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Growth and yield of ginger (*Zingiber Officinale* Rosc.) as influenced by different seed size and spacing

Chandrashekhar G, Hore JK
Department of Spices and Plantation Crops, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Abstract
Ginger (*Zingiber officinale* Roscoe), is an important spice crop in India. An experiment was carried out at Horticultural Research Station, Mondouri, BCKV, West Bengal to identify the optimum size of seed rhizome and spacing of ginger for production of cv. Gorubathan. Among different treatment combination, maximum height of plant was observed with (42.36 cm) 25g, 20x15 cm combination at 90 DAP followed by (74.16 cm) 25g 20x20 cm combination at 150 DAP, maximum number of leaves (8.58) per tiller was observed with 25g, 20x20 cm at 90 DAP followed by 14.82 with 25g 20x15 cm at 150 DAP, highest number of tillers were observed with (141.38) 25g, 25x20 cm at 150 DAP followed by (95.64) 25g, 25x20 cm at 90 DAP, maximum weight of clump 200.65 g observed with 25g, 25x20 cm, length of clump observed with (16.05 cm) 25g, 25x20 cm, breadth of clump observed with (12.54) 25g, 20x20 cm and projected yield (t ha^{-1}) were recorded highest in planted with mother rhizome pieces directly sowing of 25g, with the spacing of 20x15 cm (29.95 t ha^{-1}) respectively.

Keywords: ginger, planting material, rhizome size and yield

Introduction

Ginger (*Zingiber officinale* Rosc.) belongs to the family Zingiberaceae, has been prized for its aroma flavour, pungency and medicinal properties since ancient times. Commonly used as a spice for over 2000 years. It is one of the earliest oriental spices known to Europe and is still in large demand today. Among the major spices grown in the country, ginger occupied an important place, as it is a valuable source of foreign exchange. 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) [8]. 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) [5]. Therefore, selecting the right size of planting material is the most critical factor in the ginger cultivation (Padmadevi *et al.*, 2012) [6]. Ginger cultivation is both capital and labour intensive. Among the inputs, the cost of planting material is particularly important as it amounts for nearly 40-46 % of the overall production cost under good management practice. In India rhizome pieces weighing 20-25 g (AICRPS, 1992) [1] are being utilized for planting.

In ginger transplanting technique mainly by using bud sprouts raised in pro-trays was standardised by Indian Institute of Spice Research, Kozhikode (IISR, 2014) [4]. The results of replicated trail with difference for fresh yield among single sprout transplanting and direct planting of 20-25 g seed rhizome. The main advantage of this transplanting technology is production of healthy planting materials as well as reduction of seed rhizome quality and eventually reduced cost on seed.

Materials and Methods

The experiment was carried out at Horticultural Research Station, Mandouri, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during 2016 and 2017 with the variety Gorubathan. The experiment were laid out in Split-plot design with three replications. Raised beds of 3.0 x 1.0 m and 15 cm height were prepared. Rhizome bits of different size (R_1 =4.0 g, R_2 =8.0 g, R_3 =12 g and R_4 =25g) with both single node and multiple nodes were used for planting. The rhizome bits were treated with a solution mixture of Metalaxyl (3g l^{-1}) and Dithane M-45 (2g l^{-1}) for thirty minutes and dried in shade. The treated rhizome bits were raised in pro-trays during first week of April, having a composition of FYM and soil in the ratio of 3:1. Seedlings of 45 days old were transplanted in the plots at a different spacing (S_1 = 20 x 15, S_2 = 20 x 15 and S_3 = 25 x 20 cm) as per the treatment. In the experiment ginger was fertilised @ 200:75:100 kg NPK ha^{-1} (Dey, 2011). The organic inputs *i.e.* farmyard manure @ 25 t ha^{-1} was applied as basal during final land preparation. The total amount of fertilizers were applied in three split doses. One third of N and full dose of P were applied as basal where as each split of 1/3rd N and ½ K were applied at 45 and 90 days after planting.

Results and Discussion

Planting method significantly influenced the growth of plant (Table 1 and 2). Different growth and yield parameters showed significant variation among the treatment combination. Among interactions both rhizome size and spacing had significant influence on plant height at different stages of plant growth. In increasing trend in plant height was noticed at 90 days after planting with increasing size of seed rhizome. The maximum plant height of 40.09 cm was noticed with highest rhizome size (25g) as compared to minimum plant height of 28.79 cm in plant raised from 4.0 g seed rhizome. In respect of sole effect of spacing, the plant raised under medium spacing (20x20 cm) recorded maximum plant height (37.42 cm) as compared to closest (35.99 cm) and widest (35.2 cm) spacing. In respect of interaction effect, the maximum plant height of 42.36 cm was recorded with 25g rhizome under closest spacing (20x15 cm). At 150 days after planting, in respect of sole effect of seed rhizome size, the plant height increased from 50.95 cm to 71.85 cm under 4.0 g and 25g seed rhizome. In case of spacing, the maximum plant height of 61.53 cm was noticed when plants were grown under 20x15 cm. As per interaction the R_4S_2 (25g, 20x20 cm) combination recorded maximum plant height of 74.16 cm followed by R_4S_1 (25g, 20x15 cm) as compared to minimum plant height of 49.02 cm under R_1S_2 (4g, 20x20 cm). At 90 days after planting, the maximum number of tillers (8.25) was observed. In respect of sole effect of spacing, the increasing trend was observed with increasing the spacing (20x15 cm to 25x20 cm). Among different combination, maximum tiller number (8.58) was noticed with R_4S_2 (25g, 20x20 cm) followed by R_4S_1 (8.34) as compared to minimum tiller number (5.86) with R_1S_1 (4g, 20 x 15 cm) combination. At 150 days after planting, maximum number of tillers (13.32) was observed in plants raised from 25g seed rhizome as compared to minimum tiller number (8.73) under 4g seed rhizome. Increasing trend in tiller number was noticed with increasing the spacing. Among different combination maximum tiller number (14.82) was noticed with R_4S_1 (25g, 20x15 cm) followed by R_4S_2 (14.68), though both of them were at par the minimum tiller number (8.91) was recorded with R_1S_1 (4g, 20x15 cm). Significant variation in leaf number were also observed with different combinations of seed rhizome size and spacing at different stages of growth. Leaf number increased from 74.97 to 90.13 due to increase of seed rhizome size from 4g to 25g. Among the spacing, the maximum leaf number of 85.50 was recorded with widest spacing (25x20 cm). Among the interaction, the maximum leaf number of 95.64 was recorded in R_4S_3 (25g, 20x15 cm) combination followed by (88.26), as compared to minimum (69.07) leaf number under R_1S_1 (4g, 20x15 cm) combination. In each category of seed rhizome, generally the number of leaves increased with increasing spacing at 90 days after planting. At 150 days after planting the data, showed as increasing trend in leaf number with the increasing in seed rhizome size and spacing. The leaf number increased from 117.08 to 134.35 with the increasing on seed rhizome size from 4.0g to 25g. In case of spacing, the maximum (129.55) and minimum (118.66) leaf numbers were recorded in 25x20 cm and 20x15 cm spacing respectively. In interaction, the maximum (141.38) leaf number was noticed in treatment combination R_4S_3 (25g, 25x20 cm) followed by R_4S_2 (132.75) as compared to lowest leaf number in R_1S_1 (113.56) combination. Different yield parameters like weight, length and breadth of clump, and projected yield showed significant variation among the treatments (Table 1 - 4). Increasing trend in clump weight was noticed with increasing size of seed rhizome and spacing. The clump weight increased from 120.69 g to 185.62 g due to increase in seed rhizome size from 4.0 g to 25 g. Maximum (166.13 g) and minimum (141.24 g) clump weight were observed with 25x20cm and 20x15cm spacing respectively. Among the interactions, maximum clump weight (200.65 g) was recorded in R_4S_3 (25g, 25x20 cm) combination followed by R_3S_3 (186.13 g) as compared to lowest weight (108.24g) in R_1S_1 (4g, 20x15 cm) combination.

Increasing trend in length of clump was also noticed with increasing the size of rhizome. The length of clump increased from 12.91 cm to 15.45 cm due to increase of rhizome size from 4 g to 25 g. In respect of sole effect of spacing the maximum (14.38 cm) and minimum (13.80 cm) length of clump were noticed with 25x20 cm and 20x15 cm spacing respectively. As per interaction, the maximum length (16.05 cm) of clump was noticed in R_4S_3 (25g, 25x20 cm) combination followed by R_4S_1 (15.73g) combination as compared to minimum length (12.68 cm) with R_1S_1 (4g, 20x15 cm) combination.

The breadth of clump increased from 8.68 cm to 12.14 cm due to increase of seed rhizome size from 4 g to 25 g. In case of spacing, the maximum breadth (10.61 cm) was noticed in 25x20 cm spacing. In respect of interaction, the maximum breadth (12.54 cm) was recorded in R_4S_2 (25g, 20x20 cm) combination followed by R_4S_3 (25g, 25x20 cm) combination (12.16 cm) as compared to minimum breadth (8.28 cm) in R_1S_2 (4g, 20x20 cm) combination. In case of sole effect of rhizome size the maximum (26.73 t ha^{-1}) and minimum (16.26 t ha^{-1}) yield were associated with 25 g and 4.0 g rhizome respectively (Table 3 and 4). The plants raised under closest spacing (20 x15 cm) recorded maximum (24.65 t ha^{-1}) projected yield as compared to minimum yield (17.95 t ha^{-1}) under widest spacing (25 x 20 cm). Among different interactions, maximum projected yield (29.95 t ha^{-1}) was recorded in R_4S_1 (25g, 20 x 15 cm) followed by R_4S_2 (27.13 t ha^{-1}) as compared to minimum projected yield of 13.86 t ha^{-1} in R_1S_3 (4g, 25 x 20 cm) combination. Similar results are also found (Prasath *et al.*, 2018) [7] with the 5 g single sprouts produced rhizome yield that was on par with 25 g direct plant often, apparently due to the cumulative effect of better growth in necessary and in field.

This early establishment and bulking of rhizomes of transplanted ginger might be the reason for higher yield. However, growth parameters like number of leaves $plant^{-1}$, yield attributes and yield 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) [3] in ginger.

Table 1: Effect of seed rhizome size and spacing on growth parameters of ginger (Pooled of two years)

Treatment	Plant height (cm)		Number of tillers per clump		Number of leaves per clump	
	90 DAP	150 DAP	90 DAP	150 DAP	90 DAP	150 DAP
Rhizome size						
R_1 (4g)	28.79	50.95	5.64	9.66	74.97	117.09
R_2 (8g)	36.41	56.00	6.24	11.32	79.69	120.87
R_3 (12g)	39.62	62.15	6.87	12.68	82.14	123.21
R_4 (20-25g)	40.09	71.85	8.25	14.25	90.13	134.35
S.Em. (±)	0.0359	0.061	0.008	0.0151	0.048	0.0521
C.D. (P=0.05)	0.1106	0.189	0.026	0.0465	0.149	0.1603
Spacing						
S_1 (20X15 cm)	35.99	61.53	6.51	11.84	78.57	118.66

S_2 (20X20 cm)	37.42	60.65	6.80	11.88	81.12	123.44
S_3 (25X20 cm)	35.27	58.53	6.95	12.22	85.50	129.55
S.Em. (±)	0.145	0.241	0.027	0.0486	0.330	0.499
C.D. (P=0.05)	0.418	0.696	NS	0.140	0.952	1.433

Table 2: Interaction of seed rhizome size and spacing on growth parameters of ginger (pooled of two years)

Treatment	Plant height (cm)		Number of tillers per clump		Number of leaves per clump	
	90 DAP	150 DAP	90 DAP	150 DAP	90 DAP	150 DAP
R_1S_1	28.48	52.24	5.06	8.91	69.07	113.56
R_1S_2	30.76	49.02	5.62	9.26	74.38	120.18
R_1S_3	27.12	51.58	6.24	10.82	81.46	117.52
R_2S_1	34.68	58.38	5.82	11.46	74.84	114.32
R_2S_2	38.92	55.26	6.34	10.92	85.38	121.45
R_2S_3	35.64	54.37	6.57	11.58	78.84	126.84
R_3S_1	38.45	62.93	6.82	12.17	82.12	117.82
R_3S_2	39.25	64.16	6.64	12.65	78.25	119.36
R_3S_3	41.16	59.36	7.16	13.22	86.05	132.45
R_4S_1	42.36	72.58	8.34	14.82	88.26	128.92
R_4S_2	40.74	74.16	8.58	14.68	86.48	132.75
R_4S_3	37.16	68.82	7.82	13.24	95.64	141.38
RXS S.Em. (±)	0.290	0.483	0.054	0.097	0.661	0.998
C.D.(P=0.05)	0.836	1.393	NS	0.280	1.904	2.875

Table 3: Effect of seed rhizome size and spacing on clump characters and project yield of ginger (pooled of two years)

Treatment	Weight of clump (g)	Length of clump (cm)	Breadth of clump (cm)	Projected yield (t ha^{-1})
Rhizome size				
R_1 (4g)	120.69	12.91	8.68	16.26
R_2 (8g)	134.15	13.29	9.65	18.14
R_3 (12g)	169.98	14.37	11.04	21.75
R_4 (20-25g)	185.62	15.45	12.14	26.73
S.Em. (±)	0.269	0.007	0.010	0.038
C.D. P=0.05)	0.830	0.023	0.031	0.118
Spacing				
S_1 (20X15 cm)	141.24	13.80	10.11	24.65
S_2 (20X20 cm)	150.46	14.32	10.42	20.50
S_3 (25X20 cm)	166.13	14.38	10.61	17.95
S.Em. (±)	0.671	0.056	0.041	0.090
C.D. (P=0.05)	1.933	0.162	0.120	0.259

Table 4: Interaction of seed rhizome size and spacing on clump characters and yield of ginger (pooled of two years)

Treatment	Weight of clump (g)	Length of clump (cm)	Breadth of clump(cm)	Projected yield (t ha^{-1})
R_1S_1	108.24	12.68	8.62	18.94
R_1S_2	121.78	13.14	8.28	15.97
R_1S_3	132.05	12.92	9.15	13.86
R_2S_1	124.62	13.25	9.26	21.80
R_2S_2	132.15	13.06	9.52	17.34
R_2S_3	145.68	13.56	10.17	15.29
R_3S_1	159.46	13.92	10.82	24.15
R_3S_2	164.35	14.43	11.35	21.57
R_3S_3	186.13	14.75	10.96	19.54
R_4S_1	172.65	15.73	11.72	29.95
R_4S_2	183.56	14.58	12.54	27.13
R_4S_3	200.65	16.05	12.16	23.10
RXS S.Em. (±)	1.342	0.112	0.083	0.180
C.D.(P=0.05)	3.862	0.325	0.241	0.518

Conclusion

The experiment was concluded that with different seed sizes and spacings have better growth, yield and quality potential. Yield per plant increases with narrow spacing, its mainly reflected in yield per hectare owing to the effect of density. However, using of smaller seed sizes with high multiplication ratio is preferable where planting material is scarce or limited planting material is to be multiplied.

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