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Research Article

Influences of Transplanting Approaches of Propagation on Growth, Yield and Economics of Ginger (*Zingiber officinale* rose.) Cultivation

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Transplanting propagation, bud cutting, seedling, yield, ginger

Abstract
Rhizome used as seed is utilized to cultivate ginger, and it comprises approximately half of the entire cost of production. In the Horticulture Farm of HSTU, Dinajpur, a study was carried out to assess the performance of the transplant production system of ginger cultivation with comparable growth and yield to traditional planting. A randomized complete block design with four replications was employed to conduct the study. The experiment comprised four treatments: T1= direct planting of seed rhizomes (control), T2= single bud transplanting (~5-10 g), T3= two buds transplanting (~10-15 g), T4= three buds transplanting (~15-20 g). Growth-related traits and yield of ginger were profoundly influenced by rhizome transplanting methods. In direct rhizome planting, the lowest days (40.61) for 50% emergence were noted. The direct planting of seed rhizomes resulted in the highest plant height (58.37 cm), number of tillers per hill (14.05), number of leaves per hill (159.01), yield per plant (133.46 g), and yield per ha (19.07 ton) due to the substantial food storage in it. On the contrary, the observed parameters of ginger were mostly statistically consistent across distinct transplanting methods. In respect of ginger cultivation's economics, T4 treatment provided the greatest net return (823600 TK/ha), whereas T3 treatment revealed the highest benefit-cost ratio (3.10). Considering the above facts, the results of this study demonstrated the suitability of the two-bud transplant approach due to the reduction in seed rhizome quantity, seed cost, and ultimately increased net profit in an economically feasible amount.

INTRODUCTION

A prominent commercial spice crop in tropical and subtropical climates, including Bangladesh, is ginger (*Zingiber officinale* Rose). It stretches across approximately 9311 hectares in Bangladesh and produces 77.000 metric tons annually (BBS, 2017). Because of its distinctive aroma and flavor, ginger delivers several food products a unique flavor. In traditional remedies, ginger is traditionally used to treat fevers, coughs, vomiting, constipation, flatulence, colic, edema, and asthma in traditional ways owing to its carminative, stimulant, and digestive features. Utilizing the segment of the rhizome termed as the seed rhizome, ginger is vegetatively propagated. The seed rates differ according to seed size and spacing and account for nearly 40–50% of the production cost (Nybe and Mini Raj, 2005). The larger seed rhizome (20–80 g) is typically sown to induce brisk growth and a better economic return (Whiley, 1990). Ginger demands a warm, humid habitat in order to flourish and yield satisfactorily. It is predominantly cultivated in the tropics between sea level and 1500 m. But unlike most other spices, it can still be cultivated in such a diverse variety of circumstances. In Bangladesh, ginger is extensively cultivated during the kharif season. Apart from the crop's paramount interest, there is scant information on the agronomic facets of it. Regarding diverse crops, notably ginger, the two most critical components of a production cycle are rhizome size and planting approaches (Aiyadurai, 1966). Ginger is grown in Bangladesh using direct sowing of seed rhizomes (30–40 g) at a seed rate of 2000–2500 kg ha^{-1} at a remarkably substantial cost (Hossain et al., 2005). However, farmers usually retrieve seed ginger whenever the plants have fully established their root systems. This approach, which is known as "dig up old rhizome" or "steal mother rhizome," enables farmers to recoup roughly 60% of the cost of the seeds. Nevertheless, farmers do not considerably profit from cultivating ginger. Contrarily, considering typical rhizome propagation strategies necessitate a lengthy time because of a dormant phase, a prompt mode of multiplication is desired, particularly for newly developed high yielding cultivars that are scarcely available (Prasath et al., 2014). A production method for ginger implementing single bud sprouts (small cuttings) may be optimized to produce superior rhizome at a reasonable cost in order to alleviate the drawbacks of the traditional planting system. Prior initiatives to use detached sprouts from seed rhizomes as planting material seemed economically efficacious (Ara et al., 2019; Shil et al., 2018; Prasath et al., 2014). Yet, no comprehensive research has been carried out regarding the use of ginger sprouts as seedlings for commercial cultivation on a large scale. In ergo, a tiny cutting with distinct buds is utilized in an attempt to minimize the quantity of seed rhizomes and, inevitably, the expense of seeds. The current study was carried out in order to ascertain the impacts of the transplanting method of propagation on growth, yield, and economics of ginger cultivation.

MATERIALS and METHODS

Site of the research work

In order to accomplish the study's outcomes, the field experiment was carried out the Horticultural farm of HSTU, Dinajpur, from July 2020 to June 202. The field of research is indeed a medium-high geographical region with a sea level average altitude of above 37.5 m and modest drainage efficiency.

Treatments and experimentation

A randomized complete block design (RCBD) with four replications was employed in the experiment's layout. Four distinct treatments were intended to make up the experiment such as, T1= direct planting of seed rhizomes (control), T2= single bud transplanting (~5-10 g), T3= two buds transplanting (~10-15 g), T4= three buds transplanting (~15-20 g). The seed rhizomes were supposed to be treated with Dithane M-45 at 3 g per liter of water for approximately 30 minutes preceding direct planting and then harnessed for planting. Transplanting approach was followed according to Prasath et al. (2014) with minimal alterations; seed rhizomes were split in compliance with the treatment at the onset of the season. Prior to planting, the bud(s) had been medicated for 30 minutes with Mancozeb 0.3% in 3 g L^{-1} water. Pro-trays have been used to plant the ginger bud sprouts. In less than 30-35 days, seedlings were prepared for transplantation into the main field.

Fertilization of study soil

Cow dung (5 t ha^{-1}), N-140, P-54, K-117, S-20, and Zn-3 kg ha^{-1} were incorporated to fertilize the land. Throughout this land preparation, cow dung, P, S, Zn, and half of the K were all implemented in full quantities. At 50 DAP, 50% of N was supplied. At 80 and 110 DAP, the rest of K and N was applied in two equal splits.

Intercultural operations

Ridomil Gold (2 g L^{-1} of water) was subjected to the seeds of ginger to suppress the soft rot disease. Ridomil Gold was applied three times through foliar application, each one 10 days apart, beginning at 75 DAP, to alleviate the same disease. Weeding was carried out 50, 80, and 120 days following planting.

Data collection, calculation and analysis

The days to 50% emergence, plant height (cm), the number of leaves and tillers per hill, and the yield (t ha^{-1}) were all properly considered when recording the data. To attain the research aims, obtained data were edited, summarized, tabulated, and analyzed. The study's results were analyzed and interpreted by utilizing diverse statistical tools and tabular modes of analysis. On the premise of benefit-cost analysis, gross return, and net return, the profitability of ginger production was determined. In Table 1, expenses and the seed rate administered to the treatments are displayed.

Table 1. Requirements and expenses of varied seed rhizome planting materials

Treatments	Seed rate (kg ha^{-1})	Seed Price (TK ha^{-1})
T1= direct planting of seed rhizomes	2200	330000
T2= single bud transplanting (~5-10 g)	600	90000
T3= two buds transplanting (~10-15 g)	800	120000
T4= three buds transplanting (~15-20 g)	1000	150000

Where, Price per kg seed was 150 TK (market price), kg= kilograms, ha= hectare, TK= Bangladeshi taka

The diverse calculations were accomplished through the following formula,

$$(i) Cost\ of\ cultivation = Seed\ cost + Labor\ cost\ (including\ family\ labor) + Miscellaneous$$

$$(ii)\ Net\ return\ (TK/ha) = Gross\ return - Cost\ of\ cultivation$$

$$(iii) Benefit : Cost\ (B{:}C) = \frac{Gross\ return}{Cost\ of\ cultivation}$$

When assessing the overall cost of cultivation or entire cost, the opportunity cost of family labor was included in the calculation. According to Islam et al. (2012), all operating costs were accounted for as variable costs while computing gross return.

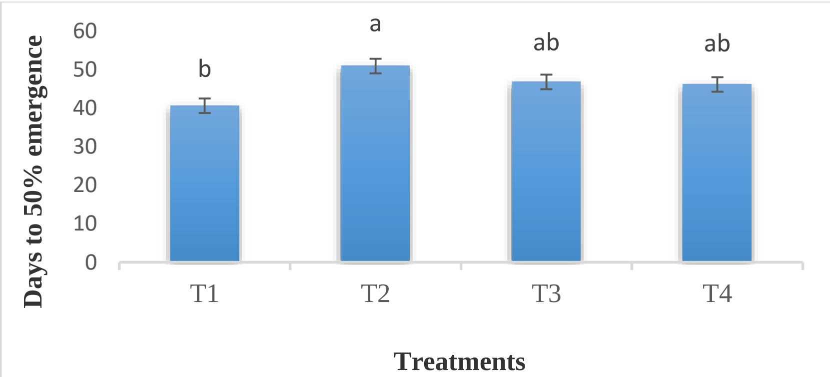
RESULTS AND DISCUSSION

Influence of transplanting method on the growth associated attributes

Days to 50% emergence

During this investigation, rhizome transplantation had a profound impact on the number of days until 50% of the ginger plants emerged (Figure 1).

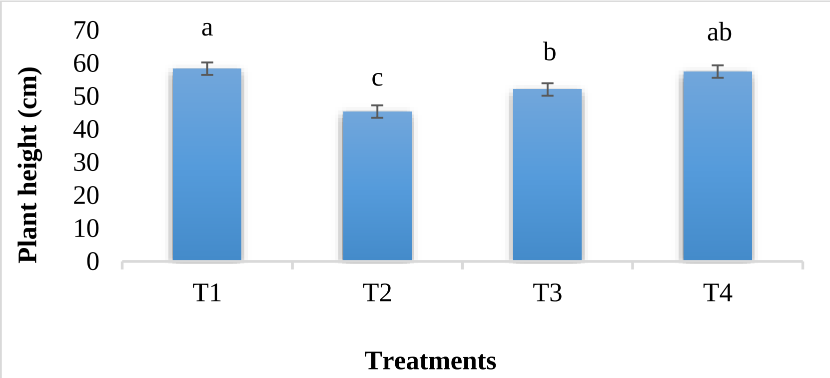
The days to 50% emergence following direct rhizome planting, or the control treatment, were considerably lower and statistically significant (40.61 days) than for other bud-cutting planting methods. The T2 treatment took a maximum of 50.93 days to attain 50% ginger emergence due to the planting material size's influence on propagation time, which is statistically equivalent to the T3 (46.80 days) and T4 (46.14 days) treatments. In light of the findings, it was anticipated that the size and quantity of buds in the planting material would expedite the days towards emergence since the rhizomes would have a higher capacity for energy storage. Similar trends were seen for ginger plants growing from varying rhizome incisions, as documented by Ara et al. (2019). On the days of bud germination, evidence that is highly comparable was noticed in the literature (Chukwudi et al., 2020). Also, according to Mahender et al. (2015), fewer days were needed for the first sprouting as a response to an increase in rhizome sizes.



Where, T1= direct planting of seed rhizomes, T2= single bud transplanting, T3= two buds transplanting, T4= three buds transplanting
Figure 1. Influence of transplanting method on days to 50% emergence of ginger

Plant height

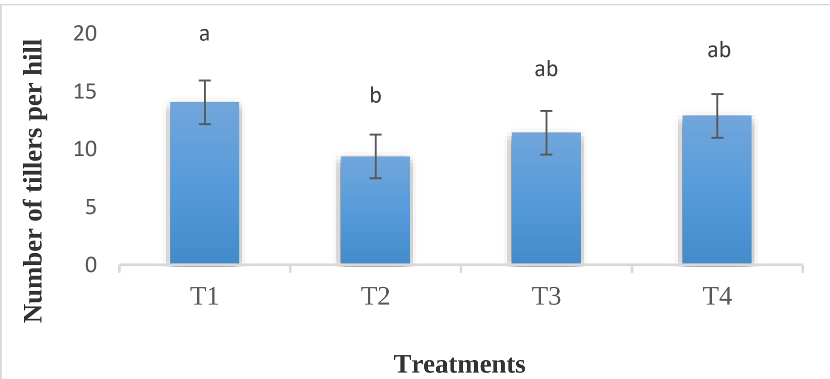
Transplanting of assorted edge-cutting rhizomes had significant consequences on the height of the emerged plants (Figure 2). T1 experienced the largest plant height (51.35 cm) (direct planting of seed rhizomes). The single bud transplanting treatment T2 yielded the least height of the plants (45.41 cm), but perhaps the left two treatments, T3 and T4, gave plants having statistically identical heights of 52.10 cm and 57.49 cm, correspondingly. Variable bud emerging transplanting materials seemed to have an impact on this distinctive feature, and we noticed enhanced plant height in the T1 treatment (direct planting of seed rhizome) compared to all other treatments as a possible consequence of plentiful food retention in the planting material. Concerning plant height, nearly similar conclusions were unearthed in a ginger cultivation experiment (Prasath et al., 2018). Ara et al., 2019, also came to similar conclusions. The robust and faster growth of the ginger transplant was triggered by a bigger planting rhizome (Islam et al., 2017), which eventually culminated in a larger plant (Monnaf et al., 2010).



Where, T1= direct planting of seed rhizomes, T2= single bud transplanting, T3= two buds transplanting, T4= three buds transplanting
Figure 2. Influence of transplanting method on plant height of ginger transplant

Number of tillers per hill

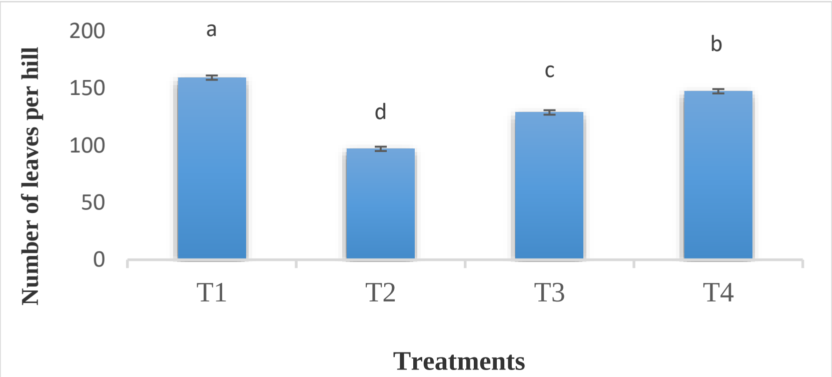
Taking into account the experiment's findings, the transplanting approach of propagation had quite a substantial influence on ginger's number of tillers per hill than that of the direct seed rhizome planting approach. Figure 3 shows statistical statistics for the number of tillers in each plant. The direct planting of seed rhizomes led to a significant increase in the number of tillers per plant (14.05), which is statistically analogous to the T3 (11.42) and T4 (12.88) treatments, which were presumably accomplished by transplanting segregated buds comprising two and three buds, respectively. Meanwhile, due to its incapacity to deposit food substances and its poor establishment potential, transplanting single bud emerging material caused the fewest tillers per plant (9.37). In relation to the transplanting of ginger, many academics (Shekhar, et al., 2021; Ara et al., 2019; Prasath et al., 2018) beforehand revealed the number of tillers per hill in conformity with the results of our study. In addition to this, Sengupta and Dasgupta (2011) asserted that the larger rhizome planting material generated the maximum number of tillers per plant, which is pretty close to the outcomes of Mahender et al. (2015).



Where, T1= direct planting of seed rhizomes, T2= single bud transplanting, T3= two buds transplanting, T4= three buds transplanting
Figure 3. Effect of transplanting system on number of tillers per plant of ginger

Number of leaves per hill

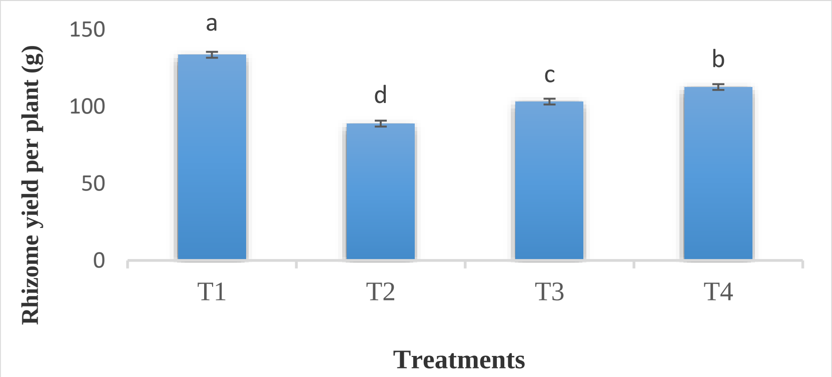
Results from the study revealed that one growth-related criterion, the number of leaves per hill, was profoundly variable in a statistically stratified sense (Figure 4). The direct planting of seed rhizomes (T1 treatment, or control), which is clearly distinguishable from those other treatments, resulted in the highest number of leaves in each hill (159.01). As contrasted to T3 treatment (two buds transplanted material) having the number of leaves per hill (128.63), T4 treatment (three buds transplanted material) seemed to have the later highest leaves per hill (147.17). In a comparable manner, T2 treatments with a single sprout transplant tactic exhibited the least number of leaves per hill (96.79). Such aspects of heterogeneity in growth-related specifications like the number of leaves in each hill could be prompted by ease of establishment and preceding growth. The observations of several prior studies (Ara et al., 2019; Prasath et al., 2018), which suggested that the frequency of leaves on a hill was regulated in a similar way, concur with the findings of the current research. Besides, each plant's number of leaves increased as its rhizome size and number of buds escalated (Islam et al., 2017).



Where, T1= direct planting of seed rhizomes, T2= single bud transplanting, T3= two buds transplanting, T4= three buds transplanting
Figure 4. Impact of transplanting approaches on number of leaves per hill of ginger

Influence of transplanting propagation technique on yield parameters and yield
Rhizome yield per plant

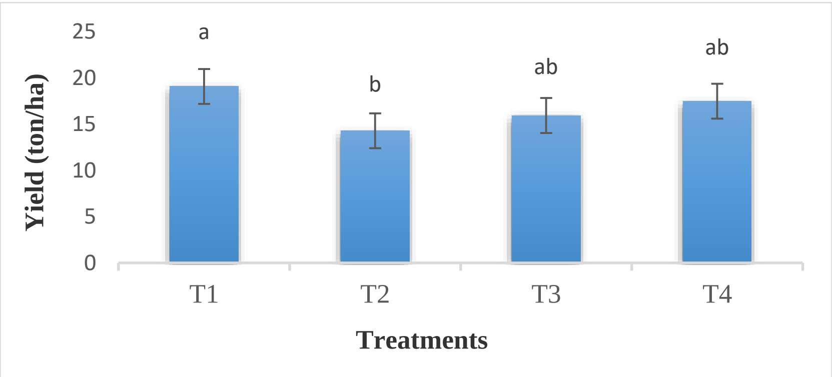
The considerable difference in rhizome production per plant is illustrated in Figure 5. With the expansion of the seed rhizome's size and the repercussions of transplanting, the rhizome yield of each plant fluctuated from 88.80 g to 133.46 g. The plants from single bud transplanting performed a noticeably lower yield (88.80 g/plant), whereas the direct planting (T1), as expected, divulged the maximum rhizome yield. The T4 treatment, on the contrary, yielded a modest amount of rhizome material per plant (112.51 g), which is in contrast to the T3 treatment's (103.06 g/plant), which had two buds for transplant. For fresh rhizome weight in each plant, the biggest rhizome size, 50 g, produced the best results (Tiwari et al., 2019). In conformity with the provisions of rhizome yield (Pandey et al., 1997) and weight of primary and secondary rhizome per hill (Ara et al., 2019), those researchers asserted that their findings were more feasible with ours.



Where, T1= direct planting of seed rhizomes, T2= single bud transplanting, T3= two buds transplanting, T4= three buds transplanting
Figure 5. Effectiveness of transplanting techniques on fresh rhizome yield per plant of ginger

Yield

Findings on ginger yield possess significant relevance as a consequence of the implementation of various treatments with diverse planting tactics, comprising direct and transplanting modes (Figure 6). The outcomes of the analysis of variance (ANOVA) unveil that the direct seed rhizome (control) plants had a considerably higher return (19.07 tons ha^{-1}) than the single bud transplanting treatment, which gave the least yield (14.28 tons ha^{-1}). With T3 (15.93 tons ha^{-1}) and T4 (17.48 ton/ha) treatments, the yield of ginger was likely influenced by growth-related traits resulting from the use of distinct transplanting techniques. Apparently, rhizome yield was impacted due to the cumulative effect of rhizome size, the convenient establishment competence of rhizome, and planting modes. Those reasons likely play prominent roles, as was assured by Girma and Kindie (2008). According to Prasath et al. (2014), accelerated growth at the initial stage boosted the yield of ginger in the final output. Likewise, the cumulative increment in the size of the rhizome implemented for ginger cultivation boosted the yield of ginger (Ghosh and Hore, 2011). This finding broadly coincided with some of what Shil et al. (2018) had observed.



Where, T1= direct planting of seed rhizomes, T2= single bud transplanting, T3= two buds transplanting, T4= three buds transplanting
Figure 6. Impact of different transplanting method on fresh yield of ginger

Economical study of different planting systems

The feasibility analysis of ginger's economics revealed distinct heterogeneity after following various planting methods (Table 2). The direct transplanting strategy (T1) generated the highest gross return (1334900 TK ha^{-1}), and the single bud transplanting approach (T2), which used less planting material, gave the least gross return (999600 TK ha^{-1}). In terms of values, T3 and T4 attained intermediate gross returns (1115100 TK ha^{-1} and 1223600 TK ha^{-1}, respectively). Awing to the total cultivation costs, the direct transplantation method had the highest production costs (550000 TK ha^{-1}), while treatments T3 and T4 had the next highest cultivation expenses of 360000 TK ha^{-1} and 400000 TK ha^{-1}, correspondingly. This discrepancy arose from the increasing incidence of buds in the planting materials, necessitating a lower seed rate than direct planting. Upon this premise, single bud transplanting (T2) seemed to have the lowest cultivation expense (340000 TK ha^{-1}). Furthermore, net return was assessed, and it was noticed that T4 had the highest value (823600 TK ha^{-1}), whilst T1 (784900 TK ha^{-1}), T3 (755100 TK ha^{-1}), and T2 (659600 TK ha^{-1}) were the subsequent three, predominantly relying on the production of ginger.

Table 2. Economic performances of different ginger planting systems

Treatment	Gross return	Net return	Total cultivation cost	Benefit: Cost (B: C)
T1	1334900	784900	550000	2.43
T2	999600	659600	340000	2.94
T3	1115100	755100	360000	3.10
T4	1223600	823600	400000	3.06

Where, Price per kg ginger was 70 TK (market price), ha= hectare, TK= Bangladeshi taka

Regarding the gross return and cost of cultivation, the most profound attribute of economic study, maximum benefit: cost (3.10) was got from T3, which was a two-bud transplantation tactic, while minimal benefit: cost (2.43) was derived from the direct transplanting method (Table 3). Treatments T4 (3.06) and T2 (2.94) were evidenced on this parameter with intermediate results. According to Shil et al. (2018), the consequence of T1 (single bud transplanting) was the generation of robust planting materials and yield improvement, which inevitably boosted the gross return but still drove up the cost of cultivation. According to Prasath et al. (2018), single sprout transplant emerged as the most cost-effective planting practice out of the four when compared to traditional planting of 20–25g rhizomes. The positive aspect of this transplantation technique is the drop in the number of seed rhizomes and, consequently, the relatively low cost of seed rhizomes. In the instance of potatoes, Singh (2012) also asserted lower cultivation expenses, higher net returns, and a superior benefit-to-cost ratio by transplanting smaller seed tubers, such as 10–20 g tubers as opposed to 50–60 g.

CONCLUSION

It is conceivable to draw the conclusion that ginger can be competently cultivated employing a transplant strategy with fewer buds (more likely a two-bud transplanting approach) with better quality, yield, and economic interest than direct rhizome planting in open-field circumstances. The effectiveness of different ginger-planting methods on rhizome growth and development in the field varied. Rhizome yield and quality were significantly analogous between direct planting and transplanting. However, in light of the decrement in seed rhizome quantity, the relatively low cost of seeds, and consequently the benefit: cost in terms of economic acceptability at the field level, the findings of this study indicated the acceptability of the two-budded transplanting method.

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