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R Ara
Senior Scientific Officer (Horticulture), Regional Spices Research Centre, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh

M Ratna
Scientific Officer (Plant Breeding), Regional Horticultural Research Station, Bangladesh Agricultural Research Institute, Lebukhali, Patuakhali, Bangladesh

R Sarker
Scientific Officer (Horticultural), Spices Research Sub-Centre, Bangladesh Agricultural Research Institute, Faridpur, Bangladesh

MM Ahmed
Scientific Officer (Horticulture), Bangladesh Agricultural Research Institute, Spices Research Sub-Centre, Lalmonirhat, Bangladesh

MM Rahman
Scientific Officer (Horticulture), Spices Research Sub-entre, Bangladesh Agricultural Research Institute, Faridpur, Bangladesh

Correspondence Author:
R Ara
Senior Scientific Officer (Horticulture), Regional Spices Research Centre, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh

Effect of rhizome cut on the yield of ginger

R Ara, M Ratna, R Sarker, MM Ahmed and MM Rahman

Abstract
The experiment was conducted at Regional Spices Research Centre, Gazipur during April to February, 2017-2018 and 2017-2018. Five seed rhizome cut consisted of one bud viz., S_1=5±2 g, S_2=10±2 g, S_3=15±2 g, S_4=20±2 g and S_5=40±2 g were used in the experiment. Unit plot size was 5.0 m × 1.0 m. Seed rhizome were planted in two row maintaining inter and intra row spacing of 50 cm and 25 cm respectively. The experiment was laid out in Randomized Complete Block Design with three replications. The rhizomes were planted on April 18, 2016 and April 20, 2017 and the crop was harvested on February 22, 2017 and 2018, respectively. The lowest days (36) was recorded for 1st emergence in 2016-2017 and that of 42 days for 50% emergence in 2017-2018 when maximum rhizome cut (40±2 g) was used as planting material. Different weighed rhizome cut had a significant effect on different yield attributes of ginger was found in 2016-2017. The highest plant height (53.87 cm), maximum number of leaves (145), tiller (15.67), primary rhizome (4.83) and heaviour secondary rhizome (250.64 g) and clump (335.5 g) was recorded in S_4 (20±2 g). But significant highest weight of primary rhizome was recorded in S_5 (68.30 g), grown from 40±2 g followed by 20±2 g (65.33 g). Similarly, in 2017-2018, maximum number of leaves (175.10) was counted in S_4 (20±2 g). Maximum number of tiller / hill (15.17) was recorded in S_5 (40±2 g) followed by S_4 (15.00). The maximum number of primary rhizome (5.47 and 5.17) was obtained from S_4 and S_5 treatments, respectively although no significant variation was found between S_4 (20±2 g) and S_5 (40±2g). Significant highest weight of primary (67.97g), secondary (301.70 g) and rhizome /clump (362.89 g) was recorded in S_4 grown from 20±2 g followed by 40±2 g. The highest yield (23.54 and 25.10 t/ha) was recorded from the plants grown from 20±2 g weighed rhizome cut in 2016-2017 and 2017-2018, respectively. The highest gross return (TK 14, 12,400/ha) and net return (TK 9, 62,022/ha) was recorded in treatment S_4 (20±2 g). But the maximum BCR (4.05) was recorded in treatment S_1=5±2g in 2016-2017 while the highest gross return (TK 15, 06,000/ha) and net return (TK 9, 96,340/ha) with maximum BCR (2.95) was obtained from treatment S_4 (20±2 g) in 2017-2018.

Keywords: Rhizome cut, effect, ginger, yield

Introduction
Ginger (*Zingiber officinale* Rosc.) is a monocotyledonous perennial herb in the family Zingiberaceae, grown mainly for its spicy and aromatic rhizomes. It is an important tropical horticultural plant valued for its aroma, flavor and medicinal properties. Ginger has basic antiseptic properties and is used as carminative and stimulant (Singh and Singh, 2000) [8]. Its seeds are virtually unknown and propagation is normally carried out using a small portion of rhizomes known as seed rhizomes or seed sets (Dupriez and De Leener, 1992; Borget, 1993; Ravindran *et al*., 2004) [3, 2]. The seed rhizome is the economic yield as well as the planting material of ginger and other rhizomatous crops and affects both the economic return of the grower and the establishment, growth and yield of the crops. The use of large seed rhizomes means the loss of the commercial product whereas the use of small seed rhizome means reduced growth and yield. The use of large seed rhizomes is generally found to increase the final yield of rhizomatous spices such as ginger (Whiley, 1990; Borget, 1993) [2, 13]. Nybe and Raj (2004) [9] indicated that large sized seed rhizomes of ginger give significantly higher yields than planting of small pieces. Hossain *et al*. (2005) found high yield of turmeric from using 30-40 g seed rhizomes, so, the seed rate of ginger is 2000-2500 kg/ha which costs is very high. But, the farmers of Bangladesh used small sized seed rhizomes (20-25g) and they usually harvested seed ginger earlier after the plants established fully, which is termed as 'dig up old rhizome' or 'steal mother rhizome' and it is believed that this practice provided proper space to developing rhizome. In some places, farmers plant whole rhizomes and unearth them

when the crop reaches about 30 to 35 cm in height (Singh, 1982) [7]. The recovery is about 94 percent at three months after planting. This practice helps the farmers to recover 60 to 70 percent of the seed cost. Although the quality of rhizome is inferior, farmers get income during off season price advantage (Rahman *et al.*, 2009). A production technique in ginger by using single bud sprouts (small cutting) may be standardized to produce rhizome with reduced cost. So, an effort is taken using small cutting consists of one bud and reduction in seed rhizome quantity and eventually reduced cost on seeds.

Materials and Methods

The experiment was conducted at Regional Spices Research Centre, Gazipur during April to February, 2017-2018 and 2017-2018. Five seed rhizome cut consisted of one bud viz., S_1=5±2 g, S_2=10±2 g, S_3=15±2 g, S_4=20±2 g and S_5=40±2 g were used in the experiment. Unit plot size was 5.0 m × 1.0 m. Seed rhizome were planted in two row maintaining inter and intra row spacing of 50 cm and 25 cm respectively. The experiment was laid out in Randomized Complete Block Design with three replications. The rhizomes were planted on April 18, 2016 and April 20, 2017 and the crop was harvested on February 22, 2017 and 2018, respectively. The land was fertilized with cowdung -5 t/ha, $N_{140,}$ $P_{54,}$ $K_{117,}$ S_{20} and Zn_3 kg/ha. The entire quantity of cowdung, P, S, Zn and half of K were applied during land preparation. 50% of N was applied at 50 DAP. The rest K and N were applied with two equal splits at 80 and 110 DAP. To control soft rot disease of ginger, seed treatment was done with Ridomil Gold (2g/l of water). To control the same disease foliar application of Ridomil Gold were done three times at 10 days interval starting from 75 DAP. Weeding was done at 50, 80 and 120 days after planting. Data were recorded considering days to 50% emergence, plant height (cm), number of leaves and number of tillers/hill at 7 month, number of primary rhizome/ hill, weight of primary and secondary rhizome/hill, weight of clump (g) at harvesting time and yield (t/ha).The collected data were analyzed and mean values were adjusted by DMRT following MSTAT software.

Results and Discussion

Days to 1st and 50% emergence of ginger plants influenced by different weighed rhizome cut in 2016-2017 is shown in figure 1. Days to emergence increased with the decrease weighed rhizome cut. The lowest days (36) was recorded for 1st emergence when maximum rhizome cut (40±2 g) was used as planting material. The rhizome cut weighed 5±2 g took the maximum days (45.25) for 1st emergence. Similar trend was recorded for 50% emergence of ginger plants grown from different rhizome cut.

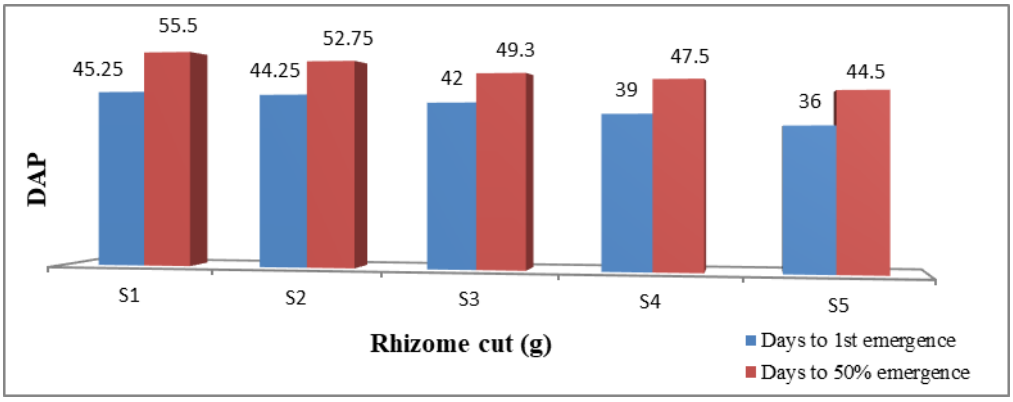

Fig 1: Days to 1st and 50% emergence influenced by different rhizome cut in 2016-2017
S_1=5±2 g, S_2=10±2 g, S_3=15±2 g, S_4=20±2 g and S_5=40±2 g

In 2017-2018, days to 50% emergence of ginger plants influenced by different weighed rhizome cut is shown in figure 2. The lowest days (42) was recorded for 50% emergence when maximum rhizome cut (40±2 g) was used as planting material. The rhizome cut weighed 5±2 g took the maximum days (60) for 50% emergence. In both year, the larger rhizome cut sprouted earlier and growth quickened in the seedling stage.

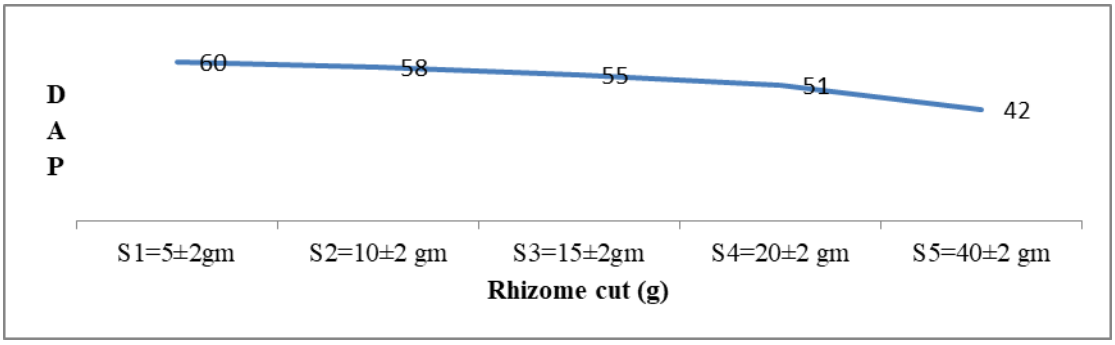

Fig 2: Days to 50% emergence of ginger using different rhizome cut as seed in 2017-2018

The yield contributing attributes of ginger affected by different rhizome cut are presented in Table 1 in 2016-2017. All the yield contributing attributes showed significant variations except number of primary rhizome.

Table 1: Effect of rhizome cut on the different yield contributing attributes of ginger in 2016-2017

Treatment	Plant height (cm)	No. of leaves	No. of tiller	No. of primary rhizome	Wt. of primary rhizome(gm)	Wt. of secondary Rhizome (gm)	Wt. of clump (gm)
S_1 (5±2 g)	50.1bc	102.03d	11.75b	3.7	51.50c	211.58 d	260.79c
S_2 (10±2 g)	51.48bc	107.70d	11.67b	4.13	58.68b	220.08 cd	287.60b
S_3 (15±2 g)	52.0b	117.77c	13.0b	4.33	61.33b	235.39 bc	312.07a
S_4 (20±2 g)	53.87a	145.0a	15.67a	4.83	65.33ab	250.64 a	335.50a
S_5 (40±2 g)	53.03ab	133.33b	15.0a	4.62	68.30a	240.04 a	322.50a
Level of significance	**	**	**	NS	*	**	**
CV%	2.35	2.83	3.54	6.71	3.49	6.71	3.03

Different weighed rhizome cut had a significant effect on plant height of ginger. The highest plant height (53.87 cm) was attained in S_4 (20±2 g) followed by S_5 (40±2 g), 53.03 cm. Similarly, the influence of rhizome cut was observed significant on number of leaves. Maximum number of leaves (145) was counted in S_4 (20±2 g). Different weighed rhizome cut showed significant variation regarding number of tiller. Maximum number of tiller (15.67) was recorded in S_4 (20±2 g) though no significant variation was found between S_4 (15.67) and S_5 (15.0). Even, rest of all treatments (S_1, S_2 and S_3) was found identical regarding tiller number (Table 1). The maximum number of primary rhizome (4.83) was obtained in S_4 where 20±2 g weighed rhizome cut used as seed although this attribute varied non significantly. But significant highest weight of primary rhizome was recorded in S_5 (68.30 g), grown from 40±2 g the highest followed by 20±2 g (65.33 g). Plants grown from S_4 (20±2 g), yielded the heaviour secondary (250.64 g) and rhizome / clump (335.5 g) followed by 40±2 g (240.01 g and 322.5 g, respectively) and the lowest rhizome / clump (260.79g) was recorded from 5±2 g (S_1) rhizome cut.

The yield contributing attributes of ginger affected by different rhizome cut are presented in Table 2 for 2017-2018. All the yield contributing attributes showed significant variations.

Table 2: Effect of rhizome cut on the different yield contributing attributes of ginger in 2017-2018

Treatment	Plant height (cm)	No. of leaves/ hill	No. of tiller/ hill	No. of primary rhizome/ hill	Wt. of primary rhizome (g)/ hill	Wt. of secondary rhizome (g)/hill	Wt. of clump (g)
S_1	55.13 d	109.33 e	10.33b	3.47 c	48.79 d	148.92 d	189.39 d
S_2	58.03 c	125.73 d	11.67 b	3.95 bc	61.35 c	180.55 c	237.58 c
S_3	59.97 bc	140.07 c	12.90 b	4.60 abc	67.25 b	231.00 b	304.25 ab
S_4	62.07 ab	175.10 a	15.00 a	5.47 a	67.97 a	301.70 a	362.89 a
S_5	64.20 a	162.93 b	15.17 a	5.17 ab	67.68 a	291.86 a	362.42 a
Level of sig.	**	**	**	*	**	**	**
CV%	2.46	0.94	4.05	14.66	1.63	3.81	5.73

S_1=5±2 g, S_2=10±2 g, S_3=15±2 g, S_4=20±2 g and S_5=40±2 g

Different weighed rhizome cut had a significant effect on plant height of ginger. The highest plant height (64.20 cm) was attained in S_5 (40±2 g) followed by S_4 (20±2 g), 62.07 cm. Maximum number of leaves (175.10) was counted in S_4 (20±2 g). Different weighed rhizome cut showed significant variation regarding number of tiller/ hill. Maximum number of tiller / hill (15.17) was recorded in S_5 (40±2 g) followed by S_4 (15.00). The maximum number of primary rhizome (5.47 and 5.17) was obtained from S_4 and S_5 treatments, respectively although no significant variation was found between S_4 (20±2) and S_5(40±2). Similarly, significant highest weight of primary rhizome was recorded in S_4 (67.97g), grown from 20±2 g followed by 40±2 g (67.68 g). Plants grown from S_4 (20±2 g), yielded the heaviour secondary rhizome (301.70 g) and rhizome / clump (362.89 g) followed by 40±2 g (291.86 g and 362.42 g, respectively) and those of the lowest from S_1(5±2 g). Korla *et al.* (1989) [4], at Himachal Pradesh, reported that rhizome bits weighing 20 to 25 g gave the best results with regard to plant height, number of tillers, rhizome length and breadth, and yield.

Finally, figure 3 showed the yield (t/ha) using different rhizome cut in 2016-2017. The highest yield (23.54 t/ha) was recorded from the plants grown from 20±2 gm weighed rhizome cut followed by S_5 (40±2 gm).

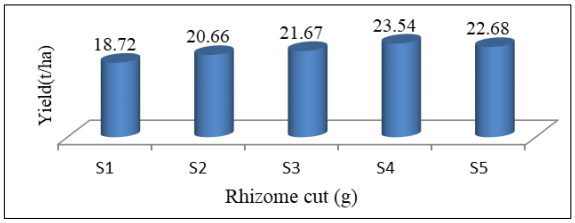

Fig 3: Yield (t/ha) using different rhizome cut in 2016-2017
S_1=5±2 g, S_2=10±2 g, S_3=15±2 g, S_4=20±2 g and S_5=40±2 g

Similarly, figure 4 showed the yield (t/ha) using different rhizome cut in 2017-2018. The highest yield (25.10 t/ha) was recorded from the plants grown from 20±2 g weighed rhizome cut followed by 24.80 t/ha in S_5 (40±2 g).

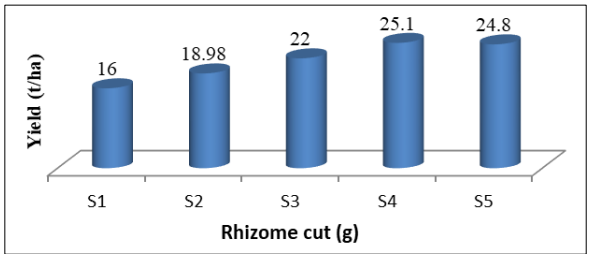

Fig 4: Yield (t/ha) using different rhizome cut in 2017-2018
S_1=5±2 g, S_2=10±2 g, S_3=15±2 g, S_4=20±2 g and S_5=40±2 g

The price of different rhizome cut used as seed materials in both studied years (2016-2017 and 2017-2018) is arranged in Table 3. It indicated the price is increased with the increase of seed size. The lowest cost was obtained when only 5-7 g (5±2) seed was used The highest seed cost per hectare was calculated (TK 4,80,000) in case of using 40±2 g weighed rhizome cut followed by 20±2 g (TK 2,40,000) per hectare.

Economic analysis

Table 3: Requirement and price of different rhizome cut used as seed materials

Seed rhizome (Rhizome cut)	Seed requirement (kg/ha)	Seed Price (Tk /ha)
S_1=5±2g	400	60,000/-
S_2=5±2g	800	1,20,000/-
S_3=5±2g	1200	1,80,000/-
S_4=5±2g	1600	2,40,000/-
S_5=5±2g	3200	4,80,000/-

Economic analysis of ginger cultivation during 2016-2017 shown in Table 4. The highest gross return (TK 14, 12,400/ha) and net return (TK 9, 62,022/ha) was recorded in treatment S_4=20±2 g. But the maximum BCR (4.05) was recorded in treatment S_1=5±2g.

Table 4: Economic performances of different Rhizome cut used as seed rhizome (2016-2017)

Treatment	Rhizome yield (t/ha)	Gross return (Tk/ha)	Total cultivation cost (Tk/ha)	Net return	Benefit cost ratio (BCR)
S_1=5±2g	18.72	10,93,200	2,69,898	8,23,302	4.05
S_2=10±2 g	20.66	12,39,600	3,30,058	9,09,542	3.76
S_3=15±2g	21.67	13,00,200	3,90,218	9,09,982	3.33
S_4=20±2 g	23.54	14,12,400	4,50,378	9,62,022	3.13
S_5=40±2 g	22.68	13,60,800	6,91,018	6,69,782	1.97

Table 5: Economic performances of different Rhizome cut used as seed rhizome (2017-2018)

Treatment	Rhizome yield (t/ha)	Gross return (Tk/ha)	Total cultivation cost(Tk/ha)	Net return	Benefit cost ratio (BCR)
S_1=5±2g	16.00	9,60,000	3,29,660	6,30,340	2.91
S_2=10±2 g	18.98	11,38,800	3,89,660	7,49,140	2.92
S_3=15±2g	22.0	13,20,000	4,49,660	8,70,140	2.93
S_4=20±2 g	25.10	15,06,000	5,09,660	9,96,340	2.95
S_5=40±2 g	24.80	14,88,000	7,49,660	7,38,340	1.98

Rhizome seed price: TK150/Kg, Urea: TK 16/Kg, TSP:TK 22/Kg, MOP:TK 15/Kg, Gypsum: TK 11/Kg,ZnSO4 : TK 120/kg, Boron: TK 220/Kg; Cowdung :TK 5/Kg, ;Human laour: TK 450/man/day; Ripcord: Tk 180/100 ml, Ridomil: TK 115/100g, Furadan: Tk 16/Kg, Autostin: TK120/100gm, Irrigation: TK 5.00/dec.; Rhizome seed sale price: TK 60/Kg

The highest gross return (TK 15, 06,000/ha) and net return (TK 9, 96,340/ha) with maximum BCR (2.95) was obtained from in treatment 20±2 g in 2017-2018. The cost-benefit analysis indicated that the use of minisetts, weighing 10 g, is more profitable (Nizam and Jayachandran, 2001) [5].

In early flourishing growth stage, ginger plants focus on growth of aerial shoots. During this period, many tiller arises, leaf area increases rapidly, root grows continuously, some fleshy roots are also produced. Rhizome branches producing finger, but their growth are slow. The fresh rhizome has already formed, old rhizome shrinks and slowly die-off (Arya, 2008). Farmers usually harvested old rhizome in the month of August- September. After mid September, the growth emphasis is shifted to the rhizome. Root becomes stabilized, tillering speed decreases and leaf area reaches about to steady state. Photosynthesis produced by leaves are mainly transported and deposited in rhizomes. In this rhizome expanding stage or active growing stage, the growing speed of plants grown from 20±2 gm weighed rhizome may quickened and vigor exceeded compare to plants grown from 40±2 gm weighed rhizome but insignificant in most attributes. A similar finding is also reported by *Xizhen et al.,* 2016.

Table 6: Weight of seed rhizome and New rhizome uprooted at two months interval influenced by different rhizome cut (2016-2017)

Rhizome cut (g)	Months							
	August		October		December		February	
	Seed rhizome (g)	New Rhizome (g)	Seed rhizome (g)	New Rhizome (g)	Seed rhizome (g)	New Rhizome (g)	Seed rhizome (g)	New Rhizome (g)
S_1=5±2g	3.9	25.5	3.0	48.5	2.1	160	0	220
S_2=10±2 g	9.5	32	9.0	74	5.8	198.30	4.0	290
S_3=15±2g	14.5	48	14.0	89.3	12.5	213.5	8.0	300
S_4=20±2g	19.55	52.3	19.00	105	15.0	300.8	12.0	410
S_5=40±2g	39.00	55.8	37.5	92.5	32.3	286.0	25	368.5

An observational trial was carried out with different weighed rhizome cut (5±2, 10±2, 15±2, 20±2 and 40±2 g), one representative plant was uprooted at two months interval and rhizome weight was taken along with seed rhizome in 2016 -2017 (Table 6). The rhizome weight increased with the increase of time and the heavier rhizome

(410g) was recorded from 20±2 gm weighed rhizome followed by 40±2 g (368.5g).Very little weight loss of the seed rhizome was recorded with the increase of time and in some cases, no seed rhizome was found during final uprooting in the month of February.

Similarly, another observation was conducted with different weighed rhizome cut (5±2, 10±2,15±2, 20±2 and 40±2 g), one representative plant was uprooted from September – January, 2017-2018 at monthly interval and rhizome weight was taken (Table 7). The rhizome weight increased with the increase of time and the heavier rhizome (530 g) was recorded from 20±2 g weighed rhizome followed by 40±2 gm (505g).

Table 7: Weight of rhizome (g) at monthly interval influenced by different rhizome cut (2017-2018)

Treatment	Months				
Rhizome cut	September	October	November	December	January
S_1=5±2g	105	165	200	249	298
S_2=10±2 g	205	275	305	328	378
S_3=15±2g	295	336	370	400	440
S_4=20±2 g	298	346	395	445	530
S_5=40±2 g	320	380	410	454	505

Actually, ginger is different from other crops- after seed rhizome sprouts and the new plant start to growing, the original seed rhizome is not influenced further by plant growth and remains in good condition, its fresh weight has not changed substantially.

From the two years observation, it may be revealed that bigger is not always better. It is better to select ensuring one strong bud of 20±2 g rhizome piece removing rest portions provides lower investment along with whole pool nutrition remains on the bud.

Conclusion

The 20±2 g weighed rhizome cut having one effective bud is suitable for maximum yield of ginger and it is economically profitable to the grower.

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