

Effects of X-ray Radiography on the Ber (*Ziziphus mauritiana* L.) Seed Germination

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Received 26 May 2017 ; Accepted 29 June 2017 ; Published online 17 July 2017

Abstract The primary objective of detecting hidden infestation in the ber has been achieved with investigations on different combinations of input factors of X-ray radiography viz., the voltage in kilovolts (KV), current in milliampere (mA) and period of exposure in seconds (s) to radiation. X-rays emanating from the voltage and current intensities used to detect the hidden infestation are soft X-rays and do not affect the viability of the seed materials. Twenty seeds per each combination were exposed to 5—32 KV, 5—9 mA and an exposure period of 12 seconds. The exposed seeds were then subjected to germination tests in plastic trays in the poly house. It was found that the germination percentage of ber seeds varied from 85—100% for different X-ray combination values. Exposure of X-ray radiation at 5, 10 and 15 KV voltage with different combinations of current with an exposure period of 12 seconds resulted in 100% germination. The radiation at 20 and 22 KV voltage with different combinations of current with an exposure period of 12 seconds resulted in 95% germination. The radiation combinations of 25, 26, 28, 30, 32

KV with their various current combinations with an exposure period of 12 seconds resulted in 90% germination except with the maximum current at 28, 30 and 32 KV with an exposure period of 12 seconds resulted in 85% germination.

Keywords X-ray radiography, Ber seed, Germination.

Introduction

Alternative use of the X-ray test to evaluate seed quality has become increasingly diverse. This study was performed primarily to establish experimental procedures and verify the effectiveness of the X-ray test to detect damage or abnormalities in seed structure associated with germination. Furthermore, X-ray analysis is a non-destructive, quick method that is relatively simple to perform. Morphological aspects of seeds possibly associated with viability may be evaluated by the X-ray test. For this reason, several researchers have reported relations between seed structure and germination or seedling morphology, obtaining information that varies according to the species. Among these are *Capsicum annum* [1, 2], embauba—*Cecropia pachystachya* Trec. [3], *Eugenia pleurantha* [4], and papaya—*Carica papaya* L. [5]. In addition, the radiographic images of the northern red oak's (*Quercus rubra* L.) acorns according to the degree of cotyledon-cotyledon and cotyledon pericarp separation and demonstrated the potential of X-ray image analysis to provide a rapid and non-destructive estimation of acorn viability and its relation with seed desiccation tolerance [6]. A lack of infor-

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Table 1. Effect of different combinations of X-ray exposure on germination of ber.

Combinations			No. seeds tak- en	No. of seeds germi- nated	Ger- mina- tion per- cen- tage (%)	Combinations			No. seeds tak- en	No. of seeds germi- nated	Germi- nation percen- tage (%)
KV	mA	S				KV	mA	S			
5	5	12	20	20	100	25	5	12	20	20	90
5	6	12	20	20	100	25	6	12	20	20	90
5	7	12	20	20	100	25	7	12	20	20	90
5	8	12	20	20	100	25	8	12	20	20	90
5	9	12	20	20	100	25	9	12	20	20	90
10	5	12	20	20	100	26	5	12	20	20	90
10	6	12	20	20	100	26	6	12	20	20	90
10	7	12	20	20	100	26	7	12	20	20	90
10	8	12	20	20	100	26	8	12	20	20	90
10	9	12	20	20	100	26	9	12	20	18	90
15	5	12	20	20	100	28	5	12	20	20	90
15	6	12	20	20	100	28	6	12	20	20	90
15	7	12	20	20	100	28	7	12	20	20	90
15	8	12	20	20	100	28	8	12	20	20	90
15	9	12	20	20	100	28	9	12	20	18	85
20	5	12	20	20	95	30	5	12	20	20	90
20	6	12	20	20	95	30	6	12	20	20	90
20	7	12	20	20	95	30	7	12	20	20	90
20	8	12	20	20	95	30	8	12	20	20	90
20	9	12	20	20	95	30	9	12	20	18	85
22	5	12	20	20	95	32	5	12	20	20	90
22	6	12	20	20	95	32	6	12	20	20	90
22	7	12	20	20	95	32	7	12	20	20	90
22	8	12	20	20	95	32	8	12	20	20	90
22	9	12	20	20	95	32	9	12	20	18	85
Control									20	20	100

mation on the association of X-ray analysis and seed viability in fruits i.e., ber to evaluate seed viability emphasizes the need for research in this area. The objective of this study was to evaluate the potential of the X-ray test in identifying damage and abnormalities in ber fruits as well as possible relationships with germination. When a beam of X-rays passes through seeds, a permanent image of them is formed on a film. The images can present a higher or lower degree of radio capacity (light) and radio luminescence (dark) depending on the absorption level of X-rays by the seeds, which is determined by factors such as composition, thickness and density of the tissues, and wavelength of the ionizing radiation [7].

Materials and Methods

In order to study the effect of harmful radiation, if

any, with these intended combinations with varied degree of X-ray radiation on seed germination, the healthy fruits were exposed to the X-rays of different combinations. The exposed seeds (extracted from fruits after exposure) were then subjected to germination tests in plastic trays in the poly house. In case of ber mechanical scarification of seeds involves cracking, nicking or partial removal of stony endocarp. This appears to be single most efficient pre-treatment to achieve highest percentage of germination. Cracking of endocarp can achieve 85—90% germination over a period of 12 days and seeds allowed for germination in plastic trays [8]. The germination rate increases to values greater than 90% at a temperature of 35°C. Thus, the optimum temperature for germination is 35°C [9]. One control line was also maintained with seeds that were not exposed to the X-ray radiation. The germination percentage was

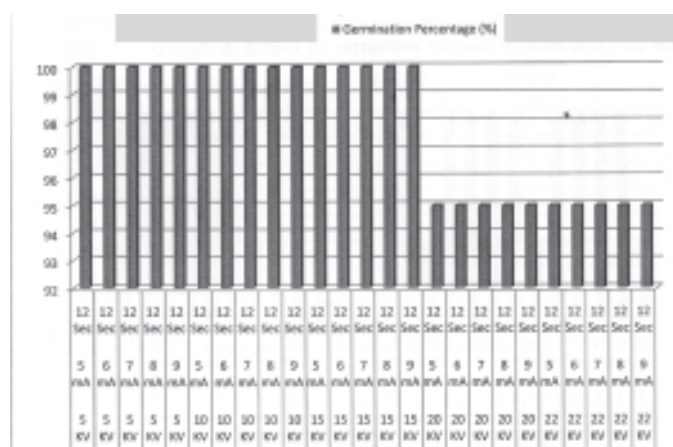


Fig. 1. Effect of different combinations of X-ray exposure on germination of ber.

then arrived at by using the formula,

$$\text{Germination percentage} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds taken for the germination test}} \times 100$$

Results and Discussion

In order to find out the effect of X-ray radiation on

ber seeds, the seed materials were exposed to different combination values. It was found that the germination percentage of ber seeds varied from 85—100% for different X-ray combination values (Table 1, Figs. 1 and 2). Exposure of X-ray radiation at 5, 10 and 15 KV voltage with different combinations of current with an exposure period of 12 seconds resulted in 100% germination. The radiation at 20 and 22 KV voltage with different combinations of current with an exposure period of 12 seconds resulted in 95% germination. The radiation combinations of 25,

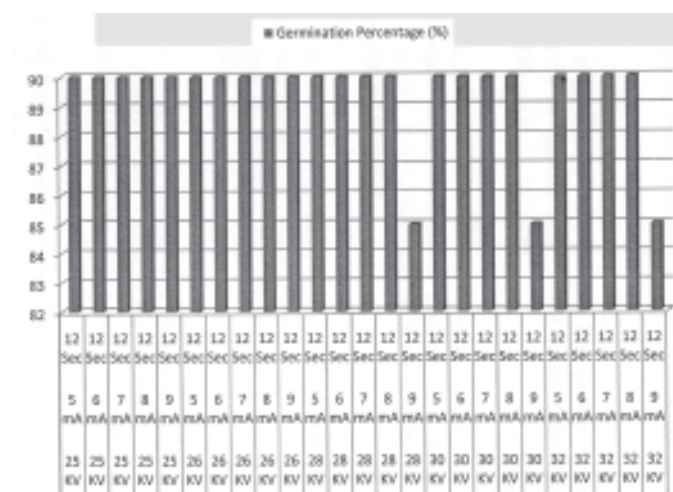


Fig. 2. Effect of different combinations of X-ray exposure on germination of ber.

26, 28, 30, 32 KV with their various current combinations with an exposure period of 12 seconds resulted in 90% germination except with the maximum current at 28, 30 and 32 KV with an exposure period of 12 seconds resulted in 85% germination.

The results revealed that ber seeds exposed to X-ray radiation retained germination of 85—100%. No harmful effects of X-ray radiation were recorded on germination of ber seeds even after exposure to 32 kilovoltage and 9 milliamperes for 12 seconds which is the highest radiation intensity in the present investigations.

References

1. Dell' Aquila A (2007a) Pepper seed germination assessed by combined X-radiography and computer-aided imaging analysis. *Biologia Plantarum* 51 : 777—781.
2. Dell' Aquila A (2007b) Towards new computer imaging techniques applied to seed quality testing and sorting. *Seed Sci & Technol* 35 : 519—538.
3. Goodman RC, Jacobs DF, Karrfalt RP (2005) Evaluating desiccation sensitivity of *Quercus rubra* acorns using X-ray. *Canadian J Forest Res* 35 : 2823—2831.
4. Pupim TL, Novembre ADLC, Carvalho MLM, Cícero SM (2008) Procedures of the X-ray test to evaluate (*Cecropia pachystachya* Trec.) seed quality. *Revista Brasileira de Sementes* 30 : 28—32 (in Portuguese with abstract in English).
5. Masetto TE, Davide AC, Silva EAA, Faria JMR (2007) Evaluation of *Eugenia pleurantha* (Myrtaceae) seed quality by the X-rays test. *Revista Brasileira de Sementes* 29 : 170—174 (in Portuguese with abstract in English).
6. Santos SA, Silva RF, Pereira MG, Machado JC, Borém FM, Gomes VM, Tonetti OAO (2009) X-ray technique application in evaluating the quality of papaya seeds. *Seed Sci & Technol* 37 : 776—780.
7. International Seed Testing Association [ISTA] (1996) International rules for seed testing. *Seed Sci & Technol* 24 : Supplement.
8. Ouedraogo M, Nikiema A (1997) Domestication de *Ziziphus mauritiana* Lam. Etude de l'aire de distribution au Burkina faso et mise au point de quelques techniques de propagation. Paper presented at the Pan-African workshop on *Ziziphus mauritiana* Lam. 16—20 Jun, 1997, Bamako, Mali.
9. Murthy BNS, Reddy YN (1989) Temperature dependence of seed germination and seedling growth in ber (*Ziziphus mauritiana* Lam) and their modification by pre-sowing treatments. *Seed Sci & Technol* 18 : 621—627.