INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 24, No. 5, p. 124-129, 2024
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Capability of the different sizes of ginger (*Zingiber officinale*) rhizome setts in producing plantlets as planting materials

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Article published on May 11, 2024

Key words: Plantlets, Planting materials, Propagation, Rhizome setts, Sowing

Abstract

Ginger (*Zingiber officinale* Rosc.) plants are perennials and the rhizomes have a pungent taste which is very important for flavoring various food products specifically in Asian cuisine. In ginger production, the matured rhizomes are commonly used as planting materials, which contributes to the highest total production cost. Therefore, other kinds of planting materials could be considered, such as using plantlets. The most common method of rapid propagation in many crops is the tissue culture method, usually done in the laboratory. On the other hand, the use of certain plant parts has also the potential for rapid propagation. Moreover, they could be adopted by any farmer because it does not require expensive facilities and special skills, lower cost of production and the propagated plantlets can be directly transplanted in the field due to their quick adaptability to varied climatic conditions. Hence, this study aims to; evaluate the effects of the different sizes of rhizomes on the propagation of plantlets to be used as planting materials, and to determine the most productive size of rhizomes to produce plantlets. The result revealed that the 150g rhizome sett had the highest number of plantlets produced per sett (8.53) and the highest net income from recovered rhizome setts. (PhP 53,590.00) after gathering the plantlets, while the 50g sett has the highest number of plantlets produced per kilogram of rhizome sett with 85.67 plantlets.

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Introduction

Ginger (*Zingiber officinale)* plants belong to the family Zingiberaceae, perennials, and are endemic to tropical Southeast Asia (Adegbola and Olufunmilola, 2017). The rhizomes are very familiar as flavoring of foods and natural additives of other products due to their pungent taste for more than 2000 years (Bartley and Jacobs, 2000). The importance of the ginger rhizome is the flavor, which contains essential oils and oleoresins (Rhode *et al.*, 2007). The odor is due to its components such as volatile oils zingerone, shogaols, and the gingerols which is 3% of the fresh weight of the ginger (Moghaddasi and Kashani, 2012). It is also an important home remedy for various illnesses. It thrives in various climatic conditions in tropical and semi-temperate countries.

The worldwide production of ginger in 2020 reached 4.3 million tons, wherein India had the highest production which shared 43% of the total world supply. It was followed by Nigeria, China, and Nepal (FAO, 2021). In ginger production, the most common planting materials used by farmers in the Philippines and in some countries are the matured rhizomes. During planting season, the cost of rhizomes increases significantly. Likewise, the required volume of rhizomes needed is very high.

On the other hand, it was reported that the tissue-cultured plantlets can be used as planting materials. This method of propagation has been considered to be an effective means of eliminating pathogens from the vegetative source of the material. The propagation of plantlets by this method can be done throughout the year. However, the tissue-cultured plantlets are very expensive and they had poor success in out-planting in the field hampering its full commercialization (Freyre *et al.*, 2019). The major reason that causes its high cost is the use of culture media such as agar-agar as a gelling agent, sucrose (as a carbon source), etc. Infrastructure, electricity, and maintenance contributed to the high cost of operation that hampers its success (Gupta and Verma, 2011). Tissue-cultured derived plantlets are a possible alternative planting material with uniform and disease-free material. However, tissue-cultured plantlets are much more expensive as compared to the seed rhizomes with possible lower yield during the first production cycle.

On the other hand, other methods have the potential for rapid propagation of plantlets, such as the sowing of certain plant parts like the rhizomes. Moreover, the production cost of this method is cheaper since it does not use expensive infrastructures, electricity, and maintenance and the procedure could be easily adopted by the farmers.

Hence, the aims of this study are; to evaluate the effects of the different sizes of rhizomes in the production of plantlets as planting materials, and to determine the cost and return of the different sizes of rhizomes on the production of plantlets.

Material and methods

Location

The study was conducted at the Experimental Farm of the Don Mariano Marcos Memorial State University, Casiaman, Bacnotan, La Union, Philippines. The experimental area was partially shaded by the trees at the surrounding.

Research design

The experiment was laid out in three blocks and the treatments were arranged following the Randomized Complete Block Design (RCBD). There were six treatments of the study as follows;

T_1 – 50g rhizome sett

T_2 – 75g rhizome sett

T_3 – 100g rhizome sett

T_4 – 125g rhizome sett

T_5 – 150g rhizome sett

Land preparation

Two months before the onset of the rainy season, the experimental area was cleared thoroughly from any stumps of previous crop, grasses and stones. The area was then plowed and harrowed twice at an interval of two weeks to expose to sunlight and eliminate any pathogen present in the soil. After another two weeks, raised beds were prepared measuring 1m × 2m to 3m in every plot depending on the size of the setts. One plot was prepared per treatment in each block or replication.

Preparation of rhizome setts

Disease-free matured rhizomes were procured from the nearby community prior to the conduct of the study. The rhizomes were divided in accordance to the required size of sett for the respective treatments then soaked for 10 minutes in 0.5% concentration of Sodium hypochlorite solution to eliminate fungal and bacterial diseases then the setts were placed on a shaded area to drip within 24 hours (Fig. 1).

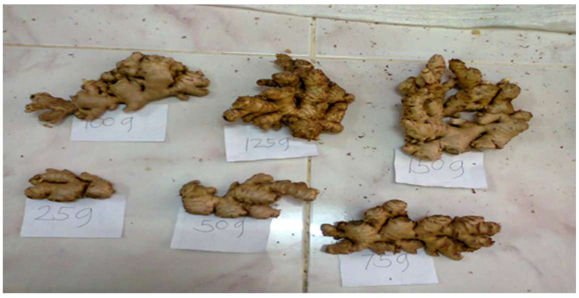

Fig. 1. The rhizome setts with different sizes

Sowing

Two weeks after the preparation of the seed beds, sowing was done by placing the setts side by side at a distance of 10 cm apart and then covered with thin soils. There were 25 pieces of setts sown in each plot. The plot was then covered with one inch thick of dried grasses as mulch.

Cultural management

Watering was done immediately after sowing and every other day in the absence of rainfall during the growing period of the plantlets. Weeding was also done when the grasses had grown up while spraying with insecticide was only done in the presence of pest.

Gathering of plantlets

Gathering of plantlets that emerged from the mother rhizome setts was done after two months from sowing or when they have already reached a height of 50 cm above the ground. This was done by digging up the sown rhizomes setts and detached the plantlets that emerged from them.

Data collection

The number of rhizome setts made in every kilogram of rhizomes was counted and recorded. The total number and weight of rhizome setts sown were counted, weighed and recorded. The number of plantlets gathered per rhizome sett and per kilogram setts were counted and recorded. Likewise, the recovered rhizomes setts were weighed and recorded. The net income (PhP) from the recovered rhizomes setts and the combined net income from the recovered rhizome setts and plantlets produced were computed.

Data analysis

The data were tabulated and analyzed using the analysis of variance (ANOVA) of Randomized Complete Block Design (RCBD) through the Statistical Tool for Agricultural Research (STAR) of the International Rice Research Institute (IRRI), Los Baños, Laguna, Philippines. The Tukey's Honest Significant Difference (HSD) Test was also used to test the significant differences between the treatment means at 0.05 probability level.

Results and discussion

Number of setts per kilogram of rhizomes

The number of setts made from one kilogram of rhizomes was due to the required size of sett of the respective treatments. The setts with bigger size had lesser number made per kilogram rhizomes, while those with smaller size of setts had more setts made per kilogram. Table 1 shows that the treatment with the smallest sett at 50g (T_1) has 20 setts made per kilogram rhizomes, while the treatment with the biggest sett at 150g (T_5) has only 6.67 setts kg^{-1} rhizomes.

Number of plantlets produced per sett and per kilogram setts

The size of the rhizomes sown has a significant influence on the production of plantlets as planting materials, particularly on the number of plantlets produced per sett or per kilogram of rhizome setts. Table 1 revealed that the setts with the biggest size (150g sett) have the highest number of plantlets produced (8.53) which is significantly differed from the setts with 50g to 100g weight ranging from 4.28 to 6.27 plantlets, but comparable to the number of plantlets produced (7.77 plantlets) by the 125g setts.

Table 1. Number of setts made per kilogram rhizome, plantlets produced per sett and per kilogram of the mother rhizome sett

Treatment	Number of Setts kg^{-1}	Number of Plantlets Produced $Sett^{-1}$	Number of Plantlets Produced kg^{-1} Setts
T_1 – 50g rhizome sett	20.00	4.28^c	85.67^a
T_2 – 75g rhizome sett	13.33	4.94^c	65.91^b
T_3 – 100g rhizome sett	10.00	6.27^b	62.67^b
T_4 – 125g rhizome sett	8.00	7.77^a	62.16^b
T_5 – 150g rhizome sett	6.67	8.53^a	56.80^b

All means in a column followed by the same letter are not significantly different at 0.05 level Tukey's Honest Significant Difference (HSD) Test.

Table 2. The number and weight of rhizome setts required and the number of plantlets propagated for one-hectare farm

Treatment	Required Total Number of Rhizome Setts	Required Total Weight of Rhizome Setts (kg)	Number of Plantlets Propagated
T_1 – 50g rhizome sett	38,909.00	1,945.45	166,666
T_2 – 75g rhizome sett	33,716.00	2,528.70	166,666
T_3 – 100g rhizome sett	26,594.30	2,659.43	166,666
T_4 – 125g rhizome sett	21,450.00	2,681.25	166,666
T_5 – 150g rhizome sett	19,561.80	2,934.27	166,666

Table 3. Net income from the recovered rhizome setts and income from plantlets and the combined net income from the recovered rhizome setts and the plantlets produced as planting materials for one-hectare farm

Treatment	Net Income from Recovered Rhizome Setts (PhP)	Income from the Plantlets Produced (PhP)	Combined Net Income from the Recovered Rhizome Setts and Plantlets Produced (PhP)
T_1 – 50g rhizome sett	34,660	166,666	201,326
T_2 – 75g rhizome sett	45,830	166,666	212,496
T_3 – 100g rhizome sett	48,430	166,666	215,096
T_4 – 125g rhizome sett	48,490	166,666	215,156
T_5 – 150g rhizome sett	53,590	166,666	220,256

The result could be attributed to the higher amount of nutrients stored in the bigger setts that sustained the full development of plantlets which coincided with the result of previous studies that growth increased depending on the size of the seed rhizome, bigger seed rhizome had bigger buds and more food stored that boost the growth of ginger (Blay *et al.*, 1988) and turmeric (Hossain *et al.*, 2005).

On the contrary, in every kilogram of setts, the setts with the smallest size (50g) significantly had the highest number of plantlets produced (85.67 plantlets) than the setts with bigger size (Table 1). This could be attributed to a greater number of setts made in every kilogram of rhizomes that resulted in a higher total number of plantlets produced although lesser number of plantlets was produced per sett.

The study of Rahman *et al.* (2022) about direct rhizome planting and transplanting of plantlets from single bud, double bud, and triple bud revealed that the direct rhizome planting has the tallest height, more tillers, and rhizome yield followed by the transplant with two buds, while the transplants, the plant height, number of tillers, and rhizome yield increased as the size of buds increased.

Likewise, Sengupta and Dasgupta (2011) emphasized that larger rhizome size as planting material produced a greater number of tillers per plant, which is similar to the result of the study of Mahender *et al.* (2015). On the other hand, the micropropagation method of producing plantlets could be considered very rapid, but their disadvantages was they don't produced optimum size of rhizome when transplanted, and they suffered environmental shock during acclimatization that causes the delay of harvesting (Bhagyalakshmi *et al.*, 1994). TC plants tended to produce more tillers and leaves, but lower rhizome yield than plants propagated from rhizomes (Flores *et al.*, 2021).

Number and weight of rhizome setts that produced the required number of plantlets for one-hectare farm

The number of setts to produce the required number of plantlets for one-hectare farm relied on the size of the setts. It was observed in this study that the number of required setts is inversely proportional to the weight per sett. The result in Table 2 shows that to produce the required number of plantlets, a total of 38,909 numbers of the smallest setts was sown with 1,945.45 kg total weight of rhizomes. On the other hand, under the bigger size of setts at 150g, the least number of setts was needed with a total of 19,561.80 setts but have the highest total weight of 2,934.27 kg setts was sown.

Required number of plantlets for one-hectare farm

The number of plantlets needed to plant a one-hectare farm at a planting distance of 20 cm x 30 cm between hills and rows respectively was 166,666 plantlets. Therefore, the total number and weight of rhizomes setts sown that produced the required number of plantlets varies with the size of setts and the number of plantlets produced per sett by the respective treatments.

Net income from the recovered mother rhizomes and combined net income from the recovered mother rhizomes and the plantlets produced

After the gathering of plantlets, the recovered mother rhizomes were still in good quality as condiments, hence they were sold immediately at higher price due to inadequate supply in the market during that period. Table 3 revealed that the 150g setts (T_5) have the highest net income from the recovered mother rhizome setts which is PhP53,590.00 as compared to the smallest treatments (T_1-50g) with PhP34,660.00.

Likewise, the 150g setts have the highest combined net income from the recovered mother rhizomes and the plantlets produced with PhP220,256.00 as compared to the smallest setts (50g) with PhP201,326.00 (Table 3).

This could be attributed to the volume of the recovered mother rhizomes because there were more rhizomes sown to produce the required number of plantlets as planting materials for one-hectare farm on the treatment with bigger size of setts (150g) than the treatment with smaller size of setts (50g).

Conclusion

The treatment with the biggest size of rhizome sett (150g) had produced the highest number of plantlets per sett due to more nutrients stored to sustain the growth of plantlets, highest net income from recovered mother rhizomes and highest combined net income from mother rhizomes and plantlets produced due to more rhizomes were sown and recovered. Likewise, the treatment with the smallest size of rhizome setts (50g) had produced the highest number of plantlets kg^{-1} sett due to a greater number of setts were made and sown in every kilogram of rhizomes.

The advantage of using this technology was the recovery of the sown rhizome setts and plantlets. The recovered rhizome setts can be sold at higher price due to inadequate supply in the market during the gathering period which could be translated to an immediate and higher income. More rhizome setts sown and recovered could generate more income. Moreover, the propagated plantlets can be transplanted directly in the field since the plantlets have established roots to support the initial growth of the plantlets with higher survival rate than the *in vitro* or tissue culture propagated plantlets.

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