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Impact of shade net condition on growth, rhizome and yield characters of ginger

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Abstract
A field trail was conducted to assess ginger (*Zingiber officinle*Rosc.) germplasm for growth, rhizome and yield parameters under shade net condition. Temperature and moisture are very important aspect for crop growth of shade loving plants like Zingiberaceae family. The experiment with ten treatments was laid out in a Randomized Block Design with three replications. Ginger germplasm *viz*.,Maran, Mahima, Regodi, Zahearabad local, Suprabha, Nadia, Pundibari, Jalsingapara local, Himachal and Narsipatnam local were selected for study. The investigation revealed Suprabha variety as the most promising germplasm line in terms of growth, rhizome and yield parameters. The highest plant height, no of tillers per plant, no of leaves per plant, leaf area per plant leaf area index per plant, highest bio mass per plant dry matter plant and crop growth rate per plant, number of finger rhizomes per plant,number of primary rhizomes per plant, number of secondary rhizomes per plant, fresh weight of primary rhizomes, fresh weight of secondary rhizomes, length of primary rhizome, length of secondary rhizome, girth of primary rhizome, girth of secondary rhizome, the rhizome yield per plant and per hectarewere recorded in the variety Suprabha followed by var. Himachal.

Keywords: Germplasm, rhizome and yield, shade net, *Zingiber officinale*

Introduction
India is the land of spices, Ginger (*Zingiberofficinale* Rosc.) is an important spice crop it play important role in export and it belongs to South East Asia. It is cultivated for underground modified stem called rhizomes; it is mainly used in fresh, dried and preserved form. Present condition India need to double production in order to meet growing demands of internal as well as export markets. (Meerabai *et al*., 2001) [7].

Ginger grows well in warm and humid climate. It is cultivated from altitude of 1500 m above sea level. Ginger can be grown both under rain fed and irrigated conditions. A friable loamy soil rich in humus is ideal for ginger cultivation. In India the average productivity is very low (4.7 t ha^{-1}). Temperature and moisture are the two most critical weather variables affecting ginger yield (Njoku *et al*., 1995) [9]. One of the reasons for low yield is lack of suitable varieties for particular agro-climatic conditions. Under multi-storied agro-forestry system ginger is compatible crop due to their shade loving nature and easily grown habit in all homesteads (Bhuiyan *et al*., 2012) [4]. Apart from suitable varieties, time of planting, nutritional requirement timely plant protection measures also play an important role in enhancing the yield in ginger. Very limited scientific information is available on varietal evaluation of ginger under shade net condition. Under local agro-climatic condition though the farmers are using their own varieties based on the availability during the season irrespective of suitability for the area under normal open cultivation of the crop. Hence, the evaluation of different ginger varieties and identification of high yielding varieties for a particular agro-ecosystem under shade net condition is of paramount importance to the growers to increase their productivity under controlled conditions. In Andhra Pradesh it is grown in high altitude areas in Srikakulam. Vizianagaram and Visakhapatnam districts and the climate in Andhra Pradesh is suitable for ginger cultivation. Ginger could be grown even in plains under partial shade and also in high altitude zone of Andhra Pradesh. Information on cultivation of ginger under shade net condition and its performance in different soil types for their growth, yield and quality is scanty. In the present study, an attempt has been made to assess the performance for rhizome characters of different varieties of ginger under local agro-climatic zone for their suitability and also to mitigate adverse condition through shade net cultivation of Andhra Pradesh.

Material and methods

The experimental site was located at the College farm at Horticultural College and Research Institute, Venkataramannagudem, West Godavari district, in Andhra Pradesh. The maximum temperature ranged between 29.25^{0}C and 42.63^{0}C, relative humidity varied from a minimum of 31.79 to 78.53 per cent which is characterized by heavy rainfall (260.08 mm) during the months of June to October and scanty during rest of the year. The soil was red sandy loam with good drainage and moderate water holding capacity. The physical composition of the soil was sand 70%, silt 20% and clay 10%. The soil P^H of 6.5-7.0, The shade net house is a framed structure made up of materials such as GI pipes. It is covered with green colour plastic net, in an area of shade net is 500 m^2 and it allows 50 per cent light. It provides partially controlled atmosphere by reducing light intensity and temperature during day time to the crops grown under it. The irrigation facility was provided by using drip irrigation and foggers maintaining for humidity. The crop was harvested when the plants attained the maturity as indicated by the drying up of leaves, pseudo stem and falling down of the plants depending upon the maturity period. One day before the digging of the rhizomes, light irrigation was given to the field and the rhizomes were removed from soil by digging and the rhizomes were separated. The rhizomes were washed with water for removing the adhering dirt, soil and other foreign matters. The rhizomes were taken from randomly selected five plants for the purpose and it was measured using to in thread and scale, fresh weight of rhizomes per plant by using balance.

Experiment Details

Design: Randomised Block Design (RBD)
Number of treatments: 10
Number of replications: 3
Season: *Kharif, 2015-16*
Plot size net: 2.0 m × 2.0 m
Plot sizes gross: 120 m^2
Spacing: 35.0 cm × 25.0 cm

Results and discussions

Significant differences were observed in growth parameters of different cultivars of ginger (Table 1). Significantly highest plant height (89.83 cm) was observed in Suprabha variety which was at par with Himachal (83.23 cm) and the lowest plant height (72.56 cm) was recorded in the variety Maran. The variety Suprabha recorded highest number of tillers per plant (28.56) followed by Himachal (24.33) which were *on par* with each other and the lowest number of tillers per plant (13.46) was recorded in the variety Nadia.Which might be due to genetic constitution of the varieties and genotypic potential and availability of nutrients in the soil, which were influenced by low light intensity and high relative humidity condition under shade net situation (Amin *et al*., 2010) [1]. Recorded increased shade influence to plant height as well as lowest plant height recorded under full sunlight.

The highest number of leaves (245.16) was recorded in the variety Suprabha followed by Himachal (241.83) which were *on par* with each other and the lowest number of leaves per plant (166.56) in the variety Nadia. This might be due to genetic constitution of the varieties and genotypic potential of the cultivars. It appears that relatively low temperatures and combine with low light intensity contributes to development of more chlorophyll in ginger plants grown in shade leading to higher number of leaves as stated by (Sreekala *et al*. 2001) [13] in ginger. The highest leaf area per plant (32.47 cm^2) was recorded in the variety Suprabha whereas, the lowest leaf area per plant (22.88 cm^2) in the variety Maran.

The highest leaf area index per plant (9.09) was recorded in the variety Suprabha followed by Himachal (8.26) which were *on par* with each other and the lowest leaf area index per plant (4.54) in the variety Nadia. The highest leaf area index per plant (10.27) was recorded in variety Suprabha at 120 DAP. However, the decreased trend of the leaf area index per plant from 150 to 180 DAP. The increased leaf area index from initial day after planting to at120 DAP is due to more number of tillers and number of leaves per plant which covered the ground area by leaves and high humidity under low light intensity condition under shade. However, the decreased trend from 120 DAP to 180 DAP is might be due to rapid vegetative growth stimulated and increased sink in terms of rhizome formulation might have decreased leaf area index in ginger in shade net condition.

The highest bio-mass of the plant (958.0 g) was recorded in the variety Suprabha followed by Pundibari (918.13 g) which were *on par* with each other and the lowest bio-mass of the plant (739.0 g) in the variety Zahearabad Local. The highest (121.35 g) dry matter per plant was recorded in Suprabha followed (113.84 g) in Himachal at 180 DAP and the lowest (71.79 g) was recorded in Nadia at 180 DAP and later at 210 DAP the highest dry matter per plant of 198.98 g in Suprabha and the lowest of 115.3 g was recorded in Nadia at 210 DAP. The increased trend of between the days of planting was also recorded irrespective of the varieties grown under shade net condition. The highest dry matter per plant in Suprabha is might be due to increased number of leaves per plant, leaf area index resulted in the development of more chlorophyll in the plants grown in shade net condition with synthesis of photosynthates and the better utilization of carbohydrates by decreased respiration at lower temperature as stated by Sreekala *et al*. (2001) [13] in ginger. Crop growth rate showed the non-significant differences among the varieties however, the highest crop growth rate of the plant (33.35 g m^{-2} day^{-1}) in the variety Pundibari was recorded followed by Suprabha (29.57 g m^{-2} day^{-1}) which were *on par* with each other and the lowest crop growth rate of the plant (16.58 g m^{-2} day^{-1}) was recorded in the variety Nadia. Similar results recorded in (Jyotsna *et al*. 2012) [6].

The analysis of variances indicated significant differences among the genotypes for rhizome and yield parameters. The highest number of finger rhizomes per plant (25.40) was recorded in the variety Suprabha followed by Himachal (23.23) which were *on par* with each other and the lowest number of finger rhizomes per plant (16.42) was recorded in the variety Nadia (Rajyalakshmi and Umajyothi 2014) [11] observed significant differences among the varieties under high altitude areas of Andhra Pradesh.

The highest number of primary rhizomes per plant (8.39) was recorded in the variety Suprabha followed by Himachal (7.49) and the lowest number of primary rhizomes per plant (3.96) in the variety Nadia. The highest number of secondary rhizomes per plant (21.66) was recorded in the variety Suprabha followed by variety Himachal (20.25) and the lowest number of secondary rhizomes per plant (11.93) in the variety Nadia.

The highest fresh weight of primary rhizomes per plant (121.62 g) was recorded in the variety Suprabha followed by variety Himachal (110.64 g) and the lowest fresh weight of primary rhizomes per plant (82.12 g) in the variety Nadia. The highest fresh weight of secondary rhizomes per plant (183.38 g) was recorded in the variety Suprabha followed by

Himachal (180.35 g) and Pundibari (178.53 g) which were *on par* with each other and the lowest fresh weight of secondary rhizomes per plant (112.87 g) was recorded in the variety Nadia. The highest fresh weight of rhizome it might be due to highest photosynthetic activity under favorable soil temperature, low light intensity and higher relative humidity under shade net condition. Similar results were also reported by (Bhuiyan *et al.* 2012) [4] in ginger.

The highest length of primary rhizome (11.81 cm) was recorded in the variety Suprabha followed by Himachal (10.92 cm) and the lowest length of primary rhizome (8.33 cm) was recorded in the variety Maran. The highest length of secondary rhizome (7.26 cm) was recorded in the variety Suprabha followed by Himachal (6.78 cm) Pundibari (6.76 cm), Regodi (6.71 cm) and Mahima (6.59 cm) which were *on par* with each other and the lowest length of secondary rhizome per plant (5.36 cm) was recorded in the variety Nadia. Which might be due to genetic constitution variety and also the increased plant height, number of leaves per plant, leaf area per plant which resulted in higher bio-mass production and partioning of photosynthates. The low light intensity and highest humidity might have resulted the highest rhizome yield was obtained in Suprabha and also due to lower photo oxidation rate and efficient translocation of photosynthates under shade net condition as reported by (Ancy and Jayachandran 2000) [2] in ginger varieties grown under different shade condition.

The highest girth of primary rhizome (2.22 cm) was recorded in the variety Suprabha followed by Himachal (2.13 cm), Pundibari (2.05 cm) and Zaherabad local (2.04 cm) which were *on par* with each other and the lowest girth of primary rhizome (1.88 cm) in the variety Nadia. The girth of secondary rhizome showed the significant differences among the varieties and the highest girth of secondary rhizome (2.14 cm) in the variety Suprabha was recorded followed by Himachal (2.0 cm) which were *on par* with each other and the lowest girth of secondary rhizome (1.70 cm) was recorded in the variety Nadia. The vegetative growth stimulated and increased the sink in terms of rhizome length and thus increasing the girth of secondary rhizome. Similar trends were also reported by (Azeze *et al.* 2013) [3] in ginger.

The data for the character of fresh rhizome yield per plant showed the significant differences among the varieties and the highest fresh rhizome yield per plant of 305.0 g in the variety Suprabha followed by Himachal (291.0 g) and the lowest fresh rhizome yield per plant of 195.0 g was recorded in the variety Nadia. The highest fresh rhizome yield per hectare (32.02 t ha^{-1}) was recorded in the variety Suprabha followed by Himachal (30.53 t/ha) and the lowest fresh rhizome yield per hectare (20.47 t/ha) in the variety Nadia. The highest fresh rhizome yield produced by some of these varieties can be mainly attributed to vegetative growth characters like plant height, number of leaves, leaf area per plant, the fresh weight of rhizomes, length of rhizome and girth of rhizome under shade net condition. It can be attributed that the yield of a variety is dependent on vigour of the plant and other rhizome characters. It is concluded the increased plant height, number of tillers per plant, number of leaves per plant and leaf area per plant which increased the rhizome characters ultimately resulted in the highest yield in Suprabha compare to other varieties under shade net condition. Similar results were also reported by (Sanwal *et al.* 2012) [12], (Chongtham *et al*. 2013) [5], (Raviraja Shetty *et al*. 2015) [10], (Azeze *et al*. 2013) [3] in ginger and (Naram Naidu and Purushotham 2013) [8] and (Virendra *et al.* 2015) [14] in turmeric. It might be due to highest photosynthetic activity under favorable soil temperature, low light intensity and higher relative humidity under shade net condition. Similar results were also reported by (Bhuiyan *et al.* 2012) [4] in ginger.

Conclusion

Based on this study, it can be inferred that ginger yield can be increased under shade net condition. It is resulted that the ginger varieties Suprabha, Himachal, Pundibari, Zaherabad local were the good varieties for the yield attributing parameters like growth, rhizome and yield characters. Suprabha variety is performed best under shade net cultivation. So, this ginger variety can be recommended to the farmers under shade net cultivation in costal Andhra Pradesh.

Table 1: Growth parameters of ginger under shade net condition

Treatments	Plant height (cm)	No. of tillers/plant	No. of leaves/plant	Leaf area (cm^2)	Leaf area index
	at 180 days after planting				
V_1-Maran	72.56	16.40	187.70	22.63	4.84
V_2-Mahima	80.46	20.13	190.53	23.85	5.18
V_3-Regodi	78.43	18.50	202.76	24.69	5.71
V_4-Zahearabad local	73.53	22.50	205.66	29.45	6.95
V_5-Suprabha	89.83	28.56	245.16	32.47	9.09
V_6-Nadia	73.03	13.46	166.56	23.71	4.54
V_7-Pundibari	82.56	23.00	215.13	28.16	6.91
V_8-Jalsingapara local	82.06	16.03	177.03	27.25	5.51
V_9-Himachal	84.63	24.33	241.83	29.88	8.26
V_{10}-Narsipatnam local	79.10	19.76	199.56	26.07	5.95
SE (m)±	2.76	1.51	4.53	2.10	0.55
CD at 5%	8.27	4.53	13.56	NS	1.64
CV%	6.01	12.93	3.86	13.58	15.14

Table 2: Biological weight of ginger varieties under shade net condition

Treatments	Bio-mass (g)	Dry matter at 180 DAP(g)	Dry matter at 210 DAP (g)	Crop growth rate (g m^{-2} day^{-1})
V_1-Maran	777.73	74.04	134.36	22.98
V_2-Mahima	895.0	109.30	169.26	22.84
V_3-Regodi	827.33	90.60	143.93	20.31
V_4-Zahearabad local	739.00	81.34	137.32	21.33
V_5-Suprabha	958.33	121.35	198.98	29.57

V_6-Nadia	815.33	71.79	115.30	16.58
V_7-Pundibari	918.13	98.45	153.13	33.35
V_8-Jalsingapara local	882.00	75.06	127.44	19.951
V_9-Himachal	880.33	113.84	167.57	20.46
V_{10}-Narsipatnam local	860.00	94.62	151.77	21.77
SE (m)±	30.88	3.65	6.13	4.23
CD at 5%	92.47	10.94	18.38	NS
C V (%)	6.25	6.80	7.09	31.97

Table 3: Morphological characters of ginger rhizomes under shade net condition

Treatments	No. of finger rhizomes/plant	No. of primary rhizomes/plant	No. of secondary rhizomes/plant	Fresh weight of primary rhizomes (g)	Fresh weight of secondary rhizomes (g)
Maran	16.53	4.06	12.80	90.00	123.00
Mahima	19.13	4.66	13.46	97.14	134.86
Regodi	21.21	5.26	16.73	104.32	139.67
Zahearabad local	21.54	5.43	17.60	103.45	146.54
Suprabha	25.40	8.39	21.66	121.62	183.38
Nadia	16.42	3.96	11.93	82.12	112.87
Pundibari	22.54	6.68	19.13	106.46	178.53
Jalsingapara local	17.66	4.26	13.40	101.88	161.11
Himachal	23.23	7.49	20.25	110.64	180.35
Narsipatnam local	17.40	5.18	12.79	98.74	122.25
SE (m) ±	0.76	0.25	0.70	3.01	4.72
CD at 5%	2.30	0.75	2.12	9.02	14.15
CV (%)	6.61	7.82	7.67	5.13	5.52

Table 4: Morphological characters of rhizome and yield of ginger under shade netcondition

Treatments	Length of primary rhizome (cm)	Length of secondary rhizome (cm)	Girth of primary rhizome (cm)	Girth of secondary rhizome (cm)	Fresh rhizome yield/ plant (g)	Fresh rhizome yield/ ha (t)
Maran	8.33	6.17	1.92	1.70	213.00	22.36
Mahima	8.55	6.59	1.92	1.78	232.00	24.36
Regodi	8.60	6.71	2.01	1.83	244.00	25.62
Zahearabad local	9.84	6.17	2.04	1.83	250.00	26.25
Suprabha	11.81	7.26	2.22	2.14	305.00	32.02
Nadia	9.48	5.36	1.88	1.81	195.00	20.47
Pundibari	10.13	6.76	2.05	1.84	285.00	29.92
Jalsingapara local	9.57	5.81	1.80	1.76	263.00	27.61
Himachal	10.92	6.78	2.13	2.00	291.00	30.53
Narsipatnam local	9.31	5.34	1.98	1.80	221.00	23.20
SE (m) ±	0.37	0.28	0.06	0.03	5.88	0.51
CD at 5%	1.11	0.86	0.20	0.09	17.61	1.53
CV (%)	6.64	7.93	5.89	2.81	4.07	3.39

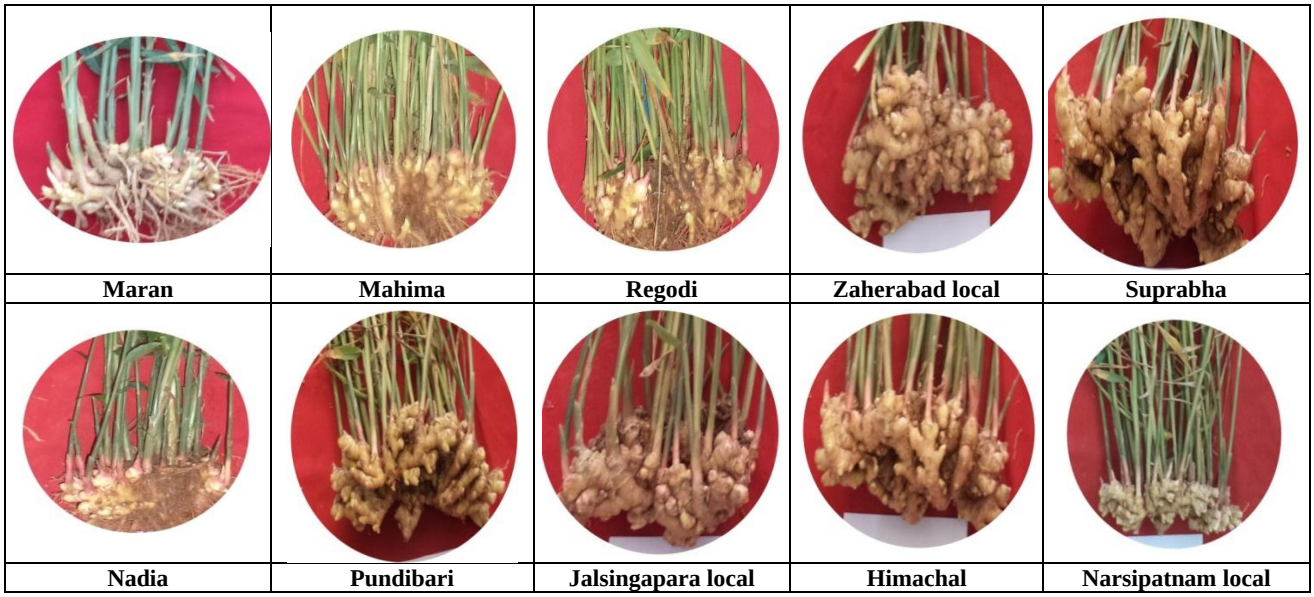

Plate 1: Fresh rhizome yield of different ginger varieties under shade net

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