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Research Article

The Influence of Storage Area, Storage Method and Seed Quality Character on the Quality of Shallot Seed

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Abstract

Shallot seed bulb has distinctive dormant period. Thus, it needs certain duration for germination. The dormant period is influenced by pre-planting condition, post-harvest period, and storages house condition. The objective of research is to understand the effect of storage area, storage method and seed quality character on the quality of shallot seed. The research is conducted from August 2013 to October 2013 in three areas of storage (Guntarano at 100 m above the sea level (a.s.l); Simoro at 300 m a.s.l; Petimbe at 500 m a.s.l, using 15 bulb characters of seed quality and two storage methods, including: (1) seeds are bundled and hanged on the pole and (2) seeds are taken apart (protol) and spread on the board. The experiment involves three replications. Statisticalanalysis by employing Anova test with theprogramof SAS 9.1. Result of research indicates that (1) storage area at 300 m a.s.l. can improve the quality of shallot seed bulb; (2) the seed with characters of small bulb and potassium level of 120 kg K_2O ha^{-1} or the seed with characters of big bulb and potassium level of 90 K_2O ha^{-1} has the best quality and can be used as shallot seed; (3) storage with protol method has produced better quality of seed than hanging method.

Keywords: Shallot seed, storage area, hanging method, protol method.

Introduction

Shallot (*Allium ascalonicum* L) represents an important horticulture commodity for farmers, peoples and nation. The productivity of shallot in Central Sulawesi has declined from year to year. Shallot production in this Province is 7.84 tons ha^{-1} in 2011 compared to 4.12 tons ha^{-1} in 2012 and 3.37 tons ha^{-1} in 2013 (BPS, 2013). It is reversely related to the increasing productivity of shallot in Indonesia. One of the causes behind the decline of shallot productivity in Central Sulawesi is the lack of the quality seed stock.
Farmers usually use poor quality seeds since farmers always rely much on the remainder of harvest yield in which the seed taken was often in small size. The quality of shallot seed may differ and depending on harvest yield obtained by every farmer. Shallot seed bulb has certain dormant period and therefore, it needs certain duration for germination. To break the dormant period, the seed is stored for ± 2 months. Shallot seed bulb in PaluValley is generally stored with hanging method, while protol method is used for the bulb with easily fallen leaves.

Dormant period of the seed is influenced by variety, pre-planting condition, post-harvest and storage condition. The storage of shallot seed bulb is aimed at breaking the dormant period and to preserve the physiological quality of the seed for the next planting. Physiological quality of the seed is influenced by pre-harvest and post-harvest conditions of the seed.

Justice and Bass (2002) say that the main goal of seed storage is to provide the preserve of seed quality from one season to next season. Kuswanto (2003) assumes that seed storage aims at providing the seed with the expected quality for the next planting season.

Local shallot seed in Palu after drying has water content about 76%-80%. This condition causes the seed to germinate easily (45 days after harvest), the seed to be exposed with the increased evaporation (the seed is shrinking), and the seed to be more susceptible to microbial attack (the seed is rotten) during the storage at 31^0C and the humidity at 71 % (Maemunah, 2010). It is consistent to Baswarsiati (2009) and Ko *et al*., (2002) who suggest that problems found in shallot seedling include very short storage age which is 4-5 months; very high weight loss of more than 30%; and pest and disease attacks during storage.

The decreased quality of shallot during storage due to mechanical, physiological and micro-organism damages involves the reduction of water content, the distorted growth of shoot, the softening of bulb, the distorted growth of root, and the rotten. Weight loss is quite high with more than 30 %. The storage age of bulb is very short and it is inevitable because genetically, shallot bulb is watery (Musaddad and Sinaga, 1994).

Shallot that is stored at 30^0C has good quality because after eight weeks of storage, the shallot still shows high firmness (2.5 mm/50 g/10"), low damage (5%) and high VRS (69.01 microgrek/g). Shallot that is stored at 20^0C has better quality than that is stored at 0^0C and 10^0C (Musaddad and Sinaga, 1994).

The storage of seed is based on local knowledge such that it is expected that the quality of seed may be preserved until the next planting and storage method can be applied by farmers.For those reasons, the objective research is to find out the effect of area and the storage method as well as seed quality character towards shallot seed quality.

Materials and Methods

Material

15 characters of shallot seed which represent the best selection from three planting areas, two bulb sizes and four potassium levels.

Equipment

Refractometer (RHC-200N-800 X 525), penetrometer (Stanhope-seta/RS232C), analytical weight (Adam PW245), sliding gauge (150 mm/6 x 0.05/1/128), thermo-hygrometer (HC520), and lux meter (LX-1010B).

The research design employed in this study is experimental research between locations with split-split plot design in group random sampling replicated three times in each location. The experiment involves there storage areas: (1) Guntarano at 100 ma.s.l, Temperature (T)= 26.80$^{\mathbf{0}}$C – 28.00$^{\mathbf{0}}$C and Relative Humidity (RH)= 74.50% - 78.20%); (2) Simoro at 300 m a.s.l, T= 27.60$^{\mathbf{0}}$C–27.80$^{\mathbf{0}}$C and RH= 78.30% - 82.30%, and (3) Petimbe at 500 m a.s.l.,T= 25.45$^{\mathbf{0}}$C–26.40$^{\mathbf{0}}$C and RH= 94.60% - 96.60%) using 15 bulb characters of seed quality (coming from three planting areas with small and big bulb, also with different potassium levels) and two storage methods, including: (1) seeds are bundled and hanged on the pole and (2) seeds are taken apart (protol) and spread over the board). Statistical analysis by employing Anova test with the program of SAS 9.1. The storage method is based on local wisdom, the follow-up test involves DMRT (P = 0.05).

Results and Discussion

The storage of shallot seed bulb for ± 2 months aims at breaking the dormant period and to preserve the physiological quality of the seed until the next planting. Physiological quality is determined by pre-harvest and post-harvest conditions. Both conditions of seed bulb will influence the storage age of the seed. The attributes of these conditions include the early quality, the moisture content of early quality, and the condition of storage room of the seed.

Storage for two months may produce water content reduction. Storage area at 100 m a.s.l., has relatively lower moisture content reduction rate (0.27%). This occurrence is apparent in the seed with characters of big bulb and potassium level of 60 kg K_2O ha^{-1} which is stored with protol method. The seed stored with hanging method has relatively higher moisture content reduction rate (15.33%). The storage at 300 m a.s.l produces moisture content reduction rate in the range from 1.04% to 7.04%. The storage area at 500 a.s.l., indicates moisture content reduction rate ranging from

0.36% to 7.37%. Relatively lower moisture content reduction rate is found in the storage with protol method.

Storage area of 100 m a.s.l., with temperatures 26.80^{0}C – 28.00^{0}C and relative humidity of 74.50% - 78.20%, resulting in a decrease in the rate of moisture content of relatively large seeds stored in the seed suspension makes more loss of water so that the seeds dry. In contrast to the storage area 300 m a.s.l., (T = 27.60^{0}C -27,80^{0}C and RH = 78.30% - 82.30%) and 500 m a.s.l., (T = 25.45^{0}C – 26.40^{0}C and RH = 94.60% - 96.60%), the rate of decline in seed moisture content is relatively small, indicating that seed has a better quality and ready to be replanted. It is appropriate (Sedaghathoor *et al*., 2013), that the decline in the quality of tea is determined by changes in the water content of tea in storage, and by Purwanti, (2004) that the soybean seed storage black and yellow at low temperatures is able to maintain seed quality remained high during the six months of storage.

The highest moisture content is found in the seed with character of big bulb and potassium level of 60 kg K_2O ha^{-1} (77.13%) that is stored at 500 m a.s.l., with protol method. The lowest moisture content is observed in the seed with the character of potassium level of 60 kg K_2O ha^{-1} (60.76%) in the storage area of 100 m a.s.l, and that is stored with hanging method. Too high or too low moisture content can reduce the quality of seed due to the damage of tissue (Table 1).

Table 1. The influence of storage area, storage method and seed quality character, onmoisture content and seed bulb firmness

Treatments*)			Moisture Content 15 DAS (%)	Moisture Content 60 DAS (%)	Bulb Firmness 15 DAS (N mm^{-})	Bulb Firmness 60 DAS (N mm^{-1})
100 m a.s.l.	seed quality characters					
	Small size bulb 60 kg K_2O ha^{-1}	Hanging methods	**77.20** ^{abcdef}	**75.29** ^{ghi}	**40.18** ^{ij}	**28.41** ^{efgh}
	Small size bulb 120 kg K_2O ha^{-1}		**76.38** ^{abcde}	**72.08** ^{cde}	**27.60** ^{cdefg}	**26.38** ^{bcde}
	Smal size bulb 150 kg K_2O ha^{-1}		**76.56** ^{abcde}	**71.57** ^{bcd}	**28.41 efg**	**25.17** ^{abc}
	Big size bulb 60 kg K_2O ha^{-1}		**76.09** ^{abcd}	**60.76** ^{a}	**23.14** ^{a}	**24.76** ^{ab}
	Big size bulb 150 kg K_2O ha^{-1}		**74.56** ^{a}	**69.15** ^{b}	**28.01** ^{defg}	**25.98** ^{bcd}
	Small size bulb 60 kg K_2O ha^{-1}	Protol methods	**76.13** ^{abcde}	**73.70** ^{cdefgh}	**40.99** ^{j}	**26.38** ^{bcde}
	Small size bulb 120 kg K_2O ha^{-1}		**75.25** ^{ab}	**73.57** ^{cdefgh}	**26.65** ^{bcdef}	**25.17** ^{abc}
	Small size bulb 150 kg K_2O ha^{-1}		**75.59** ^{ab}	**71.43** ^{bc}	**29.63** ^{fgh}	**23.14** ^{a}
	Big size bulb 60 kg K_2O ha^{-1}		**74.40** ^{a}	**73.45** ^{cdefgh}	**23.14** ^{a}	**26.79** ^{bcdef}
	Big size bulb 150 kg K_2O ha^{-1}		**75.57** ^{ab}	**73.26** ^{cdefgh}	**23.95** ^{ab}	**25.17** ^{abc}
300 m a.s.l.	**Small size bulb 60 kg K_2O ha^{-1}**	Hanging methods	**75.58** ^{ab}	**73.55** ^{cdefgh}	**24.76** ^{abc}	**28.01** ^{defg}
	Small size bulb 150 kg K_2O ha^{-1}		**74.49** ^{a}	**73.45** ^{cdefgh}	**23.54** ^{a}	**26.38** ^{bcde}
	Big size bulb 60 kg K_2O ha^{-1}		**76.33** ^{abcde}	**75.09** ^{efghi}	**26.79** ^{bcdef}	**28.82** ^{fghi}
	Big size bulb 90 kg K_2O ha^{-1}		**77.52** ^{abcdef}	**70.87** ^{bc}	**25.17** ^{abcd}	**25.57** ^{bc}
	Big size bulb 150 kg K_2O ha^{-1}		**77.78** ^{abcdef}	**74.55** ^{defghi}	**24.76** ^{abc}	**28.41** ^{efgh}
	Small size bulb 60 kg K_2O ha^{-1}	Protol methods	**75.78** ^{abc}	**73.81** ^{cdefgh}	**28.01** ^{defg}	**29.63** ^{ghi}
	Small size bulb 150 kg K_2O ha^{-1}		**77.43** ^{abcdef}	**72.34** ^{cdefg}	**23.14** ^{a}	**25.57** ^{bc}
	Big size bulb 60 kg K_2O ha^{-1}		**79.65** ^{ef}	**72.61** ^{cdefg}	**29.22** ^{fg}	**28.82** ^{fghi}
	Big size bulb 90 kg K_2O ha^{-1}		**76.64** ^{abcde}	**72.15** ^{cdef}	**25.57** ^{abcde}	**26.79** ^{bcdef}
	Big size bulb 150 kg K_2O ha^{-1}		**76.27** ^{abcde}	**72.93** ^{cdefgh}	**25.98** ^{abcde}	**27.19** ^{cdef}
500 m a.s.l.	**Small size bulb 90 kg K_2O ha^{-1}**	Hanging methods	**80.70** ^{f}	**75.19** ^{ghi}	**30.04** ^{gh}	**29.63** ^{ghi}
	Small size bulb 120 kg K_2O ha^{-1}		**80.31** ^{f}	**72.94** ^{cdefgh}	**37.75** ^{i}	**30.85** ^{i}
	Big size bulb 60 kg K_2O ha^{-1}		**77.57** ^{abcdef}	**75.9** ^{hi}	**37.75** ^{i}	**28.82** ^{fghi}
	Big size bulb 90 kg K_2O ha^{-1}		**79.23** ^{cdef}	**75.15** ^{fghi}	**47.89** ^{k}	**30.04** ^{ghi}
	Big size bulb 150 kg K_2O^{-} ha^{-1}		**78.43** ^{bcdef}	**75.29** ^{ghi}	**47.49** ^{k}	**28.82** ^{fghi}
	Small size bulb 90 kg K_2O ha^{-1}	Protol methods	**79.38** ^{def}	**73.19** ^{cdefgh}	**32.47** ^{h}	**30.85** ^{i}
	Small size bulb 120 kg K_2O ha^{-1}		**79.53** ^{def}	**73.55** ^{cdefgh}	**41.40** ^{j}	**29.63** ^{ghi}
	Big size bulb 60 kg K_2O ha^{-1}		**77.49** ^{abcdef}	**77.13** ^{i}	**42.21** ^{j}	**26.79** ^{bcdef}
	Big size bulb 90 kg K_2O ha^{-1}		**75.77** ^{abc}	**72.02** ^{cd}	**52.36** ^{l}	**30.44** ^{hi}
	Big size bulb 150 kg K_2O ha^{-1}		**75.56** ^{ab}	**72.07** ^{cde}	**49.11** ^{k}	**30.85** ^{i}

Remarks: Means followed by the same letters are statistically not significant (Duncan's multiple range test. P = 0.05, DAS= days after storage.

The seed with the character of potassium level of 60 kg K_2O ha^{-1} has less quality due to the deficit of potassium during the growth. Potassium level of 150 kg K_2O ha^{-1} has produced potassium surplus during bulb establishment. Such condition causes the seed to be more hygroscopic than other bulb seeds. They also easily absorb waters from the surrounding environment and therefore, the seed may have high moisture content. The deficit and surplus of potassium can damage the cellular wall. Both cases are reducing the level of calcium as the composer of cellular wall and also as the important part of meristem growth (Abou El- Magd *et al*., 2010; Morsy *et al*., 2012; Sumarni *et al.,* 2012; Bahari *et al*., 2014).

Storage room temperature plays a role in maintaining the quality of the seeds in storage, because it affects the seed moisture content, relative humidity of the room. At low temperatures respiration running slower than high temperature. In these conditions the seed quality can be maintained longer. Storage area 300 m - 500 m a.s.l., with temperatures 25.45^{0}C – 27.80^{0}C and relative humidity of 78.30% - 96.60% is optimal in storage onion seeds.

The seed with the character of satiated potassium level (at 90 kg K_2O ha^{-1}– 120 kg K_2O ha^{-1}) has stable water content reduction rate and also shows lower moisture content. Such condition is emerging because potassium is less functional to preserve cellular turgor pressure and plant moisture content. and therefore. failed to improve the yield and quality of the plant (Singh and Verma, 2001; Nabi *et al.,* 2010; Abou El-Magd *et al.,* 2010).

Some researches (Roy *et al.,* 2007; Hartawan and Nengsih, 2012) have reported that moisture content is important to decompose carbohydrate during the storage. High level of water content in seed bulb will increase carbohydrate decomposition. If the percentage of seed bulb loss shall increase. the quality of bulb seed will decline. Sumiati *et al.,* (2004) have reported that big bulb has greater carbohydrate content for example it produces higher level of growth and bulb yield in the next generation. Furthermore, in Arief and Saenong (2006) that there a relationship between the size of the seed with seed quality and yield, where in the seed with a smaller size gives results 10-45% lower. Seed size will also affect the physiological characteristics of plants and seed dormancy period (Mohammadi *et al*., 2014).

The best seed firmness at 15 days after storage (DAS) is obtained in the seed with the characters of big bulb, potassium level of 60 kg K_2O ha^{-1}, storage with hanging and protol methods, and storage at 100 m a.s.l. The best seed firmness is also observed in the seed with characters of small bulb, potassium level of 150 kg K_2O ha^{-1}, storage with hanging and protol methods, and storage at 300 m a.s.l. Generally, bulb firmness decreases during storage. It is because the composer of cellular wall and the other macro components are changing. The softening of cellular wall may be caused by cellular turgor change which eliminates the freshness of vegetable during storage.

At 60 days after storage, the firmness rate of the seed stored at 300 m a.s.l. is decreasing (start to soften). In the storage area at 100 m a.s.l the softening is only obvious among the seed with potassium level of 60 kg K_2O ha^{-1} and 150 kg K_2O ha^{-1}. At 500 m a.s.l the seed does not experience softening. Seed softening is a sign that the seed is germinating.

The height of storage area determines loss percentage. Higher altitudes will increase loss percentage. The loss percentage at 60 days after storage remains in the range from 7.87 % to 17.00 %. Hanging method of storage at 100 m a.s.l and 300 m a.s.l has produced higher loss percentage than protol method. At 500 m a.s.l. hanging method has lower loss percentage (Table 2). It contrasts with other researches (Komar *et al.*, 2001; Rajiman, 2010) which have found that shallot losses the weight for around 31.44% - 58.36% during storage. Morsy *et al*., (2012) have asserted that the storage for 60 days has produced loss percentage for around 14.72% - 25.75%.

Total soluble solids(TSS) of seed bulb at 60 days after storage indicates both the lowest (16.73 ^{0}brix) and the highest (23.33^{0}brix). Relatively higher TSS rate is found in the storage area at 300 m a.s.l. Similar finding is reported by Benkeblia *et al*., (2002) that total soluble solidsis decreasing at 50 days after storage at 10^{0}C. One indication of quality seed is high level of total soluble solid (Nabi *et al*., 2010).

Total soluble solids of bulb seed stored with protol method is higher than that stored with hanging method. In protol method water content reduction rate may be relatively low such that the seed is firmer than that of hanging method. It is consistent with Lantemona *et al*.,(2013) who find that the best quality of sugar palm is determined from its total soluble solids.

At 60 days after storage, the percentage of damaged bulb can be the highest and/or the lowest. The highest percentage of damaged bulb (60.52%) is found at storage area of 300 m a.s.l for the seed with characters of small bulb, potassium level of 60 kg K_2O ha^{-1}, and storage with hanging method. The lowest percentage of damaged bulb (2.94 %) is obtained at storage area of 300 m a.s.l for the seed with characters of big bulb, potassium level of 120 K_2O ha^{-1}, and storage with protol method (Table 2). If the demand for potassium is satiated (90 kg K_2O ha^{-1} – 120 K_2O ha^{-1}) during seed bulb establishment, the potassium will then be functional as the enzymatic activator in the metabolism to improve the yield and quality of plant (Singh and Verma, 2001; Islam *et al*., 2008; Nabi *et al*., 2010; Rajiman, 2010).

Table 2. The influence of storage area, storage method and seed quality character on weight lost, total soluble solids, and bulb rotten

Treatments*)			**% Bulb weight lost**	**Total Soluble Solids (^{0} brix)**	**% Bulb rottent**
			60 DAS	**60 DAS**	**60 DAS**
100 m a.s.l.	seed quality characters				
	Small size bulb 60 kg K_2O ha^{-1}	Hanging methods	**11.81^{ef}**	**20.10^{hi}**	**18.46^{hi}**
	Small size bulb 120 kg K_2O ha^{-1}		**11.72^{ef}**	**22.00^{kl}**	**25.86^{j}**
	Smal size bulb 150 kg K_2O ha^{-1}		**11.59^{ef}**	**17.00^{ab}**	**18.28^{ghi}**
	Big size bulb 60 kg K_2O ha^{-1}		**12.65^{fg}**	**17.33^{abc}**	**14.58^{ef}**
	Big size bulb 150 kg K_2O ha^{-1}		**7.87^{a}**	**19.00^{efgh}**	**3.44^{a}**
	Small size bulb 60 kg K_2O ha^{-1}	Protol methods	**8.74^{ab}**	**19.33^{fghi}**	**3.64^{a}**
	Small size bulb 120 kg K_2O ha^{-1}		**9.82^{bcd}**	**20.00^{hi}**	**9.62^{cd}**
	Small size bulb 150 kg K_2O ha^{-1}		**13.59^{gh}**	**19.67^{ghi}**	**3.22^{a}**
	Big size bulb 60 kg K_2O ha^{-1}		**8.74^{ab}**	**19.67^{ghi}**	**15.11^{efgh}**
	Big size bulb 150 kg K_2O ha^{-1}		**10.06^{bcd}**	**23.33^{m}**	**3.58^{a}**
300 m a.s.l.	**Small size bulb 60 kg K_2O ha^{-1}**	Hanging methods	**12.88^{fg}**	**19.33^{fghi}**	**60.52^{l}**
	Small size bulb 150 kg K_2O ha^{-1}		**10.74^{cde}**	**20.33^{ij}**	**17.39^{fghi}**
	Big size bulb 60 kg K_2O ha^{-1}		**11.66^{ef}**	**22.10^{kl}**	**12.20^{de}**
	Big size bulb 90 kg K_2O ha^{-1}		**10.92^{de}**	**22.07^{kl}**	**13.95^{ef}**
	Big size bulb 150 kg K_2O ha^{-1}		**10.79^{cde}**	**19.67^{ghi}**	**7.59^{bc}**
	Small size bulb 60 kg K_2O ha^{-1}	Protol methods	**10.03^{bcd}**	**20.33^{ij}**	**5.77^{ab}**
	Small size bulb 150 kg K_2O ha^{-1}		**11.79^{ef}**	**23.07^{lm}**	**2.67^{a}**
	Big size bulb 60 kg K_2O ha^{-1}		**9.81^{bcd}**	**21.67^{k}**	**14.82^{efgh}**
	Big size bulb 90 kg K_2O ha^{-1}		**12.08^{ef}**	**23.07^{lm}**	**4.67^{ab}**
	Big size bulb 150 kg K_2O ha^{-1}		**13.02^{fg}**	**21.33^{jk}**	**2.94^{a}**
500 m a.s.l.	**Small size bulb 90 kg K_2O ha^{-1}**	Hanging methods	**11.63^{ef}**	**18.10^{bcde}**	**4.60^{ab}**
	Small size bulb 120 kg K_2O ha^{-1}		**15.62^{ij}**	**16.73^{a}**	**7.53^{bc}**
	Big size bulb 60 kg K_2O ha^{-1}		**13.61^{gh}**	**17.67^{abcd}**	**4.77^{ab}**
	Big size bulb 90 kg K_2O ha^{-1}		**17.00^{j}**	**18.33^{cdef}**	**14.74^{efg}**
	Big size bulb 150 kg K_2O^- ha^{-1}		**9.39^{bc}**	**18.67^{defg}**	**49.54^{k}**
	Small size bulb 90 kg K_2O ha^{-1}	Protol methods	**11.63^{ef}**	**20.33^{ij}**	**20.29^{i}**
	Small size bulb 120 kg K_2O ha^{-1}		**16.68^{j}**	**20.33^{ij}**	**26.44^{j}**
	Big size bulb 60 kg K_2O ha^{-1}		**14.88^{hi}**	**17.00^{ab}**	**15.53^{efgh}**
	Big size bulb 90 kg K_2O ha^{-1}		**13.64^{gh}**	**17.33^{abc}**	**17.44^{fghi}**
	Big size bulb 150 kg K_2O ha^{-1}		**12.59^{fg}**	**19.00^{efgh}**	**20.69^{i}**

Remarks: Means followed by the same letters are statistically not significant (Duncan's multiple range test. P = 0.05, DAS= days after storage

The percentage of rotten bulb of the seed with characters of small bulb and potassium level of 60 kg K_2O ha^{-1} is the highest because the demand of potassium is not met during bulb seed establishment. The level of protein (Sheidaei *et al*., 2014) as the composer of cellular wall becomes low which may reduce the integrity of cellular membrane such that it is easily damaged penetrated or leaked due to the lack of total soluble solids (Comadug and Simon, 2002; Roy *et al.*, 2007; Hartawan and Nengsih, 2012).

Conclusion

From the research findings and discussion. it can be conluded that: 1. Storage area at 300 m a.s.l can preserve the quality of shallot seed2. The seed with characters of small bulb and potassium level of 120 kg K_2O ha^{-1} or the seed with characters of big bulb and potassium level of 90 K_2O ha^{-1} has the best quality and can be used as shallot seed 3. Hanging method of storage is suitable for storage area at 100 m a.s.l. while protol method of storage is useful to preserve seed quality for storage area at 500 m a.s.l. Storage area at 300 m a.s.l can employ both hanging and protol methods.

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