Journal of Root Crops, 2013, Vol. 39 No. 1, pp. 67-72
Indian Society for Root Crops
ISSN 0378-2409

Growth and Yield of Arrowroot Intercropped in Coconut Garden as Influenced by Organic Management

O. K. Swadija, V. B. Padmanabhan and Vijayaraghavakumar

College of Agriculture, Vellayani, Thiruvananthapuram 695 522, Kerala, India
Corresponding author: O. K. Swadija, e-mail: okswadija@yahoo.com
Received: 7 May 2013; Accepted: 27 June 2013

Abstract

Field experiments were conducted during 2007-2008 and 2008-2009 in the identified five panchayats, viz., Parassala, Pallichal, Kattakkada, Poovachal and Pullempara in the Western Ghat region of Thiruvananthapuram district for deriving an organic nutrient schedule for sustained yield of arrowroot (*Maranta arundinacea* L.) intercropped in coconut garden. Seven treatments were laid out in randomized block design with three replications. The treatments consisted of FYM @ 10 t ha^{-1}, 15 t ha^{-1} and 10 t ha^{-1} + organic sources to substitute NPK @ 50: 25:75 kg ha^{-1} each with and without biofertilizers (*Azospirillum* and phosphobacteria) along with absolute control. The results indicated that arrowroot can be profitably intercropped in coconut gardens. Higher rhizome yield (18.62 t ha^{-1}), net income (` 74,450 ha^{-1}) and benefit:cost ratio (1.99) could be obtained by the application of FYM @ 15 t ha^{-1} + biofertilizers.

Key words: West Indian arrowroot, organic management, biofertilizers, rhizome yield, net income, benefit:cost ratio

Introduction

West Indian arrowroot (*Maranta arundinacea* L.) is an under-exploited tuber crop, the rhizomes of which are valued as food stuff and a source of starch. The rhizome contains 25-30% starch (CSIR, 1962). Arrowroot starch is used for the preparation of bakery products especially biscuits, as a base for face powder, in the preparation of specialized glues and in the manufacture of carbonless paper for computer printouts (CTCRI, 1996). The starch possesses demulcent and anti-diarrhoeal properties and is used in the treatment of intestinal disorders which adds medicinal value to the crop. The crop comes up well under shaded conditions and no serious pests and diseases are noted in the crop. Extraction of starch can be done even in households by adopting a simple procedure. It serves as a raw material for cottage industry by unemployed women and rural youth. It is in this context that the potential of this under-exploited crop should be evaluated. Realizing the need for organic production of arrowroot, an investigation was undertaken to derive an organic nutrient management schedule for sustained yield of arrowroot intercropped in coconut.

Materials and Methods

The field experiments were conducted during June-March of 2007-2008 and 2008-2009 in the identified five panchayats, viz. Parassala, Pallichal, Kattakkada, Poovachal and Pullempara in the Western Ghat region of Thiruvananthapuram district. Arrowroot was intercropped in the inter spaces of middle aged coconut palms var. West Coast Tall with 60-65% shade. The present nutrient recommendation for arrowroot intercropped in coconut is farmyard manure (FYM) @ 10 t ha^{-1} along with NPK @ 50:25:75 kg ha^{-1} (Suja et al., 2006). Hence seven treatments as detailed below

were applied at each location in randomized block design with three replications.

T_1 : FYM @ 10 t ha^{-1}

T_2 : FYM @ 10 t ha^{-1} + biofertilizers (*Azospirillum* + phosphobacteria @ 3 kg ha^{-1} each)

T_3 : FYM @ 15 t ha^{-1}

T_4 : FYM @ 15 t ha^{-1} + biofertilizers (*Azospirillum* + phosphobacteria @ 3 kg ha^{-1} each)

T_5 : FYM @ 10 t ha^{-1} + organic sources to substitute NPK @ 50:25:75 kg ha^{-1}

(i.e., FYM @ 20 t ha^{-1} + rock phosphate (RP) @ 25 kg ha^{-1} + wood ash (WA) @ 2 t ha^{-1})

T_6 : T_5 + biofertilizers (*Azospirillum* + phosphobacteria @ 3 kg ha^{-1} each)

T_7 : Control (no manure, no biofertilizer)

The rhizomes for planting were procured from Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India. Before the experimentation, soil samples were collected from all locations and analysed for physico-chemical properties using standard procedures (Jackson, 1973). The soils were acidic with medium to high organic C, medium available N and K and high available P contents (Table 1). The quantities of organic manures were fixed based on nutrient analysis. Farmyard manure contained 0.5% N, 0.2% P_2O_5 and 0.3% K_2O, while wood ash (WA) contained 0.2% N, 0.3% P_2O_5 and 2.4% K_2O and the rock phosphate (RP) contained 20% P_2O_5.

The required quantities of FYM, rock phosphate and biofertilizers as per treatments were applied as basal dose. The rhizome pieces of 15-20 g were planted on raised beds at a spacing of 30 cm x 15 cm and mulched with dry leaves @ 15 t ha^{-1} (Suja and Nayar, 2005). Wood ash was supplied along with the first intercultural operation and earthing up at two months after planting. The second weeding and earthing up were done four months after planting.

Observations on growth characters such as plant height, number of suckers and leaves per plant and leaf area (punch method) were recorded at peak vegetative stage of the crop (5-6 months after planting). The crop was harvested nine months after planting during both the years at all locations and the rhizome yield was recorded. At harvest, samples of plant and rhizomes were collected for estimation of dry matter production. The economics of cultivation was worked out by calculating the total cost of cultivation and gross returns from the cost of inputs and labour and price of rhizome, which prevailed during those periods. The experimental data were analysed statistically by applying the analysis of variance technique (ANOVA) for randomized block design with seven treatments and three replications at five locations (Cochran and Cox, 1965).

Results and Discussion

Growth characters

In general, growth characters like plant height, number of suckers and leaves per plant and leaf area index showed an increasing trend with increase in the dose of organic manures during both the years and also in the pooled analysis (Table 2). Application of even 10 t ha^{-1} of FYM could produce significantly taller plants with more number of suckers and leaves per plant and greater leaf area index over absolute control. The favourable effects of application of FYM on growth characters of arrowroot have been reported by Veenavidyadharan and Swadija (2000). Significantly taller plants were produced by FYM @ 20 t ha^{-1} + RP @ 25 kg ha^{-1} + WA @ 2 t ha^{-1} along with biofertilizers (T_6). The pooled data also revealed

Table 1. Physico-chemical properties of the soil before the experiment at different locations

Location	Soil type	pH	Organic C (%)	Available N	Available P (kg ha^{-1})	Available K
Parassala	silty clay loam	4.9	0.8	313.6	54.8	127.8
Pallichal	loam	4.9	0.7	388.8	24.6	127.8
Kattakkada	loamy sand	6.0	0.8	388.8	25.8	112.0
Poovachal	clay loam	4.5	0.9	426.0	43.7	168.0
Pullampara	silty loam	5.1	0.9	427.2	54.8	224.0

Table 2. Growth characters of arrowroot intercropped in coconut as influenced by organic management

Treatments	Plant height (cm)			Number of suckers per plant			Number of leaves per plant			Leaf area index		
	Mean of locations		Pooled mean	Mean of locations		Pooled mean	Mean of locations		Pooled mean	Mean of locations		Pooled mean
	I year	II year		I year	II year		I year	II year		I year	II year	
FYM @ 10 t ha^{-1}	94.00	89.67	91.84	0.97	1.07	1.01	8.43	8.10	8.27	3.63	3.65	3.64
FYM @ 10 t ha^{-1} + biofertilizers	105.90	91.23	98.57	1.17	1.13	1.15	9.57	8.60	9.08	4.09	3.87	3.98
FYM @ 15 t ha^{-1}	106.00	94.30	100.15	1.23	1.43	1.33	9.63	8.70	9.20	4.04	4.08	4.06
FYM @ 15 t ha^{-1} + biofertilizers	108.30	95.97	102.13	1.47	1.53	1.50	11.03	9.70	10.37	4.79	4.27	4.54
FYM @ 20 t ha^{-1} + RP @ 25 kg ha^{-1} + WA @ 2 t ha^{-1}	108.20	92.90	100.55	1.50	1.57	1.53	10.03	10.68	10.36	4.68	4.28	4.47
FYM @ 20 t ha^{-1} + RP @ 25 kg ha^{-1} + WA @ 2 t ha^{-1} + biofertilizers	113.80	102.37	108.09	1.73	1.57	1.68	10.63	11.23	10.93	4.85	4.77	4.81
Control	78.80	77.53	78.17	0.73	0.83	0.78	6.67	7.07	6.87	2.91	3.00	2.96
CD(0.05)	4.953	7.31	7.80	0.277	0.252	0.161	0.779	0.934	0.673	0.303	0.388	0.262

FYM: Farmyard manure; RP: Rock phosphate; WA: Wood ash

that the effects of treatments, T_4, T_5 and T_6 were on par indicating the sufficiency of FYM @ 15 t ha^{-1} + biofertilizers (T_4) for producing optimum height of plants. The greatest sucker number was produced by T_6 during both the years, on par with T_4. The pooled data indicated the sufficiency of 15 t ha^{-1} of FYM for reasonable sucker production. During the first year, greater number of leaves was produced by FYM @ 15 t ha^{-1} + biofertilizers and during the second year by FYM @ 20 t ha^{-1} + RP @ 25 kg ha^{-1} + WA @ 2 t ha^{-1} + biofertilizers. The pooled data revealed the sufficiency of FYM @ 15 t ha^{-1} + biofertilizers for greater leaf production. The highest leaf area index was produced by T_6 during the first year, which was on par with T_5 and T_4 and by T_6 during the second year. The pooled data also showed significantly higher leaf area index due to the treatment T_6.

Rhizome yield

The rhizome yield of arrowroot intercropped in coconut was significantly influenced by organic management during both the years (Table 3). In general, the rhizome yield was higher during the second year. During both the years, application of even the lowest dose of FYM (10 t ha^{-1}) produced significantly higher rhizome yield over control (no manure, no biofertilizer treatment) at all locations. Pooled analysis of the data indicated that FYM @ 10 t ha^{-1} (15.46 t ha^{-1}) could produce 46% higher rhizome yield over control (10.59 t ha^{-1}). The rhizome yield increased when the level of FYM increased from 10 t ha^{-1} to 15 t ha^{-1} during both the years. Maheswarappa et al. (1987) and Veenavidyadharan and Swadija (2000) have reported the favourable effect of FYM application for enhanced yield of arrowroot intercropped in coconut garden.

Table 3. Rhizome yield of arrowroot intercropped in coconut at different locations as influenced by organic management

Treatments	Rhizome yield at different locations (t ha^{-1})												
	Parassala		Pallichal		Kattakkada		Poovachal		Pullempara		Mean		Pooled Mean
	I year	II year	I year	II year	I year	II year	I year	II year	I year	II year	I year	II year	
FYM @ 10 t ha^{-1}	14.55	23.21	12.16	17.83	12.63	13.69	11.77	18.23	11.57	18.93	12.54	18.38	15.46
FYM @ 10 t ha^{-1} + biofertilizers	14.81	23.58	14.43	18.71	14.33	14.04	11.79	19.61	13.26	20.29	13.73	19.25	16.49
FYM @ 15 t ha^{-1}	14.66	23.06	14.34	18.53	15.49	14.58	14.59	22.51	14.92	22.00	14.81	20.14	17.47
FYM @ 15 t ha^{-1} + biofertilizers	15.68	23.47	15.62	19.34	16.86	16.10	15.68	23.13	15.05	25.19	15.78	21.45	18.62
FYM @ 20 t ha^{-1} + RP @ 25 kg ha^{-1} + WA @ 2 t ha^{-1}	16.66	23.21	15.47	19.19	15.65	14.93	14.07	23.73	14.48	25.40	15.27	21.29	18.28
FYM @ 20 t ha^{-1} + RP @ 25 kg ha^{-1} + WA @ 2 t ha^{-1} + biofertilizers	19.04	24.02	15.86	19.63	16.61	16.12	15.81	24.15	15.17	26.99	16.50	22.18	19.34
Control	9.97	12.79	9.41	13.70	9.35	9.59	8.58	12.49	8.88	11.16	9.24	11.94	10.59
CD(0.05)											1.114	1.408	0.880

FYM: Farmyard manure; RP: Rock phosphate; WA: Wood ash

Application of biofertilizers (*Azospirillum* and phosphobacteria) increased the rhizome yield over respective treatments without biofertilizers during both the years, which resulted in significant increase in yield in the pooled analysis also. During both the years, the highest rhizome yield was obtained from the treatment, FYM @ 20 t ha^{-1} + RP @ 25 kg ha^{-1} + WA @ 2 t ha^{-1} + biofertilizers, but failed to produce significant increase in yield over FYM @ 15 t ha^{-1} + biofertilizers. The pooled analysis of the data also showed the same trend indicating the sufficiency of application of FYM @ 15 t ha^{-1} along with biofertilizers for getting higher rhizome yield from arrowroot intercropped in coconut garden. Veenavidyadharan and Swadija (2000) also obtained higher yields of intercrop of arrowroot with medium level of FYM (15 t ha^{-1}) among the three levels of FYM tried (10, 15 and 20 t ha^{-1}).

Dry matter production

There was not much variation in dry matter production among the various treatments during the first and second years (Table 4). During the first year, significantly greater dry matter was produced by FYM @ 15 t ha^{-1} + biofertilizers. During the second year, highest dry matter was obtained due to the application of FYM @ 20 t ha^{-1} + RP @ 25 kg ha^{-1} + WA @ 2 t ha^{-1} + biofertilizers, which was on par with FYM @ 10 or 15 t ha^{-1} + biofertilizers. The effects of biofertilizers were significant along with 10 or 15 t ha^{-1} of FYM. The pooled data indicated the sufficiency of FYM @15 t ha^{-1} + biofertilizers for higher dry matter production in arrowroot intercropped in coconut.

Harvest index

There was significant improvement in harvest index during the second year due to the various treatments (Table 4). Harvest index was maximum due to the application of FYM @ 20 t ha^{-1} + RP @ 25 kg ha^{-1} +

Table 4. Dry matter production and harvest index of arrowroot intercropped in coconut as influenced by organic management

Treatments	Dry matter production (kg ha^{-1})			Harvest index		
	Mean of locations		Pooled mean	Mean of locations		Pooled mean
	I year	II year		I year	II year	
FYM @ 10 t ha^{-1}	6395	6491	6443	0.50	0.71	0.60
FYM @ 10 t ha^{-1} + biofertilizers	7503	8085	7794	0.51	0.74	0.62
FYM @ 15 t ha^{-1}	8273	7178	7726	0.48	0.76	0.62
FYM @ 15 t ha^{-1} + biofertilizers	8672	8542	8607	0.51	0.78	0.64
FYM @ 20 t ha^{-1} + RP @ 25 kg ha^{-1} + WA @ 2 t ha^{-1}	8103	7726	7915	0.50	0.78	0.64
FYM @ 20 t ha^{-1} + RP @ 25 kg ha^{-1} + WA @ 2 t ha^{-1} + biofertilizers	8446	8600	8523	0.53	0.79	0.66
Control	5473	4244	4859	0.37	0.70	0.54
CD(0.05)	371.9	835.3	2828.1	0.036	0.024	0.022

FYM: Farmyard manure; RP: Rock phosphate; WA: Wood ash

WA @ 2 t ha^{-1} + biofertilizers during both the years, but this was on par with application of FYM @ 10 or 15 t ha^{-1} + biofertilizers during the first year and application of FYM @ 15 t ha^{-1} + biofertilizers during the second year (Table 4). The pooled data also showed significant effect of application of biofertilizers along with 10 or 15 t ha^{-1} of FYM. The pooled mean of harvest index was the highest with application of FYM @ 20 t ha^{-1} + RP @ 25 kg ha^{-1} + WA @ 2 t ha^{-1} + biofertilizers, but was on par with the same treatment without biofertilizers and FYM @15 t ha^{-1} + biofertilizers, indicating the sufficiency of the treatment FYM @ 15 t ha^{-1} + biofertilizers for getting higher harvest index.

Economic analysis

Economic analysis of the data revealed the superiority of application of even the lowest dose of FYM (10 t ha^{-1}) over control for getting higher returns (` 51,160 ha$^{-1}$ as against ` 15, 740 ha^{-1} for control) from arrowroot intercropped in coconut garden (Table 5). The net returns nearly doubled during the second year than those

Table 5. Economic analysis of organic management of arrowroot intercropped in coconut

Treatments	Net returns (` ha^{-1})			Benefit : cost ratio		
	Mean of locations		Pooled mean	Mean of locations		Pooled mean
	I year	II year		I year	II year	
FYM @ 10 t ha^{-1}	32788	69530	51160	1.49	1.89	1.69
FYM @ 10 t ha^{-1} + biofertilizers	40923	76270	58590	1.62	1.98	1.80
FYM @ 15 t ha^{-1}	49187	81580	65380	1.71	2.03	1.87
FYM @ 15 t ha^{-1} + biofertilizers	56769	92130	74550	1.82	2.16	1.99
FYM @ 20 t ha^{-1} + RP @ 25 kg ha^{-1} + WA @ 2 t ha^{-1}	46978	85180	66080	1.63	2.00	1.81
FYM @ 20 t ha^{-1} + RP @ 25 kg ha^{-1} + WA @ 2 t ha^{-1} + biofertilizers	56619	92120	74370	1.75	2.08	1.91
Control	9909	21570	15740	1.16	1.29	1.22
CD(0.05)	8798	11071	7088	0.130	0.136	0.094

FYM: Farmyard manure; RP: Rock phosphate; WA: Wood ash

during the first year. This was due to higher rhizome yield during the second year. Application of biofertilizers increased net returns during both the years and significant effect was observed in the pooled data also. The highest net returns was obtained due to the application of FYM @ 15 t ha^{-1} + biofertilizers, which was on par with application of FYM @ 20 t ha^{-1} + RP @ 25 kg ha^{-1} + WA @ 2 t ha^{-1} + biofertilizers during both years. Pooled analysis also indicated similar trend.

Application of biofertilizers increased benefit : cost ratio at all levels of organic manure during both the years and significant effect was observed in the pooled data (Table 5). The highest benefit : cost ratio was obtained from FYM @ 15 t ha^{-1} + biofertilizers during both the years. The pooled analysis indicated that the highest benefit : cost ratio was obtained due to the application of FYM @ 15 t ha^{-1} + biofertilizers, which was on par with the application of FYM @ 20 t ha^{-1} + RP @ 25 kg ha^{-1} + WA @ 2 t ha^{-1} + biofertilizers showing the same trend as that of net returns.

Conclusion

The results indicated that arrowroot can be profitably intercropped in coconut gardens. Higher rhizome yield (18.62 t ha^{-1}), net income (` 74,450 ha^{-1}) and benefit cost ratio (1.99) could be obtained by the application of FYM @ 15 t ha^{-1} + biofertilizers (*Azospirillum* and phosphobacteria @ 3 kg ha^{-1} each).

Acknowledgement

The authors acknowledge the financial support received from the Government of Kerala under Western Ghat Development Programme and the Kerala Agricultural University for providing the facilities for the study.

References

Cochran, W.G. and Cox, G.M.1965. *Experimental Designs*. Asia Publishing House, Bombay, 204 p.

CSIR. 1962. *The Wealth of India-Raw Materials.* Council of Scientific and Industrial Research, New Delhi, India, **6**:302-304.

CTCRI. 1996. *Technologies for Better Crops- Yam bean, Coleus, Arrowroot, Colocasia (Dasheeen) and Xanthosoma*. Central Tuber Crops Research Institute, Thiruvananthapuram. p. 15.

Jackson, M.L. 1973. *Soil Chemical Analysis*. Prentice Hall of India (Pvt.) Ltd., New Delhi. 498 p.

Maheswarappa, H.P., Nanjappa, H.V. and Hegde, M.R. 1997. Influence of sett size, plant population and organic manures on yield components, yield and qualitative characters of arrowroot grown as intercrop in coconut garden. *J. Root Crops*, **23**(2): 131-137.

Suja, G. and Nayar, T.V.R. 2005. Biomass distribution pattern in arrowroot (*Maranta arundinacea* L.) as influenced by plant density and mulching. *J. Root Crops*, **31**(1): 28-33.

Suja, G., Nayar, T.V.R. and Ravindran, C.S. 2006 Influence of nutrient management in arrowroot (*Maranta arundinacea* L.) on biomass production, nutrient uptake and soil nutrient status. *J. Root Crops*, **32**(2): 162-165.

Veenavidyadharan and Kumari Swadija, O. 2000. Effect of varying levels of farmyard manure, nitrogen and potassium on the yield of arrowroot under partial shade. *J. Root Crops*, **26**(2): 84-86.