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Influence of shade regimes on yield and quality of ginger (*Zingiber officinale* Rosc.)

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Abstract

The effect of different levels of shade on yield and quality of ginger (*Zingiber officinale* Rosc.) was studied during two seasons at Coconut Research Station, Thiruvananthapuram, Kerala Agricultural University, Kerala. The shade levels 20 and 40 per cent were favourable for obtaining higher dry ginger yield. Volatile oil content showed an increasing trend with increasing levels of shade. Maximum NVEE was recorded in the plants grown under 20 and 40 per cent shade levels. Higher starch content was observed in plants grown under 20 per cent shade level. Crude fibre content gradually reduced as the intensity of shade increased. The results indicate the possibility of utilizing existing shaded situations in coconut gardens and under other perennial crops for the production of ginger.

Key words: crop quality, crop ginger, shade, crop yield, *Zingiber officinale*

Introduction

Ginger (*Zingiber officinale* Rosc.) is one of the principal spice crops. India is the largest producer and exporter of ginger. Estimated global demand for dry ginger by 2005 AD is 0.25 lakh tonnes (Peter 1997). The consumption within the country is either in the form of fresh or dry ginger and the end use in the importing countries is in the form of oleoresin or essential oils. Appearance of dry ginger is important to fetch a premium price. Essential oils, oleoresin, starch, protein and crude fibre are important quality attributes of ginger (Govindarajan 1982). Quality requirements of spices for export to different countries have been formulated (Spices Board 1998). Studies conducted in India and elsewhere revealed that ginger is a shade tolerant / loving crop (Aclan & Quisumbing 1976; Jayachandran *et al.* 1991; Ravisankar & Muthuswamy 1987; Varughese 1989). Studies on coconut based intercropping; rated ginger as a shade loving crop and highly suitable for intercropping in coconut gardens (KAU 1992). There is an increasing trend to export ginger oils and oleoresin and in view of this, a need arises to assess the influence of shade regimes on quality of ginger in terms of spice oil, non-volatile ether extract, starch and crude fibre content.

Materials and methods

Rhizome bits of cultivar Rio-de-Janeiro weighing 15 g were treated with a mixture of Mancozeb (0.3%) and Malathion (0.1%) for 30 minutes, and planted in mud pots of size 30x35 cm filled with potting mixture. The experiment was laid out in a completely randomized design with four replications and the treatments included four levels of shade

(20, 40, 60 and 80 per cent) and open condition. The mean photosynthetically active radiation (PAR) under open condition was 1461m mol m^{-2} s^{-1}. The shade levels were provided with high-density polyethylene threads spread over pandals and calibrated to the required level using quantum photosensors. Destructive samples were collected at monthly intervals from first month onwards. Final harvest was done eight months after planting. Dry ginger yield was estimated by sun drying fresh rhizome to a moisture level of 10 per cent. Volatile oil content was estimated by Clevenger distillation method and Non-volatile ether extract (NVEE) by Soxhlet distillation method (AOAC 1975). Starch and crude fibre content were analysed by AOAC (1975) methods.

Results and discussion

The dry ginger yields of plants grown under 20 and 40 per cent shade were on par but produced significantly higher yield when compared to open condition, and other levels of shade during both the seasons (Table 1). In conclusion plants kept under 20 and 40 per cent shade levels produced maximum dry ginger yield and 60 and 80 per cent shade levels reduced the yield. However, open condition is found to be better than 60 and 80 per cent shade levels for rhizome yield. Enhanced rhizome yield under artificial shaded situations were observed (Ancy & Jayachandran 1993; Jayachandran *et al.* 1991) in ginger. Zhao *et al.* (1991) observed that low light intensities are favourable for increased photosynthetic efficiency. Better performance of crop under low light intensities than in open condition may be due to the fact that in open there is a threshold of illumination intensity beyond which the stomata of shade loving plants tends to close (Hardy 1958). This can be one of the reason for shade response of crop. Therefore, it may be assumed that stomata closure had a dominant influence up to the low shade 20 per cent, beyond which the availability of light for photosynthesis probably becomes the decisive limiting factor.

Volatile oil content of ginger rhizomes showed an increasing trend with increasing levels of shade (Table 2). In both the years, at 120 DAP, maximum volatile oil content was recorded under 80 per cent shade which was on par with 60 and 40 per cent shade levels. At 150 DAP, almost the same trend was observed. At 180 to 240 DAP, not much variations in volatile oil content was observed at different shade levels. In general, lowest volatile oil content was recorded under open condition during different growth stages. Though the volatile oil content under 80 per cent shade level was relatively high, the rhi-

Table 1. Effect of shade on dry ginger yield (g $plant^{-1}$)

Days after planting	Shade level									
	Open		20 per cent		40 per cent		60 per cent		80 per cent	
	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98
90	3.53	7.88	13.08	8.04	7.34	8.34	8.17	7.74	3.52	8.34
120	5.04	9.12	19.87	18.08	16.84	20.02	12.33	14.24	5.42	12.40
150	11.28	16.60	43.88	39.09	25.61	30.33	25.05	29.01	16.39	19.89
180	19.15	36.73	49.90	54.96	38.23	48.14	28.66	39.44	23.25	24.25
210	51.50	47.98	79.44	76.50	66.54	63.10	36.08	42.78	30.72	26.35
240	68.76	79.08	96.64	92.38	90.33	88.00	36.83	61.88	35.84	29.13
Mean	26.54	32.90	50.47	48.17	40.82	43.00	24.52	32.51	19.19	20.06

	1996-97		1997-98	
Effect	SE	CD (1%)	SE	CD (1%)
Shade	1.186	3.573	1.419	4.277
Shade x period	2.778	7.857	2.831	8.006

Table 2. Effect of shade on volatile oil content of ginger rhizome (v/w %) on dry weight basis

Days after planting	Shade level									
	Open		20 per cent		40 per cent		60 per cent		80 per cent	
	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98
120	1.45	1.53	1.98	1.98	2.48	2.38	2.48	2.43	2.48	2.50
150	2.40	2.23	2.78	2.73	2.38	3.28	3.53	3.68	3.93	3.70
180	2.20	2.20	2.55	2.33	2.58	2.48	2.98	2.63	2.53	2.50
210	2.03	1.75	2.18	1.93	2.23	2.21	2.25	2.08	2.40	1.93
240	2.23	2.18	2.28	2.33	2.55	2.63	2.53	2.50	2.55	2.38
Mean	2.06	1.98	2.35	2.26	2.64	2.59	2.75	2.66	2.78	2.60

	1996-97		1997-98	
Effect	SE	CD (1%)	SE	CD (1%)
Shade	0.092	0.276	0.065	0.195
Shade x period	0.149	0.420	0.112	0.316

zome yield per plant was very low thereby the total recovery of volatile oil was less. George (1992) reported increase in volatile oil content with increasing shade intensity in ginger. Ancy & Jayachandran (1993) found that volatile oil content under open condition is significantly lower when compared to that in different shade levels. Shade grown plants showed higher volatile oil content. This may be due to the accumulation of secondary metabolites such as resin, resin acids and unoxidised sugars and the retention of volatile oil which otherwise undergoes oxidation, degradation, isomerisation and polymerisation (Zachariah & Gopalam 1987).

Non-volatile ether extract (NVEE) content varied significantly in different shade levels (Table 3). During the two seasons, NVEE content under 20 and 40 per cent shade levels were found to be on par and significantly superior to that under open condition and higher shade levels (60 and 80 per cent). Shade can influence the production of secondary metabolites and reduce the oxidation and other biochemical activities resulting in high NVEE content (Zachariah & Gopalan 1987). Similar findings have been reported by Ancy & Jayachandran (1993) and Ravisankar & Muthuswamy (1987) in ginger. Contrary to this, highest content of NVEE was recorded at open condition followed by 25 per cent shade (Babu & Jayachandran

Table 3. Effect of shade on non-volatile ether extract (NVEE) content of ginger rhizome (%) on dry weight basis

Days after planting	Shade level									
	Open		20 per cent		40 per cent		60 per cent		80 per cent	
	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98
120	5.48	5.48	6.10	6.50	6.88	6.95	3.88	3.88	3.68	3.73
150	6.95	7.15	9.63	9.88	8.63	9.25	6.00	5.98	4.40	4.83
180	6.75	7.05	9.75	10.13	8.58	9.15	6.08	6.03	4.38	5.30
210	6.33	6.00	8.40	8.45	8.10	8.33	5.85	5.63	4.90	4.88
240	6.00	6.13	6.88	7.00	8.75	8.90	6.95	5.78	5.35	5.33
Mean	6.30	6.36	8.15	8.39	8.19	8.52	5.75	5.46	4.54	4.81

	1996-97		1997-98	
Effect	SE	CD (1%)	SE	CD (1%)
Shade	0.354	1.068	0.422	1.273
Shade x period	0.374	1.057	0.450	1.272

Table 4. Effect of shade on starch content of ginger rhizome (%) on dry weight basis

Days after planting	Shade level									
	Open		20 per cent		40 per cent		60 per cent		80 per cent	
	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98
120	24.19	24.75	24.39	25.13	22.28	22.00	20.75	20.75	19.75	20.50
150	27.65	25.00	28.13	27.75	30.19	29.38	28.00	27.00	24.50	25.00
180	29.63	29.63	30.63	28.75	29.88	28.75	28.63	26.75	27.88	25.88
210	32.25	32.25	36.80	38.80	32.00	31.00	31.50	32.00	30.75	30.25
240	45.00	44.50	45.25	44.00	42.50	41.25	37.63	37.00	33.90	34.00
Mean	31.74	31.23	33.04	32.89	31.37	30.48	29.30	28.70	27.36	27.13

	1996-97		1997-98	
Effect	SE	CD (1%)	SE	CD (1%)
Shade	0.380	1.145	0.519	1.563
Shade x period	1.260	3.564	1.603	NS

1997; George 1992). In general, 20 and 40 per cent shade levels were found to be favourable for more production of NVEE.

Starch content varied significantly due to different shade levels (Table 4). During both the seasons, maximum starch content was recorded by the plants grown under 20 per cent shade which was followed by open and 40 per cent shade levels. The lowest starch content was recorded under 60 and 80 per cent shade levels. Up to 180 DAP, not much variation in starch content was observed due to shade over periods. In general, the starch content under 20 per cent shade was significantly higher compared to open. Under higher shade levels (60 and 80 per cent shade) the starch content was observed to be low. The probable reasons for such variation may be due to influence shade on production of secondary metabolites and other biochemical activities (Zachariah & Gopalan 1987).

The fibre content was significantly influenced by the shade levels (Table 5). During both the seasons, maximum crude fibre content

Table 5. Effect of shade on crude fibre content of ginger rhizome (%) on dry weight basis

Days after planting	Shade level									
	Open		20 per cent		40 per cent		60 per cent		80 per cent	
	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98
120	1.93	1.90	1.80	1.93	1.55	1.45	1.34	1.25	1.10	1.45
150	2.93	2.80	2.69	2.70	2.39	2.33	2.31	2.35	2.09	2.08
180	4.25	4.30	3.74	3.75	3.69	3.80	3.43	2.90	3.30	3.20
210	5.53	6.00	5.38	5.48	4.96	4.93	4.30	4.08	4.14	3.90
240	6.00	6.30	5.73	6.00	5.60	5.50	5.26	5.13	4.18	3.83
Mean	4.12	4.26	3.87	3.97	3.64	3.60	3.33	3.14	2.96	2.89

	1996-97		1997-98	
Effect	SE	CD (1%)	SE	CD (1%)
Shade	0.076	0.229	0.124	0.373
Shade x period	0.222	0.627	-	NS

was recorded under plants grown in open condition. But during second year, the crude fibre content recorded at open condition and 20 per cent shade was on par. As the shade increased there was reduction in crude fibre content. Shade influence the production of secondary metabolites and other biochemical activities (Zachariah & Gopalan 1987). This may be a reason for the reduction in crude fibre content at higher levels of shades. There was not much variation in crude fibre content at different shade levels up to 180 DAP. During 210 and 240 DAP, the plants under open condition recorded maximum fibre content, which was on par with 20 and 40 per cent shade levels. The result was in conformity with the observations of Ancy & Jayachandran (1993) and Babu & Jayachandran (1997).

The starch, protein and crude fibre in the rhizome make the bulk of dry matter (Govindarajan 1982). This may be a reason for high dry ginger yield recorded under 20 per cent shade level. In general, the quality of ginger in terms of high NVEE and starch content are higher in plants grown under 20 and 40 per cent shade levels but volatile oil was higher under higher levels of shade. The results indicate the positive response of shade on quality parameters and yield of ginger, provided the intensity of shade is low.

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