Indian Journal of Agronomy 45 (4) : 698–706 (December 2000)

Dry-matter production and accumulation in different parts of galangal (*Kaempferia galanga*) as influenced by agronomic practices when grown as an intercrop in coconut garden

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Received: March 1999

ABSTRACT

A field experiment was conducted to study the response of galangal (*Kaempferia galanga* L.), grown as intercrop, to agronomic practices in coconut garden during 1995–98. The chlorophyll and carotenoid content did not differ significantly when mother rhizome and finger rhizome used as planting material. Plant population levels of 333,000 and 500,000/ha had the same effect with respect to chlorophyll and carotenoid contents. Organic manures like farmyard manure (FYM), vermicompost (VC) and combination of FYM + NPK and NPK applied alone had significantly higher chlorophyll and carotenoid content. The total dry-matter production increased significantly when mother rhizome, with 333,000/ha population, was used as planting material. Among organic manure treatments, FYM, VC and FYM+NPK significantly contributed to the increase in dry matter compared to composted coir pith (CCP) and NPK treatments. Fresh-rhizome yield was significantly superior with mother rhizome and with 500,000 population level. FYM + NPK combination recorded significantly higher fresh-rhizome yield. The harvest index improved significantly with mother rhizome treatment and at 333,000/ha population. Among organic manures, FYM, VC, FYM+NPK and NPK improved harvest indices compared to CCP and control treatments.

Key words : Coconut, Galangal, Intercrop, Dry matter, Organic manures, Yield

The possibility of expanding the land area under cultivations is limited, therefore intensive cultivation of crops for raising the productivity per unit area is one of the viable options for increasing food production.

A part of Ph. D. thesis submitted by first author to University of Agricultural Sciences

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Galangal is an important medicinal-cum-aromatic herbaceous plant. It is a new crop found to grow well under shade, and reported work on agronomic practices to acheieve maximum production when grown as an intercrop in coconut gardens is meagre. In this view, a field investigation was undertaken to study the influence of agronomic practices on dry-matter production, its accumulation in different parts and yield of fresh rhizomes of galangal when grown as an intercrop in coconut garden.

MATERIALS AND METHODS

The experiment was carried out during the wet season of 1995–98 at the Central Plantation Crops Research Institute, Kasaragod (12°30' N, 75°00 'E, with an elevation of 10.7 m above mean sea-level).

The CPCRI , Kasaragod, has an average annual rainfall of 3,401 mm. Of the total rainfall, 75% is received between June and August. The maximum temperature ranges between 28.8°C and 32.4°C, while the minimum temperature varies from 19.4°C to 24.2°C. The relative humidity remains between 81 and 94%.

The experimental location had red sandy loam soil with coarse sand varying between 75.6 and 77.6% fine sand, 4.0 and 4.6% silt, 3.0 and 3.8% clay and 14.8 and 16.6%. The field capacity of the soil at 0–25 cm and 25–50 cm depths were 7.4 and 8.9% respectively. The permanent wilting values were 4.2 and 4.4% respectively for the 2 depths. The bulk density of the soil for 0–25 cm and 25–50 cm depths were 1.55 and 1.45 g/cc respectively. The soil was acidic (pH 5.0), with an electrical conductivity of 0.04 dS/m at 25°C. The soil had low available N and K and high available P. The organic carbon content was relatively low (0.21% at 0–25 cm depth and 0.18% at 25–50 cm depth), with CEC of 3.5 C mol (p+)/kg soil.

The experiment was laid out in split-plot design with 3 replications. The types of planting material and plant population levels formed the main plot treatments, viz. mother rhizome with 333,000 population/ha (S_1P_1), and 500,000 population/ha (S_1P_2), finger rhizome with 333,000 population/ha (S_2P_1) and 500,000 population/ha (S_2P_2). Varying levels of organic manures, viz. farmyard manure (FYM) 24 tonnes/ha (F_1), FYM 32 tonnes/ha (F_2), composted coir pith (CCP) 29 tonnes/ha (F_3), CCP 39 tonnes/ha (F_4), vermicompost (VC) 21 tonnes/ha (F_5), VC 28 tonnes/ha (F_6), FYM (20 tonnes/ha) + NPK (50:50:50 kg/ha) (F_7), NPK (50:50:50 kg/ha) (F_8) and control treatment (F_9) formed the subplot treatments.

The treatments were superimposed in the same plot during the second and third year. The raised beds of 2 m × 1.8 m size were prepared between coconut rows by leaving 2 m radius from the bole of the coconut, thus 77% of the coconut garden was intercropped with galangal. The rhizomes were planted on a raised bed during first week of June (during 1995), second week of May (during 1996) and third week of May (during 1997) and harvested during first week of February (during 1996), third week of January (during 1997) and fourth week of January (during 1998). The intercrop was irrigated from November till harvest. Duration of the

Table 1. Chlorophyll 'a', 'b' and carotenoid (mg/g fresh weight of leaf) contents, total dry matter (g/plant), fresh rhizome yield (tonnes/ha) and harvest index of galangal as influenced by different treatmets (pooled data)

Treatment	Chl. 'a' 150 DAP	Chl.'b' 150 DAP	Carotenoid 150 DAP	Total dry matter 120 DAP	Total dry matter At harvest	Yield	Harvest index
Planting material							
S_1, Mother rhizome	0.559	0.208	0.056	3.79	12.78	4.8	0.620
S_2, Fingher rhizome	0.561	0.220	0.053	3.29	12.44	4.7	0.618
CD (P = 0.05)	NS	NS	NS	0.16	0.09	0.07	0.001
Plant population							
P_1, 333,000/ha	0.590	0.221	0.055	3.38	12.78	4.5	0.622
P_2, 500,000/ha	0.595	0.211	0.058	3.28	12.68	4.8	0.619
CD (P = 0.05)	NS	NS	NS	0.05	0.09	0.07	0.001
Organic manures							
F_1, FYM 24 tonnes/ha	0.709	0.248	0.067	3.86	14.38	5.2	0.636
F_2, FYM 32 tonnes/ha	0.718	0.265	0.073	3.79	14.47	5.2	0.636
F_3, CCP 29 tonnes/ha	0.402	0.145	0.040	2.55	10.66	3.4	0.586
F_4, CCP 39 tonnes/ha	0.405	0.154	0.039	2.68	10.87	3.4	0.586
F_5, VC 21 tonnes/ha	0.707	0.254	0.064	3.89	13.94	5.2	0.631
F_6, VC 28 tonnes/ha	0.718	0.252	0.070	3.88	13.98	5.3	0.630
F_7, FYM (20 tonnes/ha) + NPK (50 : 50 : 50 kg/ha)	0.707	0.277	0.063	3.79	14.24	6.0	0.628
F_8, NPK (50:50:50 kg/ha)	0.716	0.280	0.064	3.56	12.76	4.6	0.634
F_9, Control	0.393	0.134	0.032	2.46	9.89	2.5	0.589
CD (P = 0.05)	0.012	0.007	0.004	0.04	0.15	0.09	0.004

DAP : Days after planting; NS, non-significant

crop was about 8 months.

Observation on growth and yield-attributing characters were taken from 5 labelled plants at different growth stages. The plant samples were collected randomly at different growth stages, compartemented into leaves, root, rhizome and dried at 70°C, and dry weight was recorded. The chlorophyll and carotenoid were estimated (Arnon, 1949). The crop-growth rate was calculated following the procedure of Waston (1952) and the absolute growth rate as per West *et al.* (1920). The fresh-rhizome yield from the net plot (1.7 m × 1.0 m) was recorded (in kg) and was worked out for 1 ha intercrop raised area. The data were subjected to Fisher's method for analysis of variance and interpreted

following the procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Chlorophyll 'a', 'b' and carotenoid content

Chlorophyll and carotenoid content did not differ significantly due to mother or finger rhizome used as planting material and also due to the population levels (Table 1). Chlorophyll 'a', 'b' and carotenoid contents were significantly higher with FYM+NPK, FYM at both the levels, VC at both the levels and NPK when compared to CCP at both the levels and the control. The higher chlorophyll 'a', 'b' and carotenoid contents might be attributed to higher uptake of nutrients due to the treatments resulting in synthesis of chlorophyll 'a', 'b' and carotenoid at higher level.

Dry-matter production and distribution

Dry-matter production/plant with mother rhizome treatment was significantly higher than finger rhizome at both the stages (120 DAP and at harvest) of the crop (Table 1; Fig.1). Plant population @ 333,000/ha had significantly higher dry matter/plant than 500,000/ha population at 120 DAP and the

Table 2. Absolute growth rate (g/plant/day) and crop-growth rate (g/m^2/day) as influenced by different treatments in galangal

Treatment	Absolute growth rate		Crop-growth rate	
	60 DAP–120 DAP	180 DAP–matunity	60 DAP –120 DAP	180 DAP–maturity
Planting material				
S_1, Mother rhizome	0.029	0.086	1.413	3.553
S_2, Finger rhizome	0.024	0.080	0.863	3.340
CD (P = 0.05)	0.001	0.002	0.026	0.096
Plant population				
P_1, 333,000/ha	0.022	0.088	0.656	2.767
P_2, 500,000/ha	0.021	0.088	0.914	4.136
CD (P=0.05)	NS	NS	0.026	0.096
Organic manures				
F_1, FYM 24 tonnes/ha	0.024	0.099	0.875	4.130
F_2, FYM 32 tonnes/ha	0.021	0.099	0.898	4.159
F_3, CCP 29 tonnes/ha	0.013	0.065	0.558	2.938
F_4, CCP 39 tonnes/ha	0.014	0.068	0.604	2.953
F_5, VC 21 tonnes/ha	0.022	0.077	0.939	3.557
F_6, VC 28 tonnes/ha	0.024	0.076	0.986	3.574
F_7, FYM (20 tonnes/ha) + NPK (50 : 50 : 50 kg/ha)	0.023	0.090	0.926	3.751
F_8, NPK (50 : 50 : 50 kg/ha)	0.017	0.080	0.702	3.466
F_9, Control	0.014	0.065	0.575	2.516
CD (P = 0.05)	0.001	0.003	0.042	0.129

DAP : Days after planting; NS, non-significant

harvest. At lower plant population, the individual plants were able to exploit the higher quantum of resources available for each plant, thus producing higher dry matter/plant compared to denser plant population. The absolute growth rate (AGR) did not differ significantly at both the stages. Moreover the AGR value was same under both the treatments (Table 2). The dry-matter distribution in different parts was not influenced by 2 types of planting material and plant population levels. However, it was highest in rhizomes (62 to 62.2%), followed by roots (23.4 to 23.7%) and leaf (14.1 to 14.6%) (Fig.1). Among organic manure treatments, FYM+NPK, FYM and VC at both the levels had significantly higher total dry matter/plant than CCP and NPK alone. Higher AGR, crop-growth rate and dry-matter production under these treatments were due to higher chlorophyll 'a' and 'b' content which resulted in higher photosynthetic rate. The increase in the dry-matter accumulation in rhizomes at harvest due to FYM and VC, FYM+NPK and NPK treatment could be attributed to efficient translocation of dry matter into rhizomes.

Interaction effects of all the factors on the dry-matter production/plant were found significant at 120 DAP (Table 3). Mother rhizome (S_1) with P_1 level of population + VC at both levels produced significantly higher dry matter than other combinations. S_1P_1 + FYM at both the levels and FYM + NPK also produced significantly higher dry matter than CCP at both levels and NPK alone. S_2P_1 + VC at both the levels, FYM at both the levels and FYM+NPK produced significantly higher dry matter than S_2P_1

Table 3. Interaction effect of S × P × F on total dry matter of galangal at 120 DAP (pooled data)

Treatment	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9
S_1P_1	3.89	3.91	2.65	2.77	4.06	4.05	3.94	3.74	2.50
S_1P_2	3.78	3.79	2.50	2.68	3.94	3.94	3.81	3.60	2.42
S_2P_1	3.76	3.78	2.57	2.69	3.84	3.82	3.84	3.61	2.50
S_2P_2	3.63	3.66	2.46	2.60	3.72	3.70	3.56	3.40	2.40
CD (P = 0.05) for									
F at the same levels of S × P				0.09					
S × P at the same or different levels of F				0.10					

S, Plant material; P, plant population; F, organic manure

Table 4. Interation effects of S × F on total dry matter of galangal at harvest (pooled data)

Treatment	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9
S_1	14.56	14.53	10.48	10.46	14.12	14.18	14.51	12.78	9.63
S_2	13.81	13.80	10.72	10.32	13.79	13.68	13.96	12.70	10.10
CD (P = 0.05) for									
F at the same levels of S				0.21					
S at the same or different levels of F				0.22					

S, Plant material; P, plant population; F, organic manure

and S_2P_2 + other combinations and were at par with each other. The dry-matter produced under the control with mother rhizome or finger rhizome plus at both the levels of populations was significantly lower than that produced under other treatments and on par with each other. At harvest, the dry matter produced due to S × F interactions was significant (Table 4). Mother rhizome (S_1) with FYM at both the levels and F_7 and F_6 produced significantly higher dry matter than other combinations. Control along with S_1 or S_2 produced significantly lower dry matter than the other treatments.

Fresh rhizome yield

Fresh rhizome yield using mother rhizome as the planting material was significantly higher than that using the finger rhizome (Table 1). Increase in yield could be because of the increased number of rhizomes and higher volume (size) of rhizomes due to mother rhizome treatment. The results confirm the findings of Rajagopalan and Gopalakrishan (1985) in galangal and of Patil and Borse (1981) in turmeric. In taro, Mohankumar and Sadanandan (1988) reported higher yield by planting side-corms (cormel) or mother corms. The fresh rhizome yield was significantly higher at 500,000/ha population level than that at 333,000/ha population. The increase in yield under higher population was attributed to more population/ha. Though the growth components were superior with population 333,000/ha, yield components were at par at both the levels of population, therefore 333,000/ha population could not compensate the total yield that was realized in 500,000/ha population. The significantly higher fresh rhizome yield with FYM+ NPK could be due to combination of organic manure with chemical ferti-

Table 5. Interaction effect of S × F on fresh rhizome yield (tonnes/ha) of galangal (pooled data)

Treatment	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9
S_1	5.4	5.4	3.6	3.6	5.4	5.4	6.2	4.8	2.7
S_2	5.1	5.1	3.3	3.3	5.1	5.2	6.0	4.6	2.6

CD (P=0.05)

F at the same levels of S 0.12

S at the same of different levels of F 0.14

S, Plant material; P, planting population; F, organic manure

Table 6. Interaction effects of P × F on fresh rhizome yield (tonnes/ha) (pooled data)

Treatment	F_1	F_1	F_3	F_4	F_5	F_6	F_7	F_8	F_9
P_1	5.2	5.1	3.7	3.7	5.2	5.2	6.0	4.5	2.4
P_2	5.4	5.8	3.8	3.8	5.3	5.4	6.1	4.7	2.6

CD (P=0.05)

F at the same levels of P 0.12

P at the same of different levels of F 0.14

S, Plant material; P, planting population; F, organic manure

lizer resulted in better growth of the crop as reflected in increased chlorophyll and carotenoid contents, higher AGR, CGR and harvest index. The FYM and VC at both the levels also recorded significantly higher yield than CCP at both the levels, NPK and control treatments.

Combination of FYM + NPK application with both the levels of population significantly increased the yield compared to other combinations (Tables 5,6). With the combination of organic manures and chemical fertilizer, there would be improvement in the available nutrients resulting in better growth and yield components. Increase in yield due to combined application of FYM and inorganic fertilizer was reported in ginger by Pawar and Patil (1987) and in potato by Singh *et al.* (1996). Application of FYM

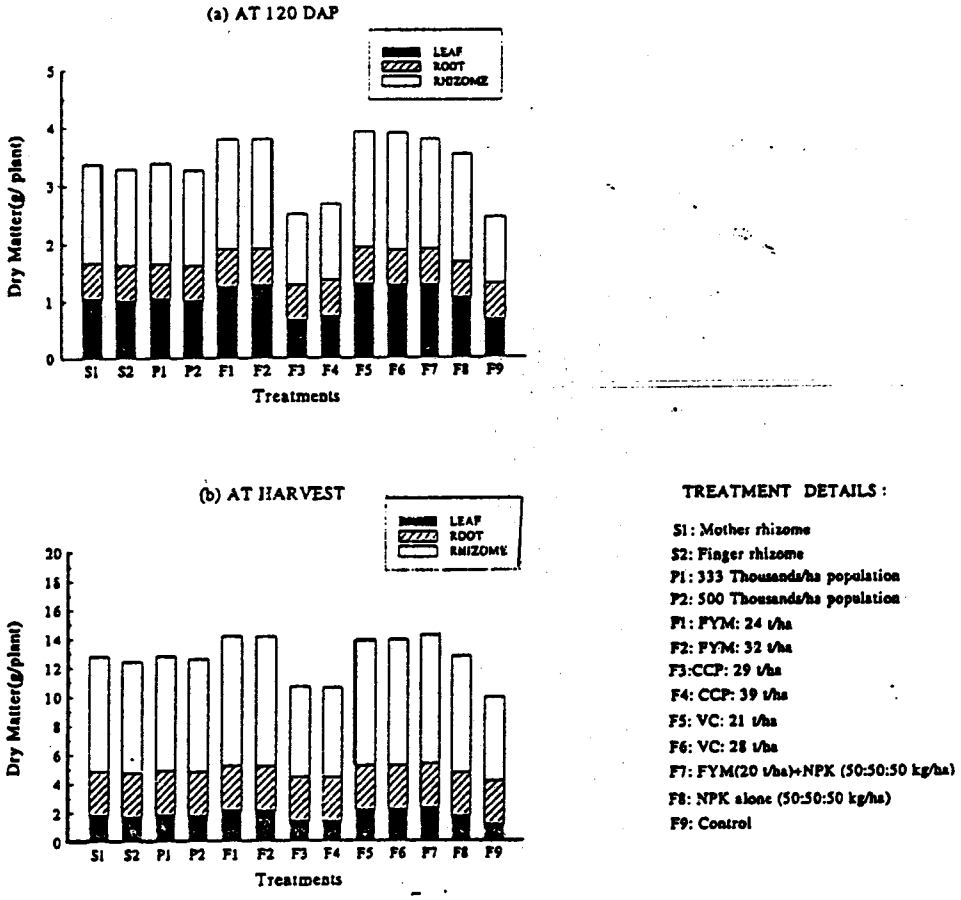

Fig. 1. Dry-matter accumulation in different parts of galangal at different stages

alone resulted in higher yield in amorphophallus (Patel and Mehta, 1987) and yam (Mohankumar and Muralidharan Nair, 1979). The overall better growth and yield under FYM, VC treatments could also be attributed the higher microbial population and dehydrogenase activity, which may have influenced higher nutrient uptake, chlorophyll synthesis, plant growth and yield. Further, these microbes are found to promote soil aggregation and thus indirectly influence root environment and plant growth.

Harvest index

The harvest undex was significantly higher with mother rhizome as planting material than finger rhizome (Table 1), that with indicating the higher capacity of partitioning the dry matter produced in the rhizomes using mother rhizome as reflected in higher dry matter in rhizomes at harvest (Fig.1). Plant population of 333,000/ha had significantly higher harvest index compared to 500,000/ha population because of the higher plant population which decreased the proportion of total dry matter diverted into the rhizomes. This is reflected in the lower rhizome dry weight at lower density. This is in conformity with the results of Ramakrishnan Nayar and Sadanandan (1990) in cassava. Among organic manures, FYM+NPK, FYM and VC at both the levels had significantly higher harvest index compared to CCP at both the levels and NPK alone. Higher harvest index was mainly attributed to better translocation of dry matter into rhizomes as reflected in higher rhizome dry weight.

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