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Desiccation tolerance of seeds of Loquat (*Eriobotrya japonica* Lindi)

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Enhancing seed longevity has proved a menace to many programmes in Kenya. Loquat (*E. japonica* Lindi) is one of those species whose seeds need to be preserved for the tree is both economically and socially important. The main concern of the study was to find out the desiccation tolerance of the seeds of loquat, so that they can be stored at economically viable conditions. The fruits of loquat were collected, transported to KEFRI seed centre, weight of the fruits were measured, and then the fruits were depulped to obtain the seeds. Loquat seeds extracted from green fruits; pale-yellow fruits and red fruits have initially very high moisture content (50%) and relatively high germination capacity (30-44.5%). After desiccating the seeds using silica-gel down to 20%, 12% and 5% moisture contents, germination capacity dropped to 13.6%, 6% and 2.67%, respectively. Experimental design was 3 x 4 factorial designs with four replicates. Anova analysis was used to test differences among levels of fruit ripeness and whether there was significant interaction between levels of moisture content and stage of ripeness. Within fruit ripeness stage values did not significantly differ according to whether the seeds were dried down to 20%, 12 % or 5% moisture content. Seeds extracted from very ripe fruits (red) have lower desiccation tolerance capacity and cannot keep their viability as long as those from the other two ripeness stages. Generally seeds of loquat are desiccation sensitive and are classified as intermediate seeds. It is advisable to store loquat seeds with initial, relatively high, moisture content, as long as the packaging material provides optimal condition for ventilation.

Key words: Desiccation tolerance, *E. japonica*, Germination Capacity, Longevity of seeds and Loquat and Tolerance sensitivity**.**

Introduction

Loquat *(E. japonica* Lindi) belonging to a family of Rosaceae is a dense evergreen tree which grows up to 7 m. The tree is of major economic importance. The tree is well known for firewood, poles, carving, food (fruit), bee forage, mulch, ornamental, shade, jam and syrup. The tree therefore serves as an agroforestry tree because of its multiple uses.

The food value of this tree is a fairly high. The protein content is 0.32-0.35 %; cellulose – 0.30-0.70 %; starch – 9.89-12.79 %; lipids – 0.03-06 % and water – 84.00 –89 % (Katende *et al*., 1995). The tree therefore does a lot in improving the diets of people and it is of particular importance to the small and young growing children.

There has been difficulty dealing with storage of the seeds of *E. japonica*, particularly desiccation tolerance of these seeds. Also proper harvesting or the timing of seed collection of the species has been a menace. The study therefore has been necessitated by the problems of desiccation tolerance of the seed, which have hitherto remained unknown or unanswered. Desiccation tolerance also aids seed handling processes. It is easier to handle seeds of low M.C than those of high M.C. This is relevant in the transportation of seeds. It is easier to transport dried seeds than those that are to be maintained at higher moisture content. The major problem with the seed of the species has been more often than not, its poor germination.

Moisture content is a factor that affects the longevity of seeds in storage and this fact justifies studies on the desiccation tolerance *E. japonica*. Even though this species can be propagated through vegetative means, the propagation through seeds cannot be under-estimated. Seeds can be used in ex-situ conservation through their storage in appropriate places. This can enable this species when its survival is threatened.

This research therefore endeavors to elucidate the most appropriate harvesting stages, seed handling techniques and storage condition for these seeds.

The objectives of this study were to determine the desiccation tolerance of *E. japonica* seeds at different levels of maturity, whether *E. japonica* seeds are recalcitrant, intermediate or orthodox. The study also determined the appropriate seed harvesting period and the most appropriate seed handling techniques for *E. japonica*.

Materials and methods

Study site

The experiment was conducted at Muguga, KEFRI, Kenya at an altitude of 2100m, a Latitude of 1^{o} 13’ S and a Longitude of 35^{o} 18’. It has a mean annual rainfall of 950 mm. The mean monthly maximum and minimum temperature are 20.9 ^{o} C and 10.8 ^{o} C, respectively, whereas the mean annual potential evaporation is 1707 mm.

Fruit collection, processing and seed measurement

Fruits of *E. japonica* were obtained from Muguga, near KEFRI Centre. Two methods were employed in seed collection process. The first method involved collecting the fruits through use of long poles to the strike fruits. Shaking the branches was also done. The second method, climbing was necessary for the fruits that could not be reached by the first method. The fruits collected were divided in three ripeness stages and these were green fruits, intermediate (pale-yellow) fruits and very ripe fruits, red in colour. These three types of fruits were packed in three different sacks.

The fruits were mechanically depulped for one hour using mechanical depulper. Immediately after depulping 200 seeds from each stage of maturity were sown in 3 separate perforated trays in 4 lines of 50 seeds. This was used as the control as it was not desiccated.

Fruits were measured before processing. This was done by randomly taking a sample of 25 fruits from each stage of ripeness.

Initial moisture content testing and desiccation

The initial moisture content was measured for each stage of ripeness immediately after depulping using infrared moisture meter. The seeds for each stage were further sub-divided into three groups of 200 seeds each. The groups were desiccated by mixing them with silica-gel in plastic bags. The containers were placed at an ambient temperature of 20-25 ^{o} C. The water loss in the seeds was monitored periodically by sieving to remove silica-gel and weighting the seeds.

Experimental design

The experimental design was 3 x 4 factorial completely randomized design. The design had 4 replicates containing 50 seeds each. There were two factors: moisture content and ripeness. Moisture content was denoted factor A and stage of ripeness denote factor B. Factor A had 4 levels (fresh seed, 20 % M.C., 12 % M.C. and 5 % M.C. Factor B had 3 levels (Green fruits, intermediate fruits and very ripe fruits). There were 12 treatments and the total number of responses in the experiment were therefore 48.

Seed sowing and data collection

In the study germination was used to assess the response due to desiccation at the three stages of ripeness. Water was applied manually so that the media (sand) was kept moist all the time without becoming waterlogged. The germination boxes were kept in a germination room with a continuous day light at a temperature of about 20-25 ^{o} C under controlled humidity of 80 %. Germination was recorded daily until no further germination occurred.

Data analysis

Since the experimental design was a 3 x 4 factorial design with four replicates, two factor. Analysis of Variance (Anova) was found to be the most appropriate method for analysis. This method used to test whether there were any difference among levels of fruit ripeness and to test whether there any significant interaction between levels of moisture and stage of ripeness. Tukey's test was used to test individual significant differences between treatments when the F value was significant ($P < 0.05$). Dunnett test (1955) was used to compare germination of the fresh seeds and that of seeds that were desiccated to various levels of moisture content.

Results and discussion

Relationship between moisture content and stage of ripeness of E. japonica seeds

The results of the study showed that the seeds extracted from the three ripeness stages initially had very high moisture content. Though green fruits had the highest moisture content, there was little difference with the other stages of ripeness (Table 1).

Table 1: Initial and target moisture contents of seeds of *E. japonica* at various stages of ripeness

Stage of ripeness	Initial M.C. (%)	Target M.C. (%)
Seeds from green fruits	53.2	20, 12, 5
Seeds from intermediate fruits	49.6	20, 12, 5
Seeds from very ripe fruits	52.4	20, 12, 5

Effect of fruit ripeness and seed moisture on germination of E. japonica

Stage of fruit ripeness

There appears to be a relationship between the stage of fruit ripeness and germination percentage of *E. japonica* . Taking the moisture content to be constant (~50 %), then the relationship is that the germination capacity of the seeds increases with maturity of fruit (Table 2).

Table 2: Fruit ripeness stages and seed moisture and interactive effect on germination (%) of *E. japonica*

Stage of ripeness	Moisture content to which seeds were desiccated (%)			
Seeds from green fruits	Fresh seeds (~ 50 %)	20 %	12 %	5 %
	14	12	4	4
	14	30	4	2
	26	34	2	2
	20	4	0	4
Seeds from intermediate fruits	20	22	12	14
	26	8	4	0
	14	16	16	0
	26	8	30	2
Seeds from very ripe fruits	50	4	0	2
	42	2	0	0
	38	8	0	2
	48	16	0	0

The percentage of germination recorded was in the order of very ripe fruits > intermediate fruits > Green fruits (Table 3). Anova, however, indicated that the stage of ripeness does not significantly affect ($P > 0.05\%$) the viability of seeds of the species.

Table 3: Fruit ripeness stages and seed moisture (%) interactive effect on germination (mean %) of *E. japonica*

STAGE OF RIPENESS	MOISTURE CONTENT			
	5 %	12 %	20 %	Fresh seeds (50%)
Green fruits	3.0a	2.5a	20.0 a	18.5 a
Intermediate fruits	4.0a	1.5a	13.5 a	21.5 a
Very ripe fruits	1.0b	0.0b	7.5 b	44.5 a

Note: Values with same letter along the column means that they are not significantly different (P > 0.05) using Tukey's test.

Seed desiccation

Desiccation of seeds also established certain trend on germination of *E. japonica.* Anova showed that moisture of content of *E. japonica* significantly affected (P > 0.05%) the germination of seeds of *E. ja*ponica. Germination decreased as the moisture content to which the seed was desiccated. Tukey's test showed that desiccation had significant differences (P < 0.05) when the means of the germination were compared. The test showed that the effect of seed moisture on mean germination percentage was ranked as follows: fresh fruit (seed of 50 % M.C) > seed of 20% M.C > seed of 12 M.C. > seed of 5 % M.C (Table 3).

Very high germination percentage was obtained from seeds extracted from maturing fruits as well as very ripe fruits. Seeds from very ripe fruits showed highest germination percentage where desiccation was not executed and lowest percentage was obtained in green seeds. On desiccating seeds to 20 % M.C., the germination dropped to 20%, 13 % and 7.5% for seeds extracted from green fruits, intermediate and ripe fruits, respectively (Table 3).

Two factor Anova showed that there was no significant interaction (P >0.05) between fruit ripeness stages and seed moisture content levels. The results indicated that the lower germination was obtained by seeds extracted from very ripe fruits when desiccation was executed than seeds extracted from intermediate or green fruits (Table 3).

The study carried out at Muguga, KEFRI clearly demonstrated that the seeds of E. japonica extracted from very ripe fruits, could not be desiccated below 20 % moisture and the still get substantial % of germination. Normally as the seeds mature, the moisture content goes down. This might be attributed to lower percentage of germination when very ripe seeds of *E. japonica.*

In certain instances their germination was as low as 0 %. Initially before desiccation, they have low water contents and when this little water is removed, the viability of the seeds is negatively affected.

The low germination percentage obtained by seeds extracted from very ripe fruits indicated the seeds suffered more from desiccation injury than the other to stages of ripeness. The present findings agree with the results obtained by Tim and Birnie (1989) that it is not possible to dry seeds without loss of viability under practical conditions. It is evident from the results that maturity occurs before the major changes in colour of fruits because even green seeds were able to germinate before desiccation.

Even though in the analyses the stage of maturity did not show any significant amongst the three stages of ripeness, the seeds with maximum germination percentage were obtained when the fruits of *E japonica* has just turned pale-yellow. Germination ability increases as the moisture content falls and often reaches a maximum before maturity.

Trends in seed desiccation tolerance usually correspond to increase in germination capacity and reaches maximum around maturity. This was confirmed in the study whereby the seeds extracted from intermediate fruits have shown high germination capacity and that it can be said that maturity for this particular species is attained when the fruits are in the intermediate stage of ripeness.

Desiccation tolerance in *E. japonica* is also improved by slow drying. Chemicals reagents like silica-gel are suitable for slow drying when used in a ratio of 1:1 with the seeds in terms of weight. Enforced rapid desiccation such as drying in the sun has been found to reduce viability of seeds (Hay and Roberts, 1995). Desiccating the seeds to low moisture content can enhance the longevity of seeds of *E. japonica*. Once the seeds are stored, they can meet the supply for the domain of seeds on years of low seed production, provision of seeds during the time they are required for propagation. Seeds can also be stored so that they can be sold for commercial purposes.

The oil content of seeds of *E.japonica* is 0.6%. This high percentage of oil lowers the desiccation tolerance. In *Ziziphus mauritiana* (Sown *et al*., 1991) which oil content of 0.3% does not show sensitivity to desiccation. It can be speculated therefore that this oil content is partially responsible for the inability of these seeds to tolerate desiccation.

The harvesting of the seeds of *E. japonica* should be done when the fruits have just started turning from green to pale-yellow. In large-scale seed collection programmes where it may be difficult to collect pale-yellow fruits, green seeds can be collected and the fruits are ripened to the targeted fruit colour like pale-yellow.

The seeds of *E. japonica* cannot be desiccated beyond 20 % M.C and still get substantial germination. The most suitable and manageable moisture content to which the seeds of *E. japonica* can be desiccated is 20 %. At this moisture content reasonable germination % will be obtained and the desiccation process will not be expensive.

The ability of seeds to tolerate high desiccation to very low moisture is a measure of seed quality. Seeds of *E. japonica* are therefore of low quality hence calls for proper seed handling particularly storage.

It has intermediate seeds that are desiccation sensitive; therefore slow drying should be adopted whenever they are dried. Rapid drying lowers the viability of the seeds. In enhancing the longevity of seeds the seeds, the moisture content be maintained at 12-20 % at a temperature of 15 ^{o} C. They should not be stored airtight containers but in bags, which allow air to circulate. To maintain low moisture content, either bags or sacks containing the seeds should be stacked in a cool place.

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