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Effect of plant density and mulching on growth and yield of arrowroot *(Maranta arundinacea* L.)

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Abstract: Field experiments were conducted during May-February in 1996-97 and 1997-98 at Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram to study the effect of spacing and mulching on growth, yield and economics of cultivation of arrowroot. Widest spacing (60 x 30 cm) favoured vegetative growth profoundly at all stages in both the years. Mulching using any of the materials *viz.*, green leaves, dried leaves or coconut fronds promoted the canopy size and leaf production. Mulching regardless of the material used, significantly promoted rhizome weight in both the years and number of rhizomes in the second year and ultimately proved beneficial for realizing significantly higher rhizome yield. Closer spacing of 30 x 15 cm produced significantly higher rhizome yield. Planting arrowroot at a spacing of 30 x 15 cm to accommodate 2,20,000 plants ha^{-1} and mulching using green leaves generated maximum net return and benefit cost ratio due to production of high rhizome yield.

Key words : Arrowroot, Plant density, Mulches, Growth, Rhizome yield, Rhizome weight, Rhizome number, Net return, Benefit Cost Ratio.

Introduction

In order to meet the growing food requirements it has become imperative to exploit the lesser-known plant resources. The established tuber crops are better known, have assured markets and risks in growing them are better understood. In contrast, minor tuber crops and their markets are mostly underdeveloped. The focus of scientific attention on a particular minor tuber crop depends on the availability of land races which can adapt relatively quickly, possess an ability to fit well into cropping systems and capability of giving high yield of acceptable products. Out of a number of minor tuber crops, arrowroot has been identified to be very potential. However, little information is available on the agronomic requirements to realize its production potential.

Arrowroot (*Maranta arundinacea* L.) is primarily grown for its quality starch, which is valued as a foodstuff, particularly for infants and invalids. The starch is often used as a thickener in all kinds of foods, dressings, soups, sauces, candies, cookies and desserts like puddings and ice-creams. Industrially, processed rhizome pulp is applied in the manufacture of paper, cardboard, cushions and wallboards and the starch as basic ingredient of powders, glues and soap. Arrowroot starch possesses demulcent properties and is used in the treatment of intestinal disorders. It is also employed in the preparation of barium meals and in the manufacture of tablets. The rhizomes are also a good substitute for maize in broiler rations. The fibrous debris after starch extraction, is used as feed and manure (Kay,1987; Villamayor and Jukeme,1996). In spite of the wide applications of arrowroot starch, it is mostly left as an unexploited crop in the homesteads with little care and management. Considering the economic importance of arrowroot starch, the present investigation was taken up to study the effect of spacing and mulching on growth and yield of arrowroot.

Table 1. Effect of spacing and mulching on growth attributes of arrowroot

Treatments	Plant height (cm)						No.of leaves					
	96-97			96-97			96-97			96-97		
	Months after planting						Months after planting					
	3	5	7	3	5	7	3	5	7	3	5	7
Spacing												
30 x 15 cm	43.52	63.73	72.23	78.35	91.10	97.67	10.85	14.45	18.50	13.08	24.21	29.17
45 x 20 cm	45.56	69.15	76.71	76.65	98.94	106.35	12.10	18.38	22.81	13.85	33.13	38.27
60 x 30 cm	48.83	69.88	81.63	77.00	99.98	106.25	14.63	26.40	33,23	18.40	34.38	38.69
Mulches												
Green leaves	52.64	72.00	83.89	87.11	105.53	112.89	13.28	22.92	28.44	15.50	34.44	39.31
Dried leaves	45.72	64.11	75.76	82.11	101.58	109.86	12.31	19.00	23.00	17.31	29.19	34.75
Coconut fronds	48.81	74.36	83.75	84.19	96.39	103.94	12.83	21.47	27.81	15.89	28.81	34.69
Control	36.72	59.86	64.01	55.92	83.19	87.00	11.69	15.58	20.14	11.75	29.83	32.75
CD (0.05)												
Spacing	NS	NS	NS	NS	NS	NS	NS	4.453	4.504	2.917	7.257	7.056
Mulches	6.278	10.295	11.838	13.29	12.252	15.568	2.222	5.142	5.201	3.368	NS	NS

Materials and Methods

Field experiments were conducted at Central Tuber Crops Research Institute (CTCRI), Sreekariyam, Thiruvananthapuram during May-February in 1996-97 and 1997-98. The soil of the experimental site is classed as an acid ultisol (pH 4.35). The soil was rated as low for available N (90.32 kg ha^{-1}) and K (107.52 kg ha^{-1}) and medium for available P (18.76 kg ha^{-1}). The test site experiences a typical humid tropical climate with mean annual rainfall of 1874.20 mm. The experiment was laid out as a factorial experiment in randomised block design (FRBD) with 12 treatments, comprising possible combinations of 3 spacing (S_1 : 30 x 15 cm (2,20,000 plants ha^{-1}); S_2 : 45 x 20 cm (1,10,000 plants ha^{1}) and S_3 : 60 x 30 (55,000 plants ha^{-1}) and 3 mulches (m_1 : green leaves; m_2 : dried leaves; ma: coconut fronds) along with a no mulch control (m_0). The treatments were replicated thrice. A promising selection of arrowroot from the germplasm collection of CTCRI (Ar.l) was used for the study. The crop was planted during May under partial shade (in the interspaces of mature coconut palms causing 40-45% shade) taking advantage of the bimodal rainfall received at the location.

Rhizome pieces of size 20-25g were planted on raised flat beds (2 x $1m^2$) at the

Table 2. Effect of spacing and mulching on yield attributes and yield of arrowroot

Treatments	No.of rhizomes plant^{-1}			Mean rhizome weight (g)			Fresh rhizome yield (t ha^{-1})		
	96-97	97-98	Mean	96-97	97-98	Mean	96-97	97-98	Mean
Spacing									
30 x 15 cm	4.72	6.36	5.34	36.68	46.17	41.43	39.03	51.31	45.17
45 x 20 cm	4.56	6.16	5.36	42.60	47.51	45.06	21.82	32.42	27.12
60 x 30 cm	5.32	5.98	5.65	41.12	49.93	45.53	12.26	15.58	13.92
Mulches									
Green leaves	5.51	6.41	5.96	43.76	50.85	47.31	29.86	39.79	34.83
Dried leaves	4.77	6.98	5.88	44.68	51.33	48.01	26.37	36.19	31.28
Coconut fronds	5.27	6.76	6.02	41.42	48.37	44.89	26.25	32.84	29.55
Control	3.91	4.51	4.21	30.68	40.92	35.80	14.99	23.58	19.29
CD (0.05)									
Spacing	NS	NS		NS	NS		9.288	4.63	
Mulches	NS	1.72		8.476	7.689		10.725	5.346	

Table 3. Physical characters of soil as influenced by various mulches.

Mulches	Apparent specific gravity (g cm^{-3})		Absolute specific gravity (g cm^{-3})		Maximum water holding capacity		% pore space	
	96-97	97-98	96-97	97-98	96-97	97-98	96-97	97-98
Green leaves	1.33	1.32	1.73	1.73	24.23	24.25	30.18	31.25
Dried leaves	1.37	1.36	1.64	1.62	26.02	27.25	32.59	32.70
Coconut fronds	1.40	1.38	1.95	1.95	24.31	24.85	32.94	33.00
Control	1.39	1.39	1.92	1.92	22.76	22.50	29.45	29.75

specified spacing and mulched with the various materials in accordance to the treatment combinations. Green leaves and dried leaves were mulched @ 15 t ha^{-1}. FYM @10 t ha^{-1} and fertilizers to provide 50:25:50 kg ha^{-1} of N, P_2O_5 and K_2O were applied. FYM and whole of P_2O_5 were given at the time of planting. Half the dose of N and K was applied one month after planting. After one month the remaining dosage of N and K were applied along with weeding and earthing up.

Biometric measurements were taken from five plants at 3, 5 and 7 months after planting (MAP). Observations on fresh rhizome yield and yield components were recorded at the time of harvest. Total cost of cultivation and gross returns were calculated from average input

cost and average market price of the produce during the period of investigation. Based on these, net return and benefit cost ratio were computed.

Results and Discussion

Growth characters

Spacing could not significantly influence the plant height at all stages of observation in both the years. In general, wider spacing resulted in taller plants due to less competition for resources. Mulching using any of the materials significantly promoted the canopy size (Table 1). Widest spacing favoured the leaf production profoundly at all occasions in both the years due to greater capture and efficient use of resources. Maheswarappa *et al.* (1999) also noticed that arrowroot plants were taller and with more leaves when intercropped at lower plant density in coconut garden. The significant effect of mulches on leaf production was conspicuous during the first year of experimentation. At most stages, mulching with green leaves produced more foliage (Table 1). It is well known that mulching stimulates crop growth by conserving soil moisture, suppressing weed growth and maintaining soil temperature. In general, spacing and mulches could not significantly affect the sucker production in arrowroot. However, sucker production was favoured as spacing widened. None of the growth characters were significantly influenced by the combined effect of spacing and mulching.

Yield components and yield

Yield attributes were not influenced by variations in spacing. It is noteworthy that mulching regardless of the materials used, significantly promoted the mean rhizome weight in both the years and number of rhizomes in the second year (Table 2). The variation in fresh rhizome yield due to different spacing and mulches were significant (Table 2). Planting at a spacing of 30x 15 cm produced significantly higher rhizome yield in both the years solely due to the effect of high plant population (2,20,000 plants ha^{-1}). Rajagopalan *et al.* (1992) and Maheswarappa *et al.* 1997) reported maximum fresh rhizome yield of arrowroot at closer spacing of 30x30 cm. Mulching using any of the materials proved beneficial for realizing significantly higher rhizome yield and enhanced yield by 65.30% over control. This can be attributed to the slight improvement in the physical properties of soil *viz.* water holding capacity, porosity and specific gravity by mulching (Table 3). The effect of mulching in enhancing yield in ginger has been reported by several workers (Randhawa and Nandpuri, 1970; Gupta and Awasthi, 1997; Babu and Jayachandran, 1997). Higher tuber yields from mulched plots due to improvement in physical properties have been reported previously in ginger (Muralidharan, 1973) and turmeric (Rao *et al.* 1975; Rao, 1979). In the present study though the interaction between spacing and mulching was not significant in the first year, in the second year closely spaced crop (30x15 cm) mulched with green leaves resulted in significantly highest rhizome yield. Further the highest average yield of 57.58 t ha^{-1} was also recorded for the above treatment combination (Table 4).

Economic analysis

Planting arrowroot at a spacing of 30 x 15 cm to accommodate 2,20,000 plants ha^{-1} and mulching using green leaves generated maximum net return (Rs.56760 ha^{-1}) and BCR of 1.97 due to production of high rhizome yield (Table 4). Maintaining the same plant density and mulching using dried leaves proved the next best viable option with a profit of Rs.38500 ha^{-1} and a BCR of 1.66.

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Table 4. Economics of cultivation of arrowroot as influenced by plant density and mulching

Treatments	Rhizome yield (t ha^{-1})	Net return (Rs. ha^{-1})	Benefit cost ratio (BCR)
30x15 cm (Green leaves)	57.58	56760.00	1.97
30x15 cm (Dried leaves)	48.45	38500.00	1.66
30x15 cm (Coconut fronds)	44.34	27130.00	1.44
30x15 cm (Control)	30.33	9760.00	1.19
45x20 cm (Green leaves)	30.41	13670.00	1.29
45x20 cm (Dried leaves)	29.68	12210.00	1.26
45x20 cm (Coconut fronds)	28.58	6860.00	1.14
45x20 cm (Control)	19.81	-30.00	0.99
60x30 cm (Green leaves)	16.49	-10060.00	0.77
60x30 cm (Dried leaves)	15.72	-11600.00	0.73
60x30 cm (Coconut fronds)	15.73	-14730.00	0.68
60x30 cm (Control)	7.74	-20060.00	0.44

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