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EVALUATION OF INFLUENCE OF RHIZOME SIZE AND PLANT SPACING ON GROWTH AND YIELD ATTRIBUTES OF GINGER (*ZINGIBER OFFICINALE* ROSC.) CV. MARAN IN MANGO-GINGER INTER CROPPING SYSTEM

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Abstract

The investigation was carried out at the experimental farm, College of Horticulture, Anantharajupeta (A.P.) during 2014-15 to Evaluate the effect of rhizome size and plant spacing of ginger (*Zingiber officinale*) cv. maran under intercropping system in mango .The experiment was laid out in a factorial randomized block design comprising of three seed rhizome sizes (R_1=20, R_2=30 and R_3=40 g) and five plant spacings (S_1=25 × 15, S_2= 25 × 25, S_3=30 × 20, S_4=30 × 30 and S_5=40 cm × 20 cm) with three replications under the mango cropping system. Rhizome size and spacing showed significant differences on growth and yield parameters of ginger. Maximum plant height at harvest (97.93cm), highest number of leaves per plant (137.47), Leaf length (23.71 cm), Leaf breadth (2.46cm), Leaf area index (4.57), Rhizome length (17.63cm), Rhizome breadth (17.16cm), Yield^{-1} plant (206.88g) and Yield^{-1} ha.(25.69 t) were reported with 40 g rhizome size. The maximum yield (25.77 t/ha) was reported with 25 × 15 cm spacing and minimum yield (20.04 t/ha) was recorded with 40 × 20 cm spacing. The best treatment combination found in case of higher yield is rhizome size of 40g with 25 × 15 cm spacing.

Key words: ginger, mango based intercropping, plant spacing, rhizome size and yield.

Introduction

Ginger (*Zingiber officinale* Rosc.) belonging to the family Zingeberaceae was one of the earliest oriental tropical underground spice crop used both as a spice and medicine. The distinct flavour, aroma and pungency of ginger is due to oleoresins and volatile oils. India is the largest producer, consumer and exporter of this crop in the world. Ginger is widely used in food, beverage and confectionery. Ginger offers good scope in diversification of inter-cropping systems. Ginger is propagated vegetatively from rhizome and the length and weight of pieces used varies from place to place and variety to variety. The seed rhizome is the economic yield as well as the planting material of ginger. The use of very large seed rhizomes means the loss of the commercial product whereas the use of very small seed rhizome means reduced growth and yield (Hailemichael and Tesfaye, 2008). Development of suitable production technology to boost the crop yield is essential as the yield potential of the variety alone is not sufficient for increasing the yield (Yadav *et al.,* 2013). Seed rhizome size, plant spacing are the important aspects of production systems of ginger. It is well documented that rhizome sizes and plant spacing have significant influences on the growth and yield of ginger (Monnaf *et al.,* 2010). One of the feasible ways of increasing the farm level income is intercropping. As ginger requires partial shade it can be grown as intercrop in mango. Growing of ginger in mango orchard proves profitable without hampering the performance of the main crop and the natural resources *i.e.*, soil, water, air space and solar radiation can be better utilized by raising the ginger as intercrop. Considering these facts, the present investigation was undertaken to evaluate the influence of seed rhizome size and plant spacing on growth and yield attributes of ginger under mango intercropping system.

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Materials and Methods

The experiment was conducted at College of Horticulture, Anantharajupet in a 20 year old mango

orchard which is located in Rayalaseema region of the Andhra Pradesh. The experiment was laid out in a factorial randomized block design with three seed rhizome sizes of ginger *viz.*, R_1 (20 g), R_2 (30 g) and R_3 (40 g) and five plant spacings *viz.*, S_1 (25 cm × 15 cm), S_2 (25 cm × 25 cm), S_3 (30 cm × 20 cm), S_4 (30 cm × 30 cm) and S_5 (40 cm × 20 cm). Fifteen treatment combinations were replicated thrice. The Ginger rhizome pieces were planted in a raised bed of 1.2 m length, 1.2 m width and 15cm height as per the treatment. Ginger cultivar used in the present experiment is Maran brought from Fruit Research Station, Sangareddy. Growth and yield attributes data were collected at appropriate times throughout the experimental period from five randomly selected plants from each plot. The data on Plant height at harvest, Days to 1st sprouting, Days to 50 % sprouting, No. of tillers per clump at harvest, No. of leafs per plant at harvest, Leaf length, Leaf breadth, Leaf area index, Rhizome length, Rhizome breadth, Yield^{-1} plant and Yield^{-1}ha were recorded. The data obtained during investigation was statistically analyzed as per the procedure and design given by Panse and Sukhatme (1985). The statistical significance was tested by applying 'F' test at 0.05 level of probability and critical differences were calculated for those parameters which turned significant (*P < 0.05) to compare the effects of different treatments.

Results and Discussion

Seed rhizome size significantly influencing the vegetative growth, yield and yield attributes. Among the seed rhizome sizes, rhizome size of R_3(40 g) recorded maximum number of tillers per plant (12.25), plant height (97.93 cm) and number of leaves per plant (137.47) at harvest. Leaf length, leaf breadth and leaf area index were found to be significantly maximum from 40 g seed rhizome size (23.71 cm, 2.46 cm and 4.57 respectively). Similarly days to first sprouting and days to 50 percent sprouting was lowest from R_3 (40 g) rhizome size. Increase in growth parameters with the increase in seed rhizome size could be due to large amount of food reserves in rhizomes. Similar results were reported by Monnaf *et al.,* (2010) and Sengupta and Dasgupta (2011).

With regard to yield and yield attributing parameters, maximum rhizome length (17.03 cm), rhizome breadth (17.16 cm), yield per plant (206.88 g) and yield per hectare (25.69 t) were recorded with 40 g rhizome size. Whereas, R_1 (20 g) seed rhizome size produced lower values for yield attributes. The variation in yield and yield attributes due to seed rhizome size might be due to the fact that the plants produced from the largest rhizome size emerged earlier and showed vigorous and rapid growth using the initial reserve food materials and producing maximum yield and yield attributes than the smaller rhizome size in ginger. Similar results were reported by Monnaf *et al.,* (2010), Ghosh and Hore (2011) and Yadav *et al.,* (2013).

Plant spacing significantly influencing the growth, yield and yield attributes of ginger except, days to first sprouting, days to 50% sprouting, rhizome length and rhizome breadth. Among the different plant spacing, S_4 (30 cm × 30 cm) spacing showed maximum values for number of tillers per plant (12.36) and number of leaves per plant (135.20) at harvest. Leaf length, leaf breadth and leaf area (23.24 cm and 2.11 cm) were highest with S_4 (30 cm × 30 cm) spacing. The plant density had marked influence on the capacity of plants to utilize environmental factors in building up the plant tissues through regulation of absorption capacity of plants due to better utilization of resources and lesser plant to plant competition. Hence, widely spaced plants produced more number of tillers per plant and leaves per plant. These results are in line with Yadav *et al.,* (2013) in ginger crop.

However, Maximum plant height (98.20cm) at harvest and highest leaf area index (6.61) was recorded from a spacing of S_1 (25 cm × 15 cm). Minimum days to first sprouting (10.11) and days to 50% sprouting (19.11) were reported from S_4 (30 cm × 30 cm) spacing.

With regard to yield and yield attributing parameters, maximum rhizome length (16.54 cm), rhizome breadth (17.12 cm) and yield per plant (200.93 g) were observed from a wider spacing of 30 cm × 30 cm. Whereas, yield per hectare (25.77 t) was recorded from closest spacing of 25 cm × 15 cm. The longest, broadest rhizome with wider spacing might be due to better availability of plant nutrients, moisture and light in wider spaced plants. Under closer spacing rhizome could not expose properly, which ultimately resulted in smaller rhizome. Similar results were reported by Yadav *et al.,* (2013).

The interaction effect between seed rhizome size and plant spacing was found to be significant for certain growth and yield attributes except, days to first sprouting, days to 50% sprouting, number of leaves at harvest, leaf area index and rhizome breadth. The highest rhizome yield per plant (220.80 g) was obtained from a combination of 40 g rhizome size with 30 cm × 30 cm spacing (R_3S_4). However, yield per hectare (30.56 t) was found to be maximum with 40 g rhizome size and 25 cm × 15 cm spacing (R_3S_1). The highest rhizome yield with larger seed rhizome size and closer spacing might be due to more number of plants per unit area with vigorous and rapid growth of the plant using the initial reserve food material. However growth parameters like tillers per plant

Table 1: Effect of Rhizome size, plant spacing on days to 1st sprouting, days to 50% sprouting and plant height under mango- ginger intercropping.

Rhizome size	Days to 1st sprouting						Days to 50% sprouting						Plant Height (cm) at harvest					
	Plant spacing																	
	S1	**S2**	**S3**	**S4**	**S5**	**Mean**	**S1**	**S2**	**S3**	**S4**	**S5**	**Mean**	**S1**	**S2**	**S3**	**S4**	**S5**	**Mean**
R1	11.67	11.33	11.67	10.67	11.33	11.33	21.67	21.67	22.33	21.00	21.67	21.67	93.07	91.13	89.67	88.73	93.40	91.20
R2	11.00	11.00	10.67	10.33	11.00	10.80	20.33	20.67	20.00	20.00	19.67	20.13	98.67	96.47	93.20	97.80	91.20	95.47
R3	10.33	10.00	9.67	9.33	9.00	9.67	17.00	18.67	17.67	16.33	16.33	17.20	102.87	98.60	97.87	98.27	92.07	97.93
Mean	11.00	10.78	10.67	10.11	10.44		19.67	20.33	20.00	19.11	19.22		98.20	95.40	93.58	94.93	92.22	
	S.Em ±	CD(5%)					S.Em ±	CD(5%)					S.Em ±	CD(5%)				
R	0.19	0.55					0.22	0.63					0.72	2.08				
S	0.24	NS					0.28	0.81					0.93	2.69				
R X S	0.42	NS					0.48	NS					1.61	4.66				

Table 2: Effect of rhizome size, plant spacing on no. of tillers per plant, no. of leaves per clump and length of the leaf under mango- ginger intercropping

Rhizome size	No.of Tillers per plant at harvest						No.of leaves per clump at harvest						Length of Leaf (cm)					
	Plant spacing																	
	S1	**S2**	**S3**	**S4**	**S5**	**Mean**	**S1**	**S2**	**S3**	**S4**	**S5**	**Mean**	**S1**	**S2**	**S3**	**S4**	**S5**	**Mean**
R1	6.80	6.33	8.92	9.60	9.53	8.24	121.67	114.67	113.07	122.47	117.47	117.87	21.07	21.53	21.59	21.00	22.25	21.49
R2	10.73	10.27	11.00	12.60	11.50	11.22	127.20	119.87	121.27	139.13	129.20	127.33	23.71	20.73	23.53	23.95	22.93	22.97
R3	11.27	10.47	12.13	14.87	12.50	12.25	132.00	137.73	136.93	144.00	136.67	137.47	22.97	24.47	22.76	24.77	23.58	23.71
Mean	9.60	9.02	10.68	12.36	11.18		127	124.09	123.76	135.20	127.78		22.58	22.24	22.63	23.24	22.92	
	S.Em ±	CD(5%)					S.Em ±	CD(5%)					S.Em ±	CD(5%)				
R	0.19	0.54					1.48	4.28					0.26	0.76				
S	0.24	0.7					1.91	5.52					0.34	NS				
R X S	0.42	1.21					3.3	NS					0.59	1.71				

R1=20g R2=30g R3=40g S1=25 × 15 cm, S2=25 × 15 cm, S3=30 × 20 cm, S4=30 X 30 cm, S5=40 × 20 cm

Table 3: Effect of Rhizome size and plant spacing on breadth of leaf, Leaf area Index, length of the rhizome under mango- ginger intercropping.

Rhizome size	Breadth of Leaf(cm)						Leaf area Index						Length of the rhizome(cm)					
	Plant spacing																	
	S1	**S2**	**S3**	**S4**	**S5**	**Mean**	**S1**	**S2**	**S3**	**S4**	**S5**	**Mean**	**S1**	**S2**	**S3**	**S4**	**S5**	**Mean**
R1	2.12	2.21	1.79	2.14	2.03	2.06	6.51	3.81	3.97	2.90	3.48	4.13	12.80	13.67	14.93	15.35	14.83	14.32
R2	2.26	2.19	2.24	2.60	2.45	2.35	6.60	4.45	4.44	3.17	3.51	4.43	17.93	16.63	14.77	15.67	17.30	16.46
R3	2.45	2.47	2.29	2.63	2.47	2.46	6.72	4.50	4.54	3.46	3.61	4.57	17.37	16.09	17.18	18.59	15.91	17.63
Mean	2.28	2.29	2.11	2.46	2.32		6.61	4.25	4.32	3.18	3.53		16.03	15.46	15.63	16.54	16.01	
	S.Em ±	CD(5%)					S.Em ±	CD(5%)					S.Em ±	CD(5%)				
R	0.05	0.15					0.08	0.22					0.26	0.76				
S	0.07	0.19					0.10	0.28					0.34	NS				
R X S	0.11	NS					0.17	NS					0.58	1.69				

Table 4: Effect of rhizome size and plant spacing on breadth of rhizome, fresh rhizome yield per plant and yield per ha. under mango- ginger intercropping.

Rhizome size	Breadth of the rhizome(cm)						Rhizome yield per plant (g)						yield per ha. (t)					
	Plant spacing																	
	S1	**S2**	**S3**	**S4**	**S5**	**Mean**	**S1**	**S2**	**S3**	**S4**	**S5**	**Mean**	**S1**	**S2**	**S3**	**S4**	**S5**	**Mean**
R1	13.73	13.51	14.63	17.37	14.87	14.82	152.00	162.93	181.13	192.73	180.97	173.95	18.97	22.78	24.76	18.28	17.83	20.52
R2	15.73	16.00	16.70	15.58	17.53	16.31	213.00	206.73	183.27	189.23	197.40	197.93	27.78	25.73	17.03	21.49	23.13	23.03
R3	16.57	16.83	17.43	18.43	16.57	17.16	198.83	208.67	200.93	220.80	208.17	206.88	30.56	25.85	27.03	25.83	19.18	25.69
Mean	15.35	15.44	16.25	17.12	16.32		187.94	192.78	188.44	200.93	194.51		25.77	24.79	22.94	21.87	20.04	
	S.Em ±	CD(5%)					S.Em ±	CD(5%)					S.Em ±	CD(5%)				
R	0.31	0.91					1.68	4.86					1.07	3.09				
S	0.41	1.18					2.17	6.28					1.38	3.99				
R X S	0.7	NS					3.75	10.87					2.39	6.91				

R1=20g R2=30g R3=40g S1=25 × 15 cm, S2=25 × 15 cm, S3=30 × 20 cm, S4=30 × 30 cm, S5=40 × 20 cm

and leaves per plant and yield attributes like rhizome length, breadth and yield per plant was highest with larger seed rhizome and wider plant spacing might be due to better availability of plant nutrients, light and moisture and better utilization of resources due to lesser plant competition. Similar results were reported by Ghosh and Hore (2011) in ginger.

Conclusions

From the investigation, "Evaluation of influence of rhizome size and plant spacing on growth and yield attributes of ginger (*Zingiber officinale* L.) in ginger-mango based inter cropping system", it could be concluded that an increase in seed rhizome size of ginger significantly improved the growth and yield components of ginger under mango cropping systems.

Regarding plant spacing, it could be concluded that closer spacing was found to increase the yield per hectare. However, wider spacing improving the yield per plant and other rhizome attributing characters *viz.,* rhizome length and breadth. Interaction effect of rhizome size and plant spacing exhibited significant variation on the yield of ginger. The yield per hectare showed highest value under the treatment combination of largest rhizome size (40 g) with closer plant spacing (25 cm × 15 cm) and on the other hand, lowest yield was reported from the treatment combination of smallest rhizome size with wider plant spacing.

It is also observed that most of the vegetative growth parameters were found to be higher under mango cropping system. In rhizome characters and fresh rhizome yield was found to be lower under mango cropping. This might be due bushy and more shading under 20 years old mango cropping system. It could be concluded that mango inter spaces can be better utilized in the initial stages of mango upto 10 years of age before its full canopy spread. The effect of light intensity in relation to day temperature and allopathic effect of inter crop during ginger crop growth period is further needs to be studied under dense mango cropping system. Further it may also required to study the impact of ginger inter crop on mango flowering and yield.

Future line of work

Increased rhizome size with closer spacing seems to improve the plant growth parameters and yield attributes in zinger under mango intercropping. The influence of rhizome size and plant density on quality parameters and allelopathic effect of intercrop on growth and quality parameters need to be studied as future line of work. Further, the shade influence on ginger under different cropping systems like coconut may be studied.

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