

Analysis of growth, physiological aspects and yield of elephant foot yam, *Amorphophallus campanulatus* Roxb Blume cv Gajendra in spice intercropping system under sloppy foothills of Imphal East

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ABSTRACT

An investigation was carried out to study the effect of intercropping spice crops (ginger and turmeric) on growth, physiological aspects and yield of elephant foot yam. Sole crop of elephant foot yam was grown and between the inter-row spaces ginger/turmeric was intercropped in single/double row planting. Spacing of 90 x 90 cm between elephant foot yam and 25 x 25 cm for intercrops was adopted. Growth parameters were recorded from sole crop of elephant foot yam. Maximum fresh weight (918.48 g) and dry weight of the plant (107.68 g) were observed in elephant foot yam with single row turmeric. Superiority in physiological parameters like leaf area index (1.88) and harvest index (47.09%) was recorded in elephant foot yam with single row turmeric and sole crop of elephant foot yam respectively. Remarkable variation was observed in the performance of elephant foot yam-spice intercropping system under sloppy foothills of Imphal East.

Keywords: *Amorphophallus*; growth; intercropping; spice crops

INTRODUCTION

Elephant foot yam, *Amorphophallus campanulatus* Roxb Blume belongs to the Araceae family and is originated in southeast Asia. In India it is commercially grown in Gujarat,

Maharashtra, Bihar, Andhra Pradesh and Madhya Pradesh. In spite of wide scope and importance only limited efforts have been made towards elephant foot yam (EFY) research and development in northeast region of India. There is need for focused research efforts to increase the

area and production of minor tuber crops like elephant foot yam to meet the requirements of tribal areas.

No cultivable land under EFY has been noticed in Manipur. As local EFY grown in kitchen gardens of Manipur produces irritative corms with high calcium oxalate content acidity free cv Gajendra from Kovvur region of Andhra Pradesh has been introduced and studied (to meet the food requirements of tribal areas) in the spice intercropping system with local lines of turmeric and ginger to compensate in case of crop failure and ensure the profitable returns along with the food security for small holdings of Manipur. Even though inclusion of any of the intercrops reduced the yield of main crop (Chattopadhyay et al 2008, Singh et al 2013), highest profitability was recorded among intercropped treatments (Quayyam and Ebrahim 1988). Salter (1986) indicated that simultaneous growing of two or more crops not only gives more yield and net profit but it also cuts the cost of cultivation. Therefore the present investigation was carried out to study the growth, physiological aspects and yield of elephant foot yam cv Gajendra in spice intercropping system under sloppy foothills of Imphal East.

MATERIAL and METHODS

The present investigation was carried out at Horticultural Research Farm, Department of Horticulture, College of

Agriculture, Central Agricultural University, Imphal, during the year 2013 with elephant foot yam cv Gajendra. The experimental soil was acidic (pH 5.26) and clayey. The experiment was laid out in a randomized block design with seven treatments and three replications. The treatments comprised EFY sole crop (T_1), single row of turmeric planted in the inter-rows of EFY (T_2), double row of turmeric planted in the inter-rows of EFY (T_3), single row of ginger planted in the inter-rows of EFY (T_4), double row of turmeric planted in the inter-rows of EFY (T_5), turmeric sole crop (T_6) and ginger sole crop (T_7). Constant spacing of 90 x 90 cm was followed in EFY and 25 x 25 cm spacing for turmeric/ginger rhizomes whereas in single row planting only one row of ginger/turmeric was planted in the inter-rows of EFY at 25 cm spacing between plant to plant. In double row planting 2 rows of turmeric/ginger were planted in the inter-rows of EFY at a distance of 25 x 25 cm plant to plant in rows.

Five uniform plants were selected randomly in each treatment for recording plant height (cm) from base to the tip of the plant, pseudo-stem height (cm) from the base of the plant to the point where pseudo-stem was divided into 3 rachises, canopy of the plant (cm^2) and diameter of the pseudo-stem (cm). Estimation of leaf area for EFY was done according to the formula developed by Ravi et al (2010) which is as follows:

Total leaf area= $P \times 0.65 \times \text{total number of leaflets per plant}$

where P is the average value of length and breadth of few observations.

The pseudo-stem at the top was divided into three rachises which were further branched and bore many sessile lateral primary leaflets and one terminal leaflet. This number of leaflets was counted and the average was calculated. Corm fresh weight (g), corm dry weight (g), whole plant fresh weight (g) and whole plant dry weight (g) were recorded from 60 days after planting (DAP) with 30 days interval.

Leaf area index (LAI) of the plant and harvest index (%) were recorded by the formula given by Watson (1947) and Yoshida (1981) respectively.

$$\text{Harvest Index} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Net assimilation rate (NAR) (g/m²/day), crop growth rate (CGR) (g/day) and Relative growth rate (RGR) (g/g/d) were recorded by the following formulae given by Gregory (1926), Gardner et al (2010) and Reddy and Reddi (2008) respectively:

$$\text{NAR} = \frac{W_2 - W_1}{L_2 - L_1} \times \frac{\log L_2 - \log L_1}{t_2 - t_1}$$

$$\text{CGR} = \frac{W_2 - W_1}{t_2 - t_1}$$

$$\text{RGR} = \frac{\log W_2 - \log W_1}{t_2 - t_1}$$

where W_1 , W_2 and L_1 , L_2 refer to the whole plant dry weight and leaf area on two successive periods at t_1 and t_2 . Rhizome weight (g) of the intercrops has been recorded on per plant basis.

RESULTS and DISCUSSION

Growth parameters of elephant foot yam

Spice crops raised as intercrop affected the growth of EFY (Table 1) significantly under all the treatments. Maximum plant height (73.61 cm), pseudo-stem height (63.89 cm), plant canopy (9911.33 cm²), diameter of pseudo-stem (5.55 cm), leaf area (78.74 cm²) and number of leaflets (307.04) were recorded in EFY sole crop. Amanullah et al (2006a) and Silwana and Lucas (2002) also reported that intercropping reduced vegetative growth of component crops in line with the present findings.

It has been noticed that corm formation of EFY was just initiated at 60 days after planting and among the observations recorded from the destructive samples, maximum corm fresh weight (807.81 g) and corm dry weight (173.52 g) were recorded from sole EFY (Table 2b). Maximum fresh weight of the plant (917.70 g) was recorded from the EFY with double row of turmeric whereas

Table 1. Effect of intercropping spice crops on growth parameters of elephant foot yam

Treatment	Plant height (cm)	Pseudo-stem height (cm)	Plant canopy (cm ²)	Diameter of pseudo-stem (cm)	Leaf area (cm ²)	# leaflets
T ₁	73.61	63.89	9911.33	5.55	78.74	307.04
T ₂	63.06	53.55	6570.67	3.96	69.11	273.72
T ₃	70.56	58.45	7633.33	4.53	73.70	289.59
T ₄	70.89	59.45	8406.67	4.70	61.47	247.30
T ₅	62.00	53.51	8200.00	4.45	67.00	266.43
T ₆	—	—	—	—	—	—
T ₇	—	—	—	—	—	—
SEm±	1.89	1.78	567.39	0.29	3.22	11.14
CD _{0.05}	6.18	5.82	1850.36	0.94	10.50	36.34

Table 2a. Effect of intercropping spice crops on destructive samples of elephant foot yam

Treatment	Corm fresh weight (g)			Corm dry weight (g)		
	90 DAP	120 DAP	150 DAP	90 DAP	120 DAP	150 DAP
T ₁	164.59	451.33	807.81	51.50	103.88	173.52
T ₂	46.55	287.67	526.81	11.14	58.85	128.17
T ₃	120.44	367.04	602.15	41.85	87.16	154.49
T ₄	150.67	398.33	684.33	51.02	89.37	163.92
T ₅	63.00	327.63	539.41	31.69	68.31	143.46
T ₆	—	—	—	—	—	—
T ₇	—	—	—	—	—	—
SEm±	4.22	10.85	18.47	1.51	5.08	5.83
CD _{0.05}	13.76	35.37	60.23	4.94	16.55	19.00

maximum whole plant dry weight (106.61 g) was recorded in EFY with single row of turmeric (Table 2b). However among the intercropped treatments EFY intercropped with single row of ginger recorded maximum fresh weight (950.00 g) and dry weight

(235.18 g) of the corm. The experimental data showed that all these parameters increased rapidly from 60 to 120 days and thereafter increased at diminishing rate upto 150 days after planting irrespective of treatments. The competition between the

Table 2b. Effect of intercropping spice crops on destructive samples of elephant foot yam

Treatment	Whole plant fresh weight (g)				Whole plant dry weight (g)			
	60 DAP	90 DAP	120 DAP	150 DAP	60 DAP	90 DAP	120 DAP	150 DAP
T ₁	292.22	593.33	747.67	907.11	29.84	46.79	65.48	81.62
T ₂	344.89	628.81	802.11	918.48	23.66	64.00	88.48	106.61
T ₃	331.15	564.92	755.67	917.70	14.12	34.67	52.93	93.03
T ₄	304.67	613.33	722.44	913.89	14.30	28.66	71.45	89.13
T ₅	286.00	505.67	677.89	795.04	14.71	33.38	77.57	103.15
T ₆	—	—	—	—	—	—	—	—
T ₇	—	—	—	—	—	—	—	—
SEm±	9.78	23.90	22.94	26.19	1.19	2.78	2.50	3.39
CD _{0.05}	31.90	77.93	74.80	85.39	3.90	9.07	8.16	11.05

DAP= Days after planting

EFY and intercrops for various resources might pave the way for reduction in the above parameters. The effect of intercrops on EFY plant dry weight could be an important factor which results in the conversion of more dry matter for growth and therefore reduced carbohydrate availability for storage corm. This competition resulted in inefficient conversion of dry matter into biomass among the intercropped treatments. Whereas conversion of simultaneously supplied assimilates to the corm might be the reason for superior EFY sole crop.

Physiological parameters of elephant foot yam

The data regarding the physiological parameters as affected by various treatments have been presented in Table 3. In spite of treatment effect the LAI of EFY

increased with age (Njoku and Muoneke 2008). The highest LAI was recorded in EFY with single row of turmeric (1.88). Irrespective of the treatment effect, net assimilation rate and relative growth rate of the EFY were continuously reduced with the duration of the crop but the crop growth rate increased with advancing of days. The higher rate of net assimilation and relative growth at initial 60-90 days after planting could be due to rapid increase of dry matter in the plant and corm of the EFY and this observation is in line with the findings of Das et al (1997) and Ram and Singh (2003). Even though intercropped EFY showed higher NAR, CGR and RGR than the sole EFY in accordance by Ram and Singh (2003), these parameters were having no significant affect at 150 days after planting. Maximum harvest index (47.09%) was recorded from sole EFY which was

Table 3. Effect of intercropping spice crops on physiological parameters of elephant foot yam

Treatment	Leaf area index			Harvest index			Net assimilation rate (g/m ² /day)			Crop growth rate (g/day)			Relative growth rate (g/g/day)		
	90	120	150	90	120	150	90	120	150	90-90	90-120	120-150	90	120	150
	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP	DAP
T ₁	0.73	1.08	1.59	30.02	37.70	47.09	0.0509	0.0270	0.0200	2.28	2.37	2.86	0.0173	0.0078	0.0060
T ₂	0.74	1.23	1.88	6.89	26.37	36.44	0.0473	0.0380	0.0244	1.72	2.41	2.91	0.0167	0.0098	0.0067
T ₃	0.74	1.26	1.82	17.57	32.71	39.61	0.0519	0.0263	0.0264	2.08	2.12	3.58	0.0245	0.0088	0.0082
T ₄	0.37	0.80	1.18	19.72	35.52	42.80	0.0669	0.0454	0.0284	2.18	2.70	3.07	0.0249	0.0101	0.0066
T ₅	0.62	0.95	1.45	11.22	32.56	40.51	0.0459	0.0392	0.0278	1.68	2.69	3.36	0.0215	0.0117	0.0076
T ₆	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T ₇	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
SEm±	0.03	0.091	0.125	0.65	1.09	1.13	0.0025	0.0024	0.0027	0.11	0.12	0.34	0.00095	0.00061	0.00076
CD _{0.05}	0.12	0.295	0.407	2.10	3.55	3.67	0.0083	0.0080	NS	0.37	0.38	NS	0.00311	0.00198	NS

DAP= Days after planting

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Table 4. Effect of intercropping on yield of elephant foot yam and spice crops

Treatment	Corm yield (tons/ha)	Rhizome wight (g/plant)
T ₁	13.02	—
T ₂	07.17	334.44
T ₃	11.27	264.44
T ₄	11.73	195.56
T ₅	07.20	204.56
T ₆	—	264.22
T ₇	—	234.44
SEm±	0.55	17.03
CD _{0.05}	1.78	55.54

significantly higher than the other treatments and was significantly reduced when intercropped with turmeric/ginger and the observation is in line with the findings of Daellenbach et al (2005). Higher biological yield than the economical yield could be the reason for this reduction.

Yield of elephant foot yam and spice crops

In respect of the EFY corm yield (Table 4) experimental results showed significant differences among the different intercropping systems. Maximum corm yield (13.02 tons/ha) was recorded from EFY sole crop which was significantly higher than the rest of the treatments. Among the intercropped treatments maximum yield (11.73 tons/ha) was recorded in EFY with single row of ginger and minimum corm yield of EFY (7.17 tons/ha) in EFY with single row of turmeric was due to high biological yield.

Whereas higher rhizome weight of the intercrop has been recorded in the EFY intercropped with single row of turmeric (334.44 g/plant). On the other hand the lowest rhizome weight of intercrops was recorded in single row planting of ginger (195.56 g/plant).

Higher rhizome weight of turmeric in single row planting could be due to minimum intra-specific competition. Poor yield performance of EFY in intercropped treatments may be due to simultaneous structural growth and corm/rhizome development between EFY and intercrops (turmeric/ginger) and thus demands simultaneous supply of assimilates to both sinks which may lead to intensive competition between the two sinks resulting in less synthesis of food material and poor development of corm in term of yield and yield attributes. These findings are analogous to Osundare and Agboola

(2003), Amanullah et al (2006a) and Amanullah et al (2006b) in cassava and Chattopadhyay et al (2008) in EFY.

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