Laboratory Tests for Predicting Seedling Emergence of Safflower (Carthamus tinctorius L.) Cultivars

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ABSTRACT

The lack of information about predicting seedling emergence of safflower (Carthamus tinctorius L.) in field conditions prompted us to study the relationship between laboratory tests and field emergence. This experiment was conducted at Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran. Seeds from five cultivars of safflower (‘Abade’, ‘Hartman’, ‘Kino76’, ‘PI19829’ and ‘Zarghan279’) were used in these experiments. Laboratory tests included standard germination (SG), accelerated aging (AA), seedling growth rate (SGR) and electrical conductivity (EC). The results revealed that the AA and EC tests provided better separation of safflower seed vigor levels than SG and SGR. Seed from ‘Zarghan279’ was the lowest quality with no difference in seed quality among the other cultivars. The fitted regression of the laboratory tests and field emergence trials showed that germination percentage after aging ($R^2 = 0.92^{**}$) and EC ($R^2 = 0.94^{**}$) were better related to field emergence than any of the other tests. Thus, EC and AA tests were the most successful in predicting the emergence potential of the safflower seeds.

EXPERIMENTAL TECHNIQUES

Seed germination is usually the most critical stage in seedling establishment, determining successful crop production (Almansouri et al., 2001). Crop establishment depends on an interaction between the seedbed environment and seed quality (Brown et al., 1989; Khajeh-Hosseini et al., 2003).

Seed lot physiological quality is routinely evaluated by the standard germination test. Germination tests give information about the capacity of seeds to produce normal seedling under optimum conditions; nevertheless, under field conditions several environmental stresses greatly impair seedling emergence (Hampton and Coolbear, 1990). Seed vigor has been defined as those seed properties which determine the potential for rapid, uniform emergence and development of normal seedlings under a wide range of field conditions (AOSA, 2002). Studies have shown that seed vigor is a more sensitive measure of seed quality (McDonald, 1975). Various vigor tests have been developed (Hyatt and TeKrony, 2008; Noli et al., 2008; Artola and Castaneda, 2005; Demir et al., 2004) and some are now internationally accepted. Electrical conductivity (EC) has been satisfactorily used for evaluating the vigor of pea and soybean seeds (Hampton and TeKrony, 1995). The accelerated aging (AA) test...
is one of the most frequently used vigor test methods (Ferguson, 1990). This test is used to measure seed vigor and is conducted by exposing seeds to high temperature and high relative air humidity (Delouche and Baskin, 1973). A list of appropriate time and temperature variables for standard use of AA for various species were given in the ISTA Handbook of Vigor Test Methods (Hampton and TeKrony, 1995). A list of laboratory tests for estimating seed vigor of various species was also given in this handbook. However, studies for evaluating seed vigor in safflower seeds are scarce.

The objective of this study was to evaluate commonly used seed germination and vigor tests to determine applicability in assessing seed quality of safflower cultivars as it relates to field emergence.

This study was conducted at the seed laboratory and the research farm of the Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran. This experiment evaluated seed from five safflower (Carthamus tinctorius L.) cultivars that included ‘Abade’, ‘Hartman’, ‘Kino76’, ‘PI19829’, ‘Zarghan279’. The germination, vigor and field emergence tests were performed using a randomized complete block experimental design with three replications of 50 seeds in all experiments.

**Standard germination (SG):** seed samples were sown on moistened rolled paper and kept at a temperature of 25 °C. On the seventh day, normal seedlings were counted according to the evaluation criteria established by the International Rules for Seed Testing (ISTA, 2003).

**Seedling growth rate vigor test (SGR):** seed samples were sown as for the SG test and normal seedling length and dry weight were measured after 7 d.

**Accelerated aging vigor test (AA):** 42 g of seeds were placed in single layer on a screen surface inside a plastic box (gerbox) holding 40 mL of water and maintained at 38 °C for 72 h (Hampton and TeKrony, 1995) with relative humidity (inside the gerbox) near 100% in a germination chamber. After aging, SG was calculated by the methodology described above.

**Electrical conductivity vigor test (EC):** the test was carried out according to the methodology proposed by Hampton and TeKrony (1995) using 250 mL deionized water and 20 °C for 24 h. Conductivity of the leachate was then measured and results were expressed as µS cm⁻¹ g⁻¹.

**Seedling field emergence (FE):** seeds of each cultivar were hand sown in rows 2.0 m long, 0.30 m apart and 0.03 m deep. Soil moisture was kept sufficiently wet for germination. The percentage and rate of emerged seedlings were counted until 10 days after sowing.

A statistical analysis was conducted using the Statistical Analysis System (SAS) and significant differences among treatments were determined by LSD test (P = 0.05).

**RESULTS AND DISCUSSION**

There were no significant differences among seed lots from the five cultivars for germination percentage (range: 82–91.3%), germination rate (range: 0.0495–0.0583 h⁻¹), germination rate after AA (range: 0.035–0.042 h⁻¹), seedling dry weight (range: 0.019–0.025 mg d⁻¹) and seedling length (range: 17.87–
20.93 cm) (Table 1). However, there were significant differences among cultivars for germination percentage after AA (range: from 70.7–88.0%) and EC (range: from 22.5–32.76 µS cm$^{-1}$ g$^{-1}$). Results from AA indicated that ‘Abade’ and ‘PI19829’ had the highest seed vigor and ‘Zarghan279’ had the lowest quality. The EC test also indicated that ‘Zarghan279’ had the lowest seed vigor with 32.76 µS cm$^{-1}$ g$^{-1}$ leakage. The other four cultivars showed leakage values between 22.5 and 26.69 µS cm$^{-1}$ g$^{-1}$. Field emergence percentage and rate ranged from 59.3–72.0% and 0.012–0.014 h$^{-1}$, respectively (Table 1).

The fitted linear regression of the laboratory tests to field emergence trials indicated a non-significant relationship for laboratory germination percentage, ($R^2 = 0.55$), germination rate ($R^2 = 0.09$), seedling length ($R^2 = 0.66$), seedling dry weight ($R^2 = 0.62$) and germination rate after aging ($R^2 = 0.43$) (Fig. 1). However, there was a significant relationship between two vigor tests, germination after aging ($R^2 = 0.92^{**}$) and electrical conductivity ($R^2 = 0.94^{**}$), and field emergence.

These results indicate that laboratory tests of seed germination, germination rate and seedling growth rate did not detect any significant differences in physiological quality among seed lots of the five safflower cultivars. There was a significant difference among seed from these cultivars when seed was tested for germination percentage after aging (AA) and EC, which implies that these two laboratory tests are more sensitive in determining seed vigor. Those cultivars with higher seed vigor in the laboratory (‘Abade’ and ‘PI19829’) also had higher field emergence. Therefore, AA and EC are more sensitive than the SG and SGR to determine the physiological quality among seed of safflower cultivars. The AA and EC tests have been successfully used for prediction of

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<th>Cultivar</th>
<th>Standard germination</th>
<th>Germination after AA</th>
<th>Field emergence</th>
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<tr>
<td></td>
<td>Percentage</td>
<td>Rate</td>
<td>Percentage</td>
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<tr>
<td>Abade</td>
<td>86.0</td>
<td>0.0562</td>
<td>86.7</td>
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<tr>
<td>Hartman</td>
<td>84.7</td>
<td>0.0531</td>
<td>85.3</td>
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<td>Kinno76</td>
<td>82.7</td>
<td>0.0495</td>
<td>80.0</td>
</tr>
<tr>
<td>PI19829</td>
<td>91.3</td>
<td>0.0583</td>
<td>88.0</td>
</tr>
<tr>
<td>Zarghan279</td>
<td>82.0</td>
<td>0.0554</td>
<td>70.7</td>
</tr>
<tr>
<td>LSD(0.05)</td>
<td>12.0</td>
<td>0.0013</td>
<td>17.5</td>
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Table 1. Standard germination, accelerated aging (AA), seedling growth rate, conductivity and field emergence for seed of five safflower (Carthamus tinctorius) cultivars.
seed vigor in other crops such as cotton (Gossypium hirsutum L.), soybean (Glycine max (L.) Merr.), wheat (Triticum aestivum L.), corn (Zea mays L.) and other plants (Hampton and TeKrony, 1995). Ferguson (1990) and McDonald (1998) also reported that the AA test is one of the most popular seed vigor

**Figure 1.** Relationship between field emergence (%) and laboratory tests of seed germination and vigor for five safflower (Carthamus tinctorius) cultivars.
tests since it is simple, easy to standardize and can be applied to a large number of crops. The Handbook of Vigor Test Methods of ISTA (Hampton and TeKrony, 1995) suggested an AA regime of 38 °C for 72 h for safflower seed. The present study showed adequate separation in seed vigor using this testing regime. However, this test takes 10 days to complete whereas the conductivity test takes only 24 h, which provides a time advantage for EC. In this study, both EC and AA tests were successful in predicting the emergence potential of the safflower seeds.

REFERENCES


