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ORIGINAL ARTICLE

Determination of seed viability of eight wild Saudi Arabian species by germination and X-ray tests

Turki A. Al-Turki [a,*], **Carol C. Baskin** [b,c]

[a] *National Center of Agricultural Technology, Life Science & Environmental, King Abdulaziz City for Science and Technology (KACST), Box 6068, Riyadh 11442, Saudi Arabia*
[b] *Department of Biology, University of Kentucky, Lexington, KY 40506, USA*
[c] *Department of Plant and Soil Sciences, University of Kentucky, Lexington, KY 40546, USA*

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Abstract Our purpose was to evaluate the usefulness of the germination vs. the X-ray test in determining the initial viability of seeds of eight wild species (*Salvia spinosa*, *Salvia aegyptiaca*, *Ochradenus baccatus*, *Ochradenus arabicus*, *Suaeda aegyptiaca*, *Suaeda vermiculata*, *Prosopisfarcta* and *Panicumturgidum*) from Saudi Arabia. Several days were required to determine viability of all eight species via germination tests, while immediate results on filled/viable seeds were obtained with the X-ray test. Seeds of all the species, except *Sa.aegyptiaca*, showed high viability in both the germination (98–70% at 25/15 °C, 93–66% at 35/25 °C) and X-ray (100–75%) test. Furthermore, there was general agreement between the germination (10% at 25/15 °C and 8% at 35/25 °C) and X-ray (5%) tests that seed viability of *Sa.aegyptiaca* was very low, and X-ray analysis revealed that this was due to poor embryo development. Seeds of *P.farcta* have physical dormancy, which was broken by scarification in concentrated sulfuric acid (10 min), and they exhibited high viability in both the germination (98% at 25/15 °C and 93% at 35/25 °C) and X-ray (98%) test. Most of the nongerminated seeds of the eight species except those of *Sa.aegyptiaca* were alive as judged by the tetrazolium test (TZ). Thus, for the eight species examined, the X-ray test was a good and rapid predictor of seed viability.

1. Introduction

Whether seeds are to be sown for crop production or stored in gene banks, information about their viability is very valuable. Thus, several tests for seed viability, have been developed: germination, cutting, embryo excision, hydrogen peroxide, indigo carmine staining (Kamra, 1964), tetrazolium staining and X-raying (*e.g.* Bonner, 1998, and Karrfalt, 2004). All these tests except the X-ray test takes several days or weeks to complete, i.e. before the viability of the seeds is known (Kamra,

* Corresponding authors.
E-mail addresses: talturki@kacst.edu.sa (T.A. Al-Turki), Carol.baskin@uky.edu (C.C. Baskin).
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1966). X-ray analysis as a way to determine that seed viability was first used in 1903 by A.N. Lundström (Kamra, 1964), but it now is widely used to determine seed quality (*e.g.* Swaminathan and Kamra, 1961; Kamra, 1964, 1966), especially for crop seeds such as *Gossypium* sp. (Ferguson and Tuner, 1971), *Solanum lycopersicum* (Van der Burg et al., 1994a), *Eugenia pleurantha* (Masetto et al., 2007), *Zea mays* (Carvalho et al., 1999), *Xylopia aromatic* (Socolowski et al., 2011) and *Capsicum annuum* (Gagliardi and Marcos-Filho, 2011) but also for trees (Simak and Gustafsson, 1953). Martin et al. (1998) and Gagliardi and Marcos-Filho, (2011) stated that the X-ray radiography technique is simple and that a high number of seeds can be examined in a relatively short period of time. In addition, X-ray analysis is non-destructive to the seeds (Chavagnat, 1987; Gagliardi and Marcos-Filho, 2011). Since the internal morphological structure of the seed, specifically the embryo, can be evaluated by the X-ray technique (Van der Burg et al., 1994a; Gagliardi and Marcos-Filho, 2011), the relationship between germination and seed structure has been investigated for several species (Simak, 1991; Jorgea and Ray, 2005; Gagliardi and Marcos-Filho, 2011), *e.g. C. annuum* (Dell Aquila, 2007a), *Z. mays* (Cícero et al., 1998; Carvalho et al., 1999), and *Carica papaya* (Santos et al., 2009).

In contrast to X-ray analysis, germination tests to determine seed viability may require 2-3 days, *e.g.* seeds of different populations of *Salicornia* species (Al-Turki, 1992), or several weeks, *e.g.* at least three weeks for testing seeds of several *Pinus* species (ISTA, 1985). Further, a tetrazolium test (TZ) of seeds that fail to germinate takes at least another 24 h, *e.g. Suaeda* species (Al-Turki, 1992), and it may be difficult if the TZ solution fails to penetrate some seeds or parts of seeds (Mackay, 1972). Thus, although X-ray radiography provides a quick test for seed viability, it also has been used to determine maturity (viability) (*e.g.* Belcher, 1973, 1977; Duffield, 1973; Kamra, 1976; Simak, 1980; Sahlen et al., 1995; Geo-HanDong, 1998; Shen and Odén, 1999) and to predict early growth (germination) (Goodman et al., 2005) of tree seeds. However, no information is available on the relative benefits of using the germination vs. the X-ray test to evaluate seed viability of wild species from Saudi Arabia. Thus, the aim of this study was to compare the germination and X-ray test for determining seed viability of eight species (*Salvia spinosa*, *Salvia aegyptiaca*, *Ochradenus baccatus*, *Ochradenus arabicus*, *Suaeda aegyptiaca*, *Suaeda vermiculata*, *Prosopis farcta and Panicum turgidum*) from Saudi Arabia.

2. Materials and methods

2.1. Study species

Eight species (*S. spinosa*, *Sa. aegyptiaca*, *O. baccatus*, *O. arabicus*, *Su. aegyptiaca*, *S. vermiculata*, *P. farcta* and *P. turgidum*) with different uses were selected for study (see Table 1).

2.2. Seed collection

Seeds of *S. spinosa*, *Sa. aegyptiaca*, *O. baccatus*, *O. arabicus*, *Su. aegyptiaca*, *S. vermiculata*, *P. farcta and P. turgidum* (black seeds) were collected from Saudi Arabia at the location and on the date given in Table 2. Seeds were air dried, cleaned and

Table 1 Study species and their uses.

Species	Family	Uses	Reference(s)
Salvia spinosa	Lamiaceae	Treating diarrhea and genorrhea	Lu and Foo (2002)
Salvia aegyptiaca	Lamiaceae	Treating stomachic and diarrhea	Al-Yousuf et al. (2002)
Ochradenus baccatus	Resedaceae	The seeds are ingested by birds	Al-Turki (1997)
Ochradenus arabicus	Resedaceae	The seeds are ingested by birds	Al-Turki (1997)
Suaeda aegyptiaca	Amaranthaceae	Treating burns	Razik (1986)
Suaeda vermiculata	Amaranthaceae	Soil remediation to reduce salinity and contamination by toxic metals.	Singh (2005)
Prosopis farcta	Fabaceae	Forage plant for livestock	Chaudary (1999)
Panicum turgidum	Gramineae	Grazing plant for domestic herds	Mandaville (1990)

Table 2 Seed collection location and date of the eight study species.

No	Species	Family	Collection-date	Location
1	*Salvia spinosa*	Lamiaceae	30 March 2014	77 km north of Riyadh QassimRoad
2	*Salvia aegyptiaca*	Lamiaceae	18 April 2014	77 km north of Riyadh QassimRoad
3	*Ochradenus baccatus*	Resedaceae	29 March 2014	77 km north of Riyadh QassimRoad
4	*Ochradenus arabicus*	Resedaceae	21 May 2014	77 km north of Riyadh QassimRoad
5	*Suaeda aegyptiaca*	Amaranthaceae	11 October 2013	Al-Hufuf City
6	*Suaeda vermiculata*	Amaranthaceae	28 May 2013	Al-Zawr village
7	*Prosopis farcta*	Fabaceae	20 July 2012	Al-Awshaziyah village
8	*Panicum turgidum*	Gramineae	15 April 2014	Al-Thumamah (55 km north-east of Riyadh)