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OPTIMIZATION OF RHIZOME SIZE AND PLANT SPACING ON GROWTH AND YIELD COMPONENT TRAITS OF GINGER

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Abstract– The rhizome seed size and plant spacing is important factor that affects the growth and yield of ginger. Two year an experiment was conducted on seed rhizome size and intra row spacing of ginger cv. Gorubathan to determine the optimum rhizome size and optimum plant spacing for yield enhancement. The experiment was conducted at the Regional Research Station (OAZ), UBKV, Majhian, during 2020-2021. The experiment considered with three different rhizome sizes (20g, 30g and 40g) and five different plant spacing (20 × 20 cm, 25 × 20 cm, 25 × 25 cm, 30 × 25 cm and 30 × 30 cm) combination following randomized block design with three replications. From the pooled data resulted larger size rhizome seed (40g) and 25 cm × 20 cm plant spacing combination resulted significantly increase and maximum value for plant height at harvest (72.08 cm), number of tillers per plant^{-1} (12), number of leaves plant^{-1} (134.50), rhizome length (18.16) and rhizome yield plant^{-1} (249.95 g) whereas 20g seed size significantly reduced yield component traits. The correlation study of yield component traits revealed that positive and significant association of rhizome yield exerted with number of tiller plant^{-1}, number of leaves plant^{-1} and rhizome length.

INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) is an important spices crops that commercially grown in temperate to tropical climate but it can also be grown in both the rainfed and irrigated situations (Sharma and Sharma, 2012). It has been cultivated for culinary purposes in the households to its distinct colour, aroma and flavor. Also due to its carminative and stimulant properties, can be use as traditional remedy to cure coughs, vomiting, asthma, constipation, hypertension and arthritis (Sekiwa *et al*., 2000, Kumari *et al.,* 2021). Fresh ginger is mostly used for culinary purpose to add flavour in food whereas dry ginger is used to make ginger oil, oleoresin, essence, soft drink and non-alcoholic beverages. India is the leading country for ginger production, consumer and exporter in the world and share about 34.6% of total area under cultivation (Patra *et al*., 2022). In India ginger is mostly grown in Madhya Pradesh, Kerala, Sikkim, Meghalaya, West Bengal, Orissa, Tamil Nadu, Karnataka, Andhra Pradesh and Madhya Pradesh is the largest producing state in India with production of 23.47% (APEDA, 2020).

In West Bengal, the cultivation of ginger is spread to most of the areas but productivity occurs low due to improper management practices and irregular maintenance of plant spacing. Among different factors influencing production of ginger, the rhizome size and plant spacing combination is considered vital factor for better plant growth, which can be manipulated to boost up the productivity. The seed rhizome is the economic yield as well as the planting material of ginger. The size of rhizome seeds play a significant role for production and yield of ginger, the size of rhizome should be more or less 20-25 g with 2.5-5 cm length having buds (Hailemichael and Tesfaye, 2008) and appropriate size crucial for its productivity, whereas very large or small sizes rhizome reduced commercial product as well as growth and yield.

The proper plant spacing is also important management practices along with optimum rhizome sizes have significant influence on the growth and yield of ginger (Monnaf *et al.*, 2010). Previously, many studies have been reported that the use of large size rhizome seeds could increases the rhizome yield of ginger than the small sizes (Whiley, 1990; Borget, 1993; Nybe and Raj, 2004), but optimum size and plant spacing for general cultivation was fail to explain. Considering these facts, the present investigation was undertaken with ginger cultivar Gorubathan to optimize the seed rhizome size and plant spacing for obtaining higher yield of ginger in Old Alluvial Zone of West Bengal.

MATERIALS AND METHODS

Experimental area

An experiment was carried out at the Regional Research Station (OAZ), Uttar Banga Krishi Viswavidyalaya (UBKV), Majhian from 2020 to 2021 to evaluate the effect of rhizome size and intra row spacing on growth and yield attributing traits of ginger cultivar Gorubathan. The experimental site is situated at latitude 25°19′ N and longitude 88°46′ E with an altitude of about 43 m above mean sea level.

Treatments and experimental design

The seed rhizome was one year old having at least two active buds. Rhizome seed used in the experiment was from the ginger cultivar Gorubathan, which was collected from UBKV, Pundibari. The experiment was considered with three different rhizome sizes consisting of small (20g), medium (30g) and large (40g); and five different plant spacing (20 × 20 cm, 25 × 20 cm, 25 × 25 cm, 30 × 25 cm and 30 × 30 cm). Plot size of each treatment was maintained at $3m^2$. The treatments combinations (Table 1) were planted field following Randomized Block Design with three replications.

Planting procedures

The seed rhizome of ginger cv. Gorubathan was planted at mid March of 2020 and 2021. The experimental land was well prepared manually and depth of planting was 5-10 cm. The recommended dose of FYN 25 ton ha^{-1} and inorganic fertilizer (NPK-120:60:80 kg h^{-1}) were applied as per the schedule. Nitrogen applied in two split doses with half part at before planting of seed rhizome and rest part at 40DAP. Intercultural operations were given according to the requirements of the crop.

Data recording

Data on various growth and yield component traits of ginger were collected from samples of five plants in each plot during maturity stage. The observations were taken for days to first sprouting, plant height (cm) at maturity, no. of tiller $plant^{-1}$ at maturity, no. of leaves per plant, rhizome length (cm), rhizome breadth (cm) and yield $plant^{-1}$ (gm).

Statistical analysis

The data generated throughout the course of the study were statistically analyzed using SPSS var. 16 software. Significance test for the treatment differences were done at P<0.5% level. Correlation analyses were done among the growth and yield components traits using Pearson's correlation coefficient.

RESULTS AND DISCUSSION

The results showed significant differences ($P < 0.05$) of rhizome seed size and plant spacing combinations for all the yield component traits except days to sprouting (DFS), where it was found non-significant responses (Table 2). The interaction of rhizome seed size and plant spacing significantly influenced to plant height of ginger. Plant height was significantly increased in the wider spacing compared with closer spacing. It has been revealed that highest plant height was observed in treatment R_3S_2 (72.16 cm and 72 cm) followed by R_3S_5 (70.1 cm and 69.3 cm) and minimum height was found in R_1S_1 (55.2 cm and 54.0 cm) in both the years. Highest plant height in ginger cultivation by large size

Table 1. Treatment details of ginger cultivation

Sl. No.	Treatments	Rhizome size	Spacing
1	R1S1	20g	20 x 20cm
2	R1S2	20g	25 x 20cm
3	R1S3	20g	25 x 25cm
4	R1S4	20g	30 x 25cm
5	R1S5	20g	30 x 30cm
6	R2S1	30g	20 x 20cm
7	R2S2	30g	25 x 20cm
8	R2S3	30g	25 x 25cm
9	R2S4	30g	30 x 25cm
10	R2S5	30g	30 x 30cm
11	R3S1	40g	20 x 20cm
12	R3S2	40g	25 x 20cm
13	R3S3	40g	25 x 25cm
14	R3S4	40g	30 x 25cm
15	R3S5	40g	30 x 30cm

rhizome (40g) also reported by Mahender *et al.* (2015).

Like wise maximum number of tiller plant^{-1} was obtained from R_3S_3, i.e. large size rhizome (40g) with spacing (25 cm x 25cm) combination (13 and 12.6) followed by R_3S_1 (12 and 11.6) and lowest was exerted from small size rhizome (20g) with close spacing (20 cm x 20 cm), i.e R_1S_1 (8 and 7.6) in both the years. This may be due to large seed rhizome conserved the more food materials and nutrients as well as moisture that ultimately result produced more number of tiller plant^{-1} (Ghosh *et al.,* 2011; Mahender *et al.,* 2015).

The maximum number of leaves and rhizome length was recorded from large size rhizome (40g) with spacing (25 cm x 20cm) combination (R_3S_2) and lowest was from small size rhizome (20g) with wide spacing (30 cm x 30 cm). In this study, large seed rhizome produced more leaves than the small size seed rhizome (Korla *et al.,* 1989). Rhizome breadth was maximum in R_3S_3 (19.25g and 18.67g) and minimum was R_1S_2 (11.7g and 11.6g). The reason for longest and broadest rhizome production by use of large size rhizome and wider spacing might be due to better availability of plant nutrients, moisture and light (Monnaf *et al*., 2010; Sengupta and Dasgupta, 2011; Mahender *et al.,* 2015; Modupeola *et al*., 2013; Yadav *et al*., 2013). Significant difference in yield plant^{-1} was noticed by the effect of different rhizome size and plant spacing combination. The maximum yield plant^{-1} was obtained from R_3S_2 (250.2 g and 249.6 g) combination followed by R_3S_4 (215.2 g and 218 g) and lowest was recorded in R_1S_5 (150 g and 152 g). Here larger rhizome seed size (40g) produced pronounces and significant yield increases in ginger (Islam *et al.,* 2017). Significant yield improvement by large seed rhizome showed vigorous growth than those of the smaller ones, which might be help to plants to produce more photosynthesis activity and enhanced crop growth rate resulted in efficient metabolism for plant growth (Asish and Wamana, 1989; Yadav *et al*., 2013; Lal *et al.,* 2022). 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 (Mahender *et al.,* 2015). The reduction in yield traits under close spacing and small size rhizome combination might be due to comparatively poor growth and development of individual plants owing to competition for growth resource like space, sunlight, nutrients, moisture etc (Mohanti *et al*., 1993; Singh *et al*., 2000).

The character association study of growth and yield component traits among the different treatments were presented in Table 3. It was found

Table 2. Effect of different rhizome size and spacing on yield traits in ginger

Treatments	DFS		PH		NTPP		NLPP		RL		RB		YPP	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
R1S1	14.0	13.6	55.2	54.0	8.0	7.6	101.0	99.6	14.2	13.6	12.0	11.0	170.2	169.6
R1S2	16.0	15.3	65.1	65.0	8.0	8.6	100.0	101.6	12.0	12.6	11.7	11.6	165.2	165.6
R1S3	14.0	14.3	62.2	62.0	9.0	9.0	98.0	98.0	13.8	14.0	14.2	14.0	160.9	161.3
R1S4	13.0	13.6	61.7	61.6	9.0	9.6	100.0	100.6	13.0	14.3	12.5	12.0	190.2	194.0
R1S5	14.0	14.6	60.0	60.3	7.0	7.3	96.0	97.67	14.0	14.0	14.1	13.6	150.0	152.0
R2S1	13.0	13.3	69.2	69.3	11.0	11.0	120.0	120.0	14.2	14.0	15.9	16.0	180.2	177.0
R2S2	12.0	13.0	64.0	64.0	9.0	9.0	105.0	104.3	15.1	15.6	16.2	16.6	200.05	200.3
R2S3	13.0	13.6	69.2	69.3	11.0	11.0	116.0	116.3	14.8	15.3	15.6	15.6	199.9	200.3
R2S4	14.0	13.6	60.1	59.0	10.0	10.6	102.0	103.0	16.2	15.3	17.1	17.0	210.7	211.0
R2S5	14.0	14.6	62.0	62.0	9.0	9.0	110.0	110.0	12.0	12.3	14.9	15.6	190.2	190.6
R3S1	13.0	13.0	69.0	68.6	12.0	11.6	120.0	119.3	15.1	16.3	18.2	18.6	200.1	200.6
R3S2	13.0	12.6	72.1	72.0	11.0	13.0	135.0	134.0	18.6	17.6	16.1	16.6	250.2	249.6
R3S3	11.0	12.3	66.3	65.6	13.0	12.6	102.0	102.0	15.0	16.0	19.2	18.6	195.3	194.6
R3S4	12.0	14.0	68.2	69.3	10.0	10.3	110.0	110.0	16.0	15.3	18.1	18.0	215.2	218.0
R3S5	14.0	15.0	70.1	69.3	11.0	10.6	116.0	115.3	14.8	14.6	14.0	14.6	200.1	202.0
C.D. (0.5%)	N/A	N/A	1.59	2.23	2.29	1.89	2.96	3.75	1.95	1.23	1.89	2.43	7.84	5.76
SE(m)	0.89	0.99	0.55	0.77	0.79	0.65	1.02	1.29	0.67	1.11	0.65	0.83	13.0	1.98
C.V.	11.61	12.44	1.46	2.05	13.76	11.27	1.62	2.05	7.93	13	7.34	9.42	11.94	1.78

DFS= Days to first sprouting, PH= Plant height (cm) at maturity, NTPP= Number of tiller plant^{-1} at maturity, RL= Rhizome length (cm), RB =Rhizome breadth (cm), YPP= Yield plant^{-1} (gm)

Table 3. Character association among the treatments for traits in ginger

Characters	DFS	PH	NTPP	NLPP	RL	RB	RY
DFS	1	-0.031	-0.519	-0.068	-0.554	-0.649	-0.319
PH		1	0.447	0.789**	0.203	0.054	0.213
NTPP			1	0.341	0.321	0.466	0.662*
NLPP				1	0.399	-0.005	0.652*
RL					1	0.389	0.761**
RB						1	0.076
RY							1

DFS= Days to first sprouting, PH= Plant height (cm) at maturity, NTPP= Number of tiller plant^{-1} at maturity, RL= Rhizome length (cm), RB =Rhizome breadth (cm), YPP= Yield plant^{-1} (g)

that rhizome yield positive and significantly association with number of tiller plant^{-1}, number of leaves plant^{-1} and rhizome length. Plant height was found positive and significantly association with number of leaves plant^{-1}.

CONCLUSION

The result suggested that rhizome yield and yield component traits of ginger significantly affected by the rhizome sizes and different plant spacing combination. The growth and yield traits of ginger were significant improving occurred by use large seed rhizome (40g). Planting with 40 g seed rhizome with 25 cm x 20 cm spacing may be recommended for ginger for maximising the yield. Also growth characteristics such as plant height, number of tiller, number of leaves and root length were found maximum responses from the larger size rhizome (40 g).

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