of the corm throughout its growth were always associated with yield and therefore presumably dependent on high concentrations of these major nutrients. Fractional applications might have resulted in the better availability of nutrients thereby leading to efficient absorption by plants (Mohankumar and Sadanandan, 1990) [13].

The effect of treatments on available N, P_2O_5 and K_2O status of the soil after harvest was assessed. It was evident from the post-harvest soil analysis, while comparing initial nutrient status of the soil available nitrogen, phosphorus and potassium were reduced considerably in almost all the treatments after crop harvest. This could be probably due to the depletion caused by crop removal and by other types of losses such as fixation, leaching and volatilization etc., However, fertility status of the soil was increased with increased level of fertilizers. Particularly, the residual soil nitrogen content was steeply increased at 120 kg nitrogen per hectare in T_8 to 250 kg nitrogen per hectare in T_5 and similar trend was found in phosphorus and potassium (12.5 to 21 kg P_2O_5 and 480 to 712 kg K_2O per hectare). A similar trend in the availability of potassium was reported by Mohankumar and Sadanandam (1991) [15].

The highest yield of corm was obtained in the treatment T_5 that received the combination of water soluble and straight fertilizers. The net return was also the highest in this treatment. The BC ratio was also the highest in T_5 (3.96) and lowest in T_8.

The minimum net return and BC ratio were recorded in T_7. This might probably be due to lower yield in proportion to the input applied and labor cost.

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