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Propagation of ginger *(Zingiber officinale)* plantlets as planting materials through sowing the matured rhizomes in various media

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Abstract

Ginger (*Zingiber officinale)* is perennial plant native in South East Asia with pungent rhizome taste that make it as important ingredients of Asian cuisine and other kinds of foods. It is also a good home remedies of common illnesses. The most common planting materials used by most farmers in the world are the matured rhizomes which consists 70% from the overall cost of production. Hence, this research aimed was to explore the propagation of plantlets as low-cost planting material in view of the appropriate sowing media and the economic return. The result revealed that the mixture of 50% soil + 50% rice hull (T_5) produced the tallest plantlets (58.33 cm), highest number of plantlets per rhizome sett (11.08) and per kilogram setts (221.67) due to the availability of nutrients from the soil and sufficient amount of moisture retained by the rice hull. On the other hand, those sown in river sand (T_1) have the highest computed number and weight of setts sown with 8,608.20 pc and 430.41 kg respectively. Further, it also has the highest computed weight of recovered setts (464.03 kg) due to more setts were sown to produce the required number of plantlets for one-hectare farm. Economic wise, T_5 gave the highest net income from plantlets (PhP79,289.58), and highest combined net income (PhP102,261.38) from recovered mother rhizomes and plantlets produced due to higher number of plantlets produced, while T_1 provided the highest net income (PhP31,876.80) from recovered mother rhizomes due to more rhizomes were sown and recovered.

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Introduction

Ginger (*Zingiber officinale)* is commonly consumed as condiment and as home remedies of common illnesses (Li *et al.*, 2019; Prakash, 2019). It is a perennial plant native to South East Asia and usually used by Asians as condiment due to its pungent rhizome taste (Weiss, 2002).

In ginger production, the most common planting materials used by farmers in the Philippines and in some other countries are the matured rhizomes. Big volume of rhizomes is required as planting material per year (Yusuf *et al.,* 2007). Bera and Moktan (2006) mentioned that the highest expenses in ginger production were the planting material using rhizomes which consist 70% from that of the overall cost of production. Matured rhizome is expensive due to its high demand for condiments, as an ingredient for beverages, as natural medicine and planting material. To reduce the cost of planting materials, the use of plantlets as substitute for the matured rhizomes for planting is being considered.

In ginger plantlets propagation, there is already known method such as the *in vitro* or tissue culture method of propagation in the laboratories. *In vitro* multiplication can be effective means for the elimination of pathogens from vegetative propagated material. It can also help in the year round propagation of several ginger plantlets from a just single shoot. However, the cost of tissue cultured planting materials is very high (Freyre *et al.*, 2019) and had poor success when planted in the field that restraints its commercialization (Gupta and Verma, 2011) because the *in vitro* or tissue cultured plantlets cannot be transplanted outright in the field because those kind of plantlets required hardening or acclimatization in a nursery within 3 - 4 weeks (Malamug *et al.,* 1991). Likewise, Pandey *et al.* (1996) mentioned too that tissue cultured plantlets have very low survival rate of just 42.90% when directly transplanted in the field. During the 1st generation of the hardened plantlets in the field or the 1st year of rhizome production, a very small size rhizomes can be produced which can be used only as planting materials for the propagation of the 2nd generation rhizome production for the 2nd year cropping season.

Moreover, the rhizome yield of ginger from the 1st generation production has an average of 13.25g clump^{-1} of a very small rhizome size, while the rhizome yield clump^{-1} on the 2nd generation ranges from 67.98g – 152.40g, while the average rhizome yield of the ginger using matured rhizomes with 2-3 buds as planting material was 212.31g clump^{-1}. Hence, it takes three cropping season or three years before the ideal size of rhizomes for commercial purposes could be produced which an add-on to production cost is thereby decreasing the profit, if any, considering the high cost of planting materials. According to Chithra *et al.* (2004) that one of the major hindrances in the *in vitro* propagation of Zingiberacean members is the delayed formation of rhizome in field established plantlets compared to conventionally propagated plants.

On the other hand, other method that has the potential as rapid method of propagation is the sowing of matured rhizomes in the nursery at lower cost than the *in vitro* method since it does not use expensive infrastructures, maintenance cost or a complicated laboratory procedure. Moreover, this method uses only locally produced matured rhizomes and sowing media substrates that are abundant in the area, and the plantlets to be produced are bigger in size ranging from 30–50 cm height with more established roots that ensures higher survival rate when transplanted in the field. This method of propagation is usually dependent on the kind, particularly on the composition of the sowing media (Osaigbovo and Orhue, 2006).

Meanwhile, one of the most important criteria for successful germination is a reliable germination medium. The ideal sowing media must be easily drained but had high water holding capacity to minimize the amount of water needed. The influence of the medium should be felt even before the plant sprout, because of its water retention and aeration properties. According to Baiyeri (2005), the use of rice hull in the media is excellent in Musa plantlets than those with the mixture of saw dust. The supply of rice hull in the world is not less than 100 million tons per year (Okafor and Okonkwo, 2009). Hence, the study aims to evaluate the effects of the various sowing media on the propagation of ginger plantlets to be used as planting materials.

Materials and method

Location and preparation of the experimental area

The study was conducted on a partially shaded area at the Don Mariano Marcos Memorial State University - North La Union Campus Research Farm, Bacnotan, La Union, Philippines. The experimental area was cleared from any debris of woods, grasses, stubbles of previous crop, stones and then levelled.

Research design

The study was randomly laid out in three blocks employing the Randomized Complete Block Design (RCBD). There are five treatments of the study with five polybags per treatment in every block. The treatments of the study are; T_1 – Garden Soil, T_2 - River Sand, T_3 – Rice Hull, T_4 – 50% Soil + 50% River Sand, T_5 – 50% Garden Soil + 50% Rice Hull.

Preparation of the sowing media

The garden soil was taken within the area, the sand was collected along the river while the rice hull was collected from the nearest rice mill. The sowing media was mixed thoroughly as specified in the mixture ratio for the treatments then sterilized by heating on an old galvanized iron for about two hours. During sterilization, the sowing media mixtures were occasionally stirred to ensure that they were uniformly and properly sterilized. After sterilization, the sowing media mixtures were set aside to cool and then put in a 15” x 15” x 15” polybag to almost full or just two inches unfilled from the top portion of the bag.

Preparation of setts

Matured rhizomes (native ginger) free from any insect damage and diseases were procured from the local farmer-producer. One day before sowing, the rhizomes were divided into 50g sett then dipped into a 0.50% concentration of sodium hypochlorite solution for five minutes to eliminate any pathogens or contamination at the injured cut portion then placed in shaded area to drip the excess solution within one day.

Sowing and cultural management

The setts were sown by inserting them in the polybag at a depth of two inches. Two setts were sown per polybag then watered immediately. Succeeding watering was done uniformly in all the treatments every three days during the early part of the experiment due to inadequate moisture and occasional watering during the later stage in the absence of rain. Weeding was done occasionally depending on the growth and density of weeds.

Gathering of plantlets and recovery of the sown setts (mother rhizomes)

Two months after sowing, the emerged plantlets from the sown setts had already reached the ideal height of 50 cm. They were dug out from the polybag and then the plantlets were detached from the setts. This was done by cutting the attached portion of the plantlets from the setts using a sharp knife.

Data collection

During the gathering of the plantlets at two months after sowing (DAS), the height (cm) was measured from the base to the tallest leaf. The number of plantlets were counted per sett and recorded while the recovered sown setts (mother rhizomes) were weighed (kg) and recorded. The net income (PhP) was computed in per hectare basis.

Data analysis

Analysis of variance (ANOVA) was done using the Statistical Tool for Agricultural Research (STAR) version 2.0.1 (January 2014) of the International Rice Research Institute (IRRI), Los Baños, Laguna, Philippines to determine the significant differences among the treatments. The Tukey’s Honest Significant Difference (HSD) Test was also used for those significant ANOVA result for pairwise comparison on the significant differences between the treatments means at 0.05 levels.

Results

Plant height

The plantlet height was measured at two months after sowing. The plantlets gathered from T_5 (media mixture of 50% garden soil + 50% rice hull) were the tallest (58.33 cm) but comparable to those sown in mixture of 50% garden soil + 50% river sand (T_4) with 56.50 cm height (Table 1). On the other hand, the shortest plantlets were attained by those sown in pure river sand (47.50 cm).

Number of plantlets produced per sett

The number of plantlets produced by the setts within two months from sowing is presented in Table 1. The setts sown on mixture of 50% garden soil + 50% rice hull (T_5) significantly produced the highest number of plantlets (11.08) per sett, followed by those sown in the mixture of 50% garden soil + 50% river sand (T_4) with 10.17 plantlets per sett but comparable to those sown in garden soil (T_1) with 9.58 plantlets per sett. On the other hand, the lowest number of plantlets (7.75) produced were those sown in river sand.

Number of plantlets produced per kg setts

The setts sown in media of 50% garden soil + 50% rice hull (T_5) significantly produced the highest number of plantlets (221.67) per kilogram setts and followed by those sown in media of 50% garden soil + 50% river sand (T_4) with 203.33 plantlets per kilogram setts, but comparable to those sown in garden soil (T_1) with 191.67 plantlets per kilogram setts (Table 1).

Table 1. Height and number of plantlets emerged from the setts at two months after sowing (MAS) as affected by the different sowing media

Treatments	Height (cm)	Number of plantlets produced	
		Per Sett (50 g/sett)	Per kg Sett
T_1 – Garden Soil	56.00^{b}	9.58^{b}	191.67^{b}
T_2 – River Sand	47.50^{d}	7.75^{c}	155.00^{d}
T_3 - Rice Hull	51.50^{c}	8.58^{c}	171.67^{c}
T_4 - 50% Garden Soil + 50% River Sand	56.50^{ab}	10.17^{b}	203.33^{b}
T_5 - 50% Garden Soil + 50% Rice Hull	58.33^{a}	11.08^{a}	221.67^{a}

*Means in a column followed by the same letter are not significantly different from each other at 0.05 level (Tukey's HSD Test).

Table 2. The quantity of rhizome setts sown on the propagation of the required number of plantlets for one-hectare ginger farm

Treatments	Quantity of rhizome setts sown on the propagation of plantlets for one-hectare farm	
	Computed number of rhizome Setts (50g sett^{-1})	Computed total weight of rhizome Setts (kg)
T_1 – Garden Soil	$6{,}957.60^{c}$	347.88^{c}
T_2 –River Sand	$8{,}608.20^{a}$	430.41^{a}
T_3 - Rice Hull	$7{,}786.60^{b}$	389.33^{b}
T_4 - 50% Garden Soil + 50% River Sand	$6{,}560.93^{cd}$	328.05^{c}
T_5 - 50% Garden Soil + 50% Rice Hull	$6{,}024.07^{d}$	301.20^{d}

*Means in a column followed by the same letter are not significantly different from each other at 0.05 level (Tukey's HSD Test).

Computed number of setts (50g sett^{-1}) sown to produce the required number of plantlets for one-hectare farm

Table 2 revealed significant differences among the treatments on the computed number of setts sown to produce the required number of plantlets to plant one-hectare farm. The river sand (T_2) although produced the least number of plantlets per sett but had the highest number of setts sown (8,608.20 setts).

Table 3. Computed weight of recovered rhizome setts on the propagation of planting materials

Treatments	Recovered rhizome setts	
	Weight of recovered rhizome per sett (g)	Comp. wt. of recovered rhizomes setts that produced the required number of plantlets for one-hectare farm (kg)
T_1 – Garden Soil	54.33	378.02[c]
T_2 – River Sand	53.92	464.03[a]
T_3 - Rice Hull	54.25	422.36[b]
T_4 - 50% Garden Soil + 50% River Sand	54.00	354.34[cd]
T_5 - 50% Garden Soil + 50% Rice Hull	54.50	328.42[d]

*Means in a column followed by the same letter are not significantly different from each other at 0.05 level (Tukey's HSD Test).

Table 4. Computed net income from the recovered rhizome setts and plantlets produced for one-hectare ginger farm as affected by the different sowing media

Treatments	Net Income from the recovered rhizome setts (PhP)	Net income from plantlets (PhP)
T_1 – Garden Soil	26,298.00	70,891.00
T_2 – River Sand	31,876.80	57,684.80
T_3 - Rice Hull	29,305.79	70,814.40
T_4 - 50% Garden Soil + 50% River Sand	24,415.60	71,868.42
T_5 - 50% Garden Soil + 50% Rice Hull	22,971.80	79,289.58

On the other hand, T_5 (50% garden soil + 50% rice hull) produced the highest number of plantlets per sett, so it had the least computed number of setts sown (6,024.07) to produce the necessary number of plantlets to plant one-hectare farm (Table 2).

Computed weight (kg) of setts sown to produce the required number of plantlets for one-hectare farm

The result in Table 2 revealed significant differences among the treatments. The sowing medium river sand (T_2) had the highest computed weight of setts (430.41 kg) sown to produce the required number of plantlets to plant a one-hectare farm, while the setts sown in a media mixture of 50% garden soil + 50% rice hull (T_5) had the lowest computed weight of setts sown (301.20 kg).

Weight per piece (g) of recovered setts (mother rhizomes)

The plantlets were gathered two months after sowing. The result in Table 3 showed that the weight per sett has increased from the original weight of the sett which partially shriveled prior to sowing because it absorbed moisture from the soil while producing plantlets within two months from sowing. The weight per sett after detaching the plantlets ranges from 53.92g to 54.50g with no significant differences.

Computed weight (kg) of recovered setts that produced the required number of plantlets for a one-hectare farm

The computed weights of the recovered setts have significant differences among the treatments. The highest computed weight of recovered sown setts was recorded by T_2 (River Sand) with 464.03kg, while the lowest computed weight of recovered setts was exhibited by T_5 (50% garden soil + 50% rice hull) with 328.42kg rhizomes (Table 3). The result implies that the number of plantlets produced per sett is inversely proportional to the required number of setts sown.

Net income from the recovered setts

The highest net income of the recovered setts was attained by T_2 (river sand) because more setts were recovered due to more setts were sown to produce the required number of plantlets to plant one-hectare farm. This is due to lesser number of plantlets produced per sett, hence more rhizomes were sown to produce the required number of plantlets (Table 4).

Net income from the plantlets produced

The highest net income in the propagation of plantlets as planting materials for one-hectare farm was attained by T_5 (50% garden soil + 50% rice hull) because it has the least cost of polybag due to lesser number of polybags used (Table 4).

Table 5. Computed combined net income from the recovered setts and plantlets produced for one-hectare ginger farm as affected by the different sowing media

Treatments	Combined net income from the recovered setts and the plantlets produced (PhP)
T_1 – Garden Soil	100,120.19
T_2 – River Sand	89,561.60
T_3 - Rice Hull	97,189.00
T_4 - 50% Garden Soil + 50% River Sand	96,284.02
T_5 - 50% Garden Soil + 50% Rice Hull	102,261.38

Combined net income

The combined net income from the recovered setts and plantlets produced is shown in Table 5. The highest net income was registered by T_5 (50% garden soil + 50% rice hull) with PhP102,261.38 while the lowest was achieved by T_2 (river sand) with PhP89,561.60.

Discussion

Ginger plantlets are promising alternative of the matured rhizomes as planting material. Rapid proliferation and growth of plantlets is very important aspect during propagation which could be affected by the growing media. The emergence of plantlets from the seed rhizomes (setts) are usually dependent on the amount of nutrients stored and the initial number of active buds from the setts. The height usually influenced by the nutrient contents and availability of moisture in the sowing media. According to Khan *et al.*, (2006) that the water-holding capacity, electrical conductivity, organic matter content, pH, and aeration are the excellent characteristics of a growing media to be considered. Likewise, Ikram *et* al. (2012) mentioned too that essential nutrients of the growing media have great effects to attain the optimum height of any seedlings. Osaigbovo and Orhue (2006) stated that successful production of quality seedlings was greatly affected by the composition and kind of the growing media.

The result of the study revealed that the 1:1 mixture of garden soil and rice hull (T_5) proved to be the most appropriate media in propagating ginger plantlets. It produced the tallest and more plantlets per sett because of the nutrients present in the soil and sufficient moisture from by the rice hull that boost the proliferation and sustained their growth and development. The amendment of rice hull compost (RHC) increases the available water content, field capacity, electrical conductivity, soil organic matter content and the permanent wilting point, bulk density, and reduced soil pH (Demir and Gulser, 2021). According to (Mehmood *et al.,* 2013), the high amount of nutrients in growing media could boost longer vegetative period and growth. Baiyeri (2005) reported that a combination of growing media like rice hull and soil have outstanding effects because of the sufficient presence of nutrients and moisture that could sustained the growth of the plantlets. Dewayne *et al.* (2003) mentioned too that the water-holding capacity, aeration, and nutritional component of the media with a mixture of rice hull and soil are among the factors that sustained the proliferation and growth of the plantlets.

On the other hand, inferior performance of the ginger sown in pure sand could be attributed to its limited nutrient contents and low water holding capacity. Likewise, inferior performance was also observed to those sown in pure rice hull which could be due to the negligible amount of available nutrients to sustain the growth and development of the plantlets although the amount of moisture is sufficient. Similarly, according to Silver *et al.* (2000), that due to bigger pore spaces of the sand or sandy soils, the water holding capacity is poor. Crops planted on sandy soil were commonly suffered water stress which affects their growth and yield. Water holding capacity and nutrient availability are usually affected by the texture of the growing media. However, for seeds, Ibrahim *et al.* (2017) mentioned that the percentage of sprouted seeds of *Nepeta cataria* were higher in soil media with mixture of two volume sand + 1 volume clay loam soil due to the availability of nutrients at considerable amount.

The net income could be attributed to the number of plantlets produced per sett by the respective treatments; hence in T_5, since it produced the highest number plantlets per sett, so lesser number of setts were sown to produce the required number of plantlets for one-hectare farm, lesser number of polybag were used, therefore the cost of polybag and rhizome were lowest.

Conclusion

The rhizome setts sown in media with a mixture of 50% garden soil + 50% rice hull (T_5) produced the highest number of plantlets per sett and per kilogram of setts, and tallest plantlets after two months from sowing. This could be attributed to the availability of nutrients from the garden soil and sufficient moisture from the rice hull throughout the duration of propagation because of its high water-holding capacity that made the nutrients readily available from the soil for the growth and proliferation of the plantlets resulting to higher net income from the plantlets, and the combined net income from the plantlets and recovered setts because more plantlets and setts were produced and recovered respectively.

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