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# Influence of Different Storage Methods on the Viability and Field Establishment of Seed Rhizome Ginger (*Zingiber officinale* Rosc.) in Ethiopia

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**Three to four months time gap between harvesting and next planting of ginger that could lead to significant loss of planting materials necessitated devising appropriate storage method (s) of seed rhizome ginger. This experiment was conducted for two cropping seasons (2009 and 2010) to assess and identify suitable storage method (s) using two promising ginger varieties (Yali and Tepi local) and five types of storage methods. The storage treatments included: keeping seed rhizomes under thatched roof shelter on the ground, thatched roof shelter on one meter raised bed or structure, in ground pits covered with thin grass mulch, buried in pits and under tree shade covered with mulch materials. Necessary data of ginger rhizomes were recorded at different stages (before planting, during harvest and after planting) and analyzed. Percent shriveled of rhizomes were significantly influenced among the varieties. Maximum shriveled (41%) rhizomes were obtained from Tepi local. All other parameters were not significantly affected by variety. However, the storage methods significantly influenced all the parameters considered. Maximum seed rhizome viability 85.7 and 85.4% were recorded from seed rhizomes kept under tree shade and from seed rhizomes kept in pits covered with mulch materials, respectively. Whereas maximum fresh rhizome yield 282.4 and 275.2 Q•ha$^{-1}$ (quintal per hectare) were obtained from seed rhizomes kept under tree shade covered with mulch materials and from seed rhizomes kept under thatched roof shelter on the ground. The results disclosed that there are more safe options to keep seed rhizomes which could be designed and constructed easily at farmers' level.**

**Key words:** Seed setts, rhizomes, harvesting, storage methods, sprouting, planting, mulch

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## INTRODUCTION

Ginger (*Z. officinale* Rosc.) is among the important and widely used spice crops throughout the world (Hamza *et al*., 2013) and in Ethiopia (Jansen, 1981; Girma *et al*., 2008). According to the second growth and transformation plan (GTPII) of the Ministry of Agriculture and Natural Resource, the production of fresh ginger in 2015/16 was planned to be 625000 Q (fresh) and to increase to 725700 Q by 2020. Similar to this productivity was planned to increase from 200 Q/ha in 2016 to 225 Q/ha in 2020. This all plan is with overcoming the disease problem caused by ginger bacterial wilt (*Ralstonia solanacearum*) (MoANR, 2016). However, the challenge due to the bacterial wilt of ginger has been devastating that needed serious intervention. Ginger is well known and high cash crop in Ethiopia and fresh or dry rhizomes are for sale on most markets (Girma *et al*., 2008, Edossa, 1998; Jansen, 1981).

Ginger is mainly grown in the wetter regions of Kaffa, Illubabor, Gamu-Gofa, Sidamo and Wollega, mostly in gardens. According to Central Statistics Office (1970), larger-scale production is also reported from Gore (Illubabor), Wolita (Sidamo). Moreover, Kuls (1962) reported that ginger is the major cash crop for the Gumuz people (Gojam, Begemider). Ethiopia ranked $15^{th}$ in ginger production (8000 metric ton) (FAO, 2012). The country exported 47180 ton of dry ginger and generated 38 million USD and this accounted for the lion share (71%) of the total four major spices exported (Masresha, 2010). Except the current challenge of the ginger bacterial wilt, it used to be an important cash crop for farmers in the southern, southwestern and northwestern Ethiopia. Production of this spice was being expanded in more parts of the country as it can grow in wider areas provided that there is no frost and no disease threat. According to Roukens *et al*. (2005), ginger production in Southern Nation Nationality People Regional states (SNNPR) and in Oromiya regional states amounts to 3,251 and 121 hectares respectively. The production of rhizome yield from such acreage was reported to be 374,210 and 3,154 Q•$ha^{-1}$ respectively. The authors also added that ginger is cultivated mainly in SNNR accounting for about 96 percent of the total area under spices which sums up 26,498 hectares of land.

Ginger is always propagated by portions of the rhizomes known as seed pieces or seed setts (Purseglove *et al*., 1981). A rhizome is a specialized stem structure in which the main axis of the plant grows horizontally at or just below the ground surface (Hartmann *et al*., 1997). Ginger planting time in lowland areas of Ethiopia including Tepi and Bebeka is from mid-March to end of April. In most cases, optimum ginger harvesting stage is nine months after planting when the leaves turn yellow and start drying up. The harvesting time extends from November to January. There is three to four months gap between harvesting and next planting time (March or April). Thee seeds should be stored in this time gap. Different techniques or experiences of keeping or storing seed setts are adopted by the growers in various parts of the world.

According to Borget (1993) the rhizomes are harvested six weeks before they are required and are treated with Benlate fungicide immediately before planting. In India, Aiyadurai (1966) reported that the practice of retaining a portion of the crop to be used as seed in the field without harvest under thick mulch led to the recovery of a higher quality of seed material than leaving the crop in un mulched condition. The author also reported that storing seed rhizomes in pits under anaerobic conditions resulted in the maximum recovery of seed rhizomes and better development of sprouts than storing in pits under aerobic conditions. Different activities or methods are reported for maximization of viability and germination of ginger seeds.

Treating the seed rhizomes with 0.1% wet table Ceresan before storage is reported very good practice to get recovery of higher proportion of healthy rhizomes for maximum germination (Purseglove *et al*., 1981). Some experiences from Kerala Agricultural University (1983) also indicate that best seed rhizomes free from pest and disease are selected in the field while the plants are 6-8 months old and still green. Then, the seed-rhizomes are carefully handled to avoid damage to buds and selected seed rhizomes are soaked in a solution of Mancozeb and Malathion for 30 minutes. Finally, the treated rhizomes are dried in shade by spreading on the floor (Kerala Agricultural University, 1983).

In most ginger growing areas of Ethiopia, storage of seed rhizome ginger is practiced in different methods: some store under big tree shade, some leave un harvested and un mulched, and also some keep in partially dug pits covered with some grass mulch or uncovered. Such practices could lead to significant loss of seed due to decay. This fact necessitated devising suitable and effective storage techniques or methods of seed rhizome ginger. This experiment was initiated with the objective of identifying suitable storage method of seed rhizome ginger with maximum viability and germination performance.

## MATERIALS AND METHODS

This experiment was conducted in Tepi Agricultural Research Center, 1200 masl, annual rain fall of 1755 mm (seven years average), and minimum and maximum temperature of 15.5 and 29.5 ºC, respectively. Weather data records of the experiment years were summarized and presented in Table 2 (Annex Table 2). The soil of the experimental site was fertile soil suitable for production of ginger. Two varieties of ginger; Miz.180/73 (Yali) and Tepi-local were tested under different seed rhizome storage methods as indicated for two years (2009 and 2010). The treatments include two ginger varieties (Yali and Tepi-local) and 5 storage methods. The storage treatments were keeping or storing rhizomes under:

1. Thatched roof shelter on the ground
2. Thatched roof shelter on one meter raised shelf
3. In pits covered with thin grass mulch.
4. Buried in pits
5. Tree shade covered with mulch materials

Seed rhizomes of the ginger varieties were taken during harvesting and stored for three months (January to March) according to the storage methods described above. For each treatment 15 kg of seed rhizomes were used. In April of the following season, percent rotted, sprouted shriveled and viable were recorded.

The treatments (2 varieties X 5 storage methods) were factorially combined in randomized complete block design (RCBD) with three replications. Seed rhizomes from each treatment combinations were planted in the

**Table 1.** Percent rotting, sprouting, shriveling, viable and fresh rhizome yield (Q•ha$^{-1}$) of seed rhizome of two ginger cultivars under different storage methods.

| Treatments | Percent of seed rhizome | | | | Fresh rhizome yield Q•ha$^{-1}$ |
|---|---|---|---|---|---|
| | rotted | sprouted | shriveled | Viability | |
| **I. Varieties** | | | | | |
| 180/73 | 10.8 | 88.5 | 11.7 | 88.3 | 266.3 |
| Tepi local | 2.2 | 92.0 | 41 | 89.5 | 243.4 |
| **II. Storage methods** | | | | | |
| 1. Under thatched roof shelter on the ground | 0.9b | 1.5c | 17.2a | 80.0ab | 275.2a |
| 2. Under thatched roof shelter on one meter raised shelf | 0.0b | 0.17c | 26.4a | 73.0b | 264.7ab |
| 3. In pits covered with thin grass mulch | 2.5ab | 87.6a | 1.3b | 85.4a | 226.1b |
| 4. Buried in pits | 6.5a | 80.9a | 0.83b | 80.9a | 226.0b |
| 5. Under tree shade covered with mulch materials | 0.9b | 29.8b | 5.3b | 85.7a | 282.4a |
| CV (%) | 10 | 11 | 8 | 7 | 15 |
| **Significance** | | | | | |
| Cultivars | NS | NS | 0.0003 | NS | NS |
| Storage methods | 0.0031 | 0.0001 | 0.0001 | 0.027 | 0.016 |
| Cultivars*Storage methods | NS | NS | 0.0028 | 0.0001 | NS |

Means within a column having different letters are significantly different according to LSD at P$\leq$ 0.05.

field and all the necessary field management practices were applied as per the recommendation. The rhizomes were harvested when matured and rhizome yield data was recorded. Important growth and yield data were collected and analyzed. Data analysis was performed with version 9.2 of SAS software package (SAS Institute Inc., 2008, Cary, NC. USA). Analysis of variance (ANOVA) was conducted for all collected data and Duncan mean separation test was performed between means to test variety and storage methods. Moreover, combined analysis was conducted for mean values with significant interaction effects between variety and storage methods.

## RESULTS AND DISCUSSIONS

Percent shriveled of seed rhizome ginger was significantly influenced (P$\leq$ 0.001) due to varieties used for planting, but there was no significant effect on percent rotted, sprouted, viable and fresh rhizome yield due to the varieties. Whereas, significant effect of storage treatments was obtained in all of the parameters: percent rotted, sprouted, shriveled, viable and fresh rhizome yield (P$\leq$ 0.05). Interaction effect of varieties and storage methods resulted in a significant effect only on two parameters: percent shriveled and percent viable of seed rhizome (P$\leq$ 0.01 and 0.001) respectively while there was no significant interaction effect on other parameters. Even if there was no significant effect means showed variations in the treatments. As shown in Table 1, the mean percent rotted seed rhizome of variety Miz.180/73 (Yali) was higher (10.8%) than Tepi local (2.2%), while percent sprouted of Miz.180/73 (Yali) was lower (88.5%) than Tepi local (92%). Percent rotted was higher on variety Miz.180/73 (Yali) than Tepi local. This might be due to the larger rhizome size of Miz.180/73 (Yali) which most of the time has high water content due to its larger size. At the same time the fact that percent shriveled was higher in Tepi local which has relatively smaller rhizome size. It could be due to its vulnerability to shrink faster than the bigger rhizome variety Miz.180/73 (Yali). While the larger size rhizome contains more water content it didn't shrink as higher as Tepi local.

Percent shriveled was significantly influenced (P$\leq$ 0.001) by variety that, mean percent shriveled of Tepi

**Annex Table 2**. Monthly rain fall distribution (mm) and maximum and minimum air temperature for the experimental years (2009 and 2010)

| Months | Year I (2009) (16/02/09 - 20/02/10) | | | Year II (2010) (15/03/10 - 22/01/11) | | |
|---|---|---|---|---|---|---|
| | Rain Fall (mm) | Air temperature (°C) Max. | Air temperature (°C) Min. | Rain Fall (mm) | Air temperature (°C) Max. | Air temperature (°C) Min. |
| January | - | - | - | - | - | - |
| February | 92 | 33.3 | 14.8 | - | - | - |
| March | 133.1 | 31.1 | 16.1 | 175.3 | 31.9 | 16.5 |
| April | 141.9 | 30.2 | 17.3 | 111.7 | 31.1 | 16.7 |
| May | 182.6 | 29.2 | 16.7 | 155.1 | 29.8 | 16.8 |
| June | 200.8 | 27.2 | 16.0 | 131.0 | 28.5 | 16.6 |
| July | 135.7 | 27.0 | 15.8 | 105.5 | 28.0 | 16.1 |
| August | 250.2 | 27.2 | 16.4 | 150.4 | 28.0 | 16.3 |
| September | 218.1 | 28.2 | 15.8 | 143.0 | 30.0 | 16.1 |
| October | 121.5 | 28.9 | 16.2 | 259.5 | 28.9 | 15.8 |
| November | 82.9 | 29.6 | 15.9 | 28.4 | 30.5 | 15.8 |
| December | 37.4 | 31.0 | 15.8 | 91.3 | 29.9 | 15.9 |
| January | 66.5 | 31.0 | 15.5 | 18.8 | 32.2 | 14.6 |
| February | 11.8 | 33.6 | 15.6 | - | - | - |
| Total | 1674.5 | 387.5 | 207.4 | 1370.0 | 328.8 | 177.2 |
| Mean | | 27.7 | 14.9 | | 23.5 | 12.7 |

local was higher (41%) than Miz.180/73 (11.7%). This result was in line with the report by Purseglove *et al*. (1981). The Authors discussed that variety is the governing factor for all growth, harvest and postharvest performance in spices.

The most and important factor that significantly influenced/affected all the parameters under consideration was the storage methods where the seed rhizomes were kept during the off season from harvesting to the next planting. This condition includes all the microclimatic factors such as moisture carrying capacity of the covering materials used, air circulation (aerobic and anaerobic condition) that could significantly influence the parameters considered. From the storage methods used, the second treatment (keeping seed rhizomes under thatched roof shelter on one meter raised structure or bed) resulted in less rotting of seed rhizomes while maximum seed rhizome rotting (6.5%) resulted in the fourth method (keeping seed rhizomes buried in pits). Two storage methods namely; under thatched roof shelter on the ground and under tree shade covered with mulch materials resulted in 0.9% rotting of seed rhizome ginger. Maximum mean sprouting (87.6%) of seed rhizome ginger was obtained from keeping seed rhizome ginger in pits covered with thin grass mulch while minimum mean percent sprouting was obtained from keeping seed rhizome ginger under thatched roof shelter on one meter raised shelf. And next to the maximum percent sprout was 80.9% from seed rhizomes buried in pits. Maximum percent shriveled of seed rhizome (26.4%) resulted from seed rhizomes kept under thatched roof shelter on one meter raised shelf or bed; and the minimum shriveled of seed rhizome (0.83%) was obtained from keeping seed rhizomes buried in pits (Table 1). The highest seed rhizome viability 85.7% and 85.4% were obtained from storage methods under tree shade covered with mulch materials, and in pits covered with thin grass mulch. Maximum fresh rhizome yield 282.45 Q•ha$^{-1}$ was obtained from keeping seed rhizome under tree shade covered with mulch materials and next to this was 275.2 Q•ha$^{-1}$ obtained from seed rhizomes stored under thatched roof shelter on the ground (Table 2). This result supported a report on ginger from previous works by Irum (2008). The author reported that viability of seed rhizome, germination, vigour and finally yield increased from seed rhizomes stored in suitable environmental condition.

Combined analysis (Variety*storage methods) showed significant interaction effect of variety*storage methods. There was significant difference among the mean percent shriveled and percent viable. From the mean separation the maximum shriveled (41%) was obtained from Tepi local when seed rhizomes stored under thatched roof shelter on one meter raised structure or bed. And again the lowest percent shriveled (0.83%) was obtained from the same variety when rhizomes were buried in pits and Miz.180/73 when the seed rhizomes were kept in pits covered with thin grass mulch, and seed rhizomes buried in pits, respectively (Figure 1). From combined analysis, the maximum percent viability 89.5% and 88.3% was obtained from Tepi local when seed rhizomes buried in pits, and from Miz.180/73 when seed rhizomes kept under thatched roof shelter on the ground, respectively. The lowest viability (60.2%) was obtained from Tepi local

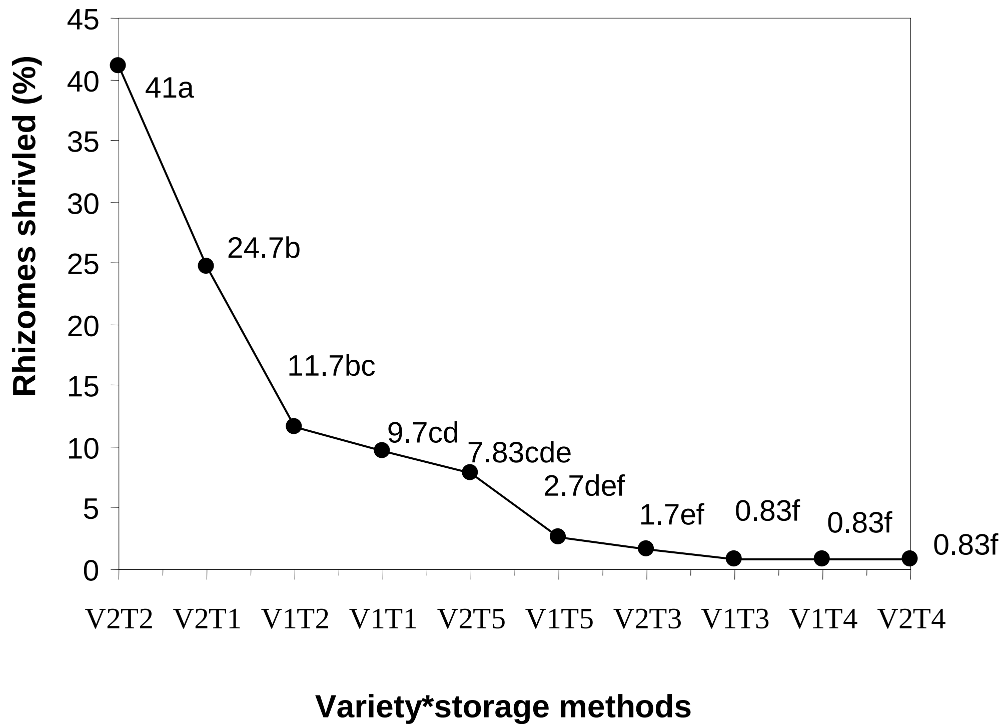


**Figure 1** Percent shriveled ness of seed rhizome ginger as influenced by the interaction of variety and storage methods used, where V1 and V2 are varieties Miz.180/73 (Yali) and Tepi local, respectively. T1= seed rhizomes kept in thatched roof shelter on the ground, T2= seed rhizomes kept in thatched roof shelter on one meter raised shelf, T3= seed rhizomes kept in pits covered with thin grass mulch, T4= seed rhizomes kept buried in pits and T5= seed rhizomes kept under tree shade covered with mulch materials. Means with different letters for each response are significantly different according to LSD at $P \leq 0.05$.

when seed rhizomes stored under thatched roof shelter on one meter raised structure or bed (Figure 2). Generally the results indicated a supportive finding with a report by Aiyadurai (1966) that storing seed rhizomes in pits under anaerobic conditions resulted in the maximum recovery of seed rhizomes and better development of sprouts than storage in pits under aerobic conditions.

## CONCLUSION AND RECOMMENDATIONS

Both variety and storage methods are important factors to attain quality seed rhizome ginger, however the second one is more crucial that affected more of the parameters under consideration. Therefore, high care is required to store ginger seed rhizomes and to preserve successfully. Storage methods that can help to have more or less anaerobic conditions during storage time to facilitate high sprouting and fast recovery of seed rhizomes should be designed from local materials. It can be concluded that seed rhizome storage can vary depending on different weather factors like rainfall, temperature. If the season is rainy, it is advisable to keep in more or less open storages. This includes keeping seed rhizomes in pits covered with thin grass mulch, under tree shade covered with mulch materials, or kept (buried) in pits. From the current results, keeping seed rhizomes under tree shade covered with mulch materials or seed rhizomes kept under thatched roof shelter on the ground can be recommended.

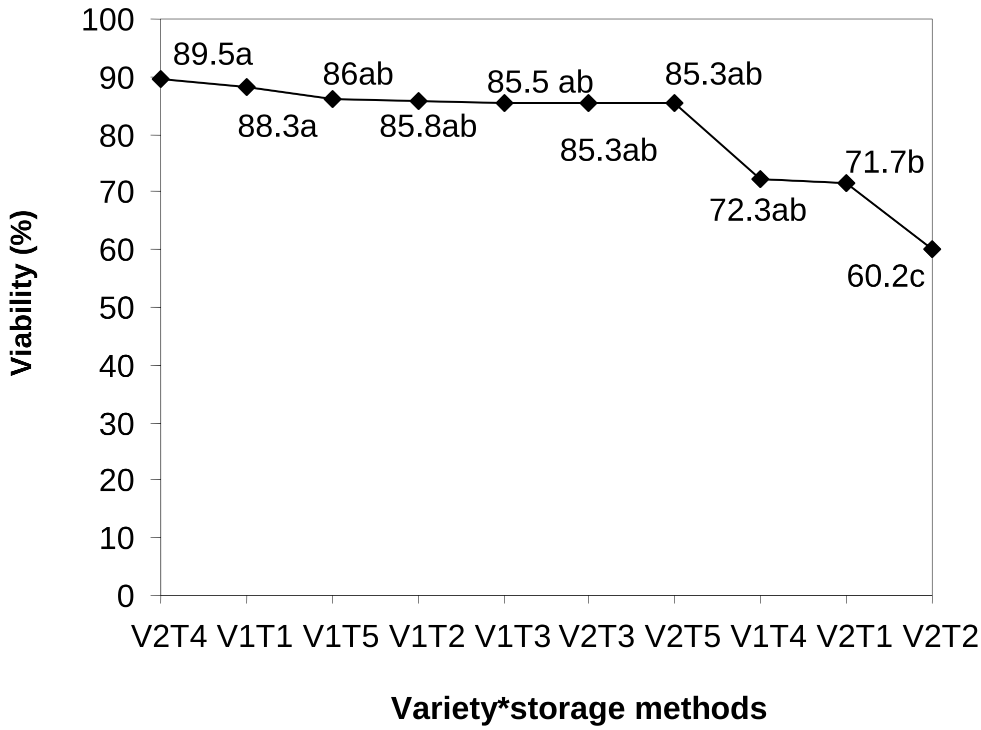


**Figure 2** Percent viability of seed rhizome ginger as influenced by the interaction of variety and storage methods used, where V1 and V2 are varieties Miz.180/73 (Yali) and Tepi local and T1, T2, T3, T4 and T5 are storage methods indicated above in Figure 1. Means with different letters for each response are significantly different according to LSD at P ≤ 0.05.


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