

# Use of Digital Analysis of Radicle Extension of Marigold Seedlings as an Early Indicator of Seed Vigor

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## INTRODUCTION

Radicle extension has been shown to be an accurate, early predictor of vigor in several horticultural crops (Bingham et al., 1994). Digital imaging of the radicle has potential to meet the criteria for an ideal vigor indicator. Several seed producers and seed testing laboratories are presently using or exploring this technology. In this study, MacRhizo® software was used to analyze digital images of the radicle captured on a flatbed scanner. This study attempts to correlate the computer-generated marigold vigor data with results from commonly used vigor tests.

In order to examine the correlation between radicle length and the standard tests that predict seed vigor, seed from a single, high-vigor lot was mildly (24 h AA) and moderately (72 h AA) deteriorated by accelerated aging (AA) in a high temperature and relative humidity environment (McDonald, 1977). Once significant differences in vigor between groups of seed was achieved, several measurements commonly used as vigor indicators were taken.

If a positive correlation exists between computer-generated radicle length analysis and the Association of Official Seed Analysts vigor test results, the use of digital images of radicles may be a reliable predictor of seed vigor.

## MATERIALS AND METHODS

**1) Aging.** From a single *Tagetes* 'Little Devil Flame' seed lot, seeds were deteriorated by AA method for 0, 24, or 72 h. Seed moisture content was measured for each treatment.

**2) Germination Test.** Seeds were incubated for 7 days in petri dishes at 30C with fluorescent light for 16 h day<sup>-1</sup> and at 20C for 8 h of darkness. One-half of the petri dishes were laid flat in the incubator and one-half were placed at an upright angle. Normal germination counts and seedling biomass were obtained.

**3) Plug Emergence Test.** Seeds were incubated under the above-described environment using six-pack cells and greenhouse propagation media.

**4) Computer Imaging.** Entire dish, individual seedlings and excised radicles were imaged and analyzed using MacRhizo® software.

## RESULTS AND DISCUSSION

Seed moisture content of the control seed was 15.23%, 40.77% for mildly-aged seed, and 52.85% for moderately-aged seed and showed significant differences (at  $P < 0.05$ ) between levels of deterioration in all but one case. Standard germination results also had significant differences between levels of deterioration (at  $P < 0.05$ ) with 84.5% germination for controls, and 49.5% germination for mildly, and 9.7% for moder-

ately aged seeds.

Digitally analyzed radicles also revealed significant differences (at  $P < 0.05$ ) in length between each vigor level. Average radicle length for control seed was 2.1 cm, 1.9 cm for mildly-aged seed, and 1.3 cm for moderately-aged seed.

Using radicle length, seedling emergence test, or AA vigor test results as predictors of seed vigor, radicle length was regressed against percent standard germination ( $R^2 = 0.797$ ) and percent seedling emergence ( $R^2 = 0.995$ ) and a positive correlation was found in each case (Table 1). Correlation coefficients ( $r$ ) based on the prediction variable means also showed a positive correlation of prediction accuracy. The  $r$  value for radicle length and seedling emergence ( $r = 0.997$ ) suggests radicle length may be a better predictor of future performance in the plug tray than the AA-standard germination test ( $r = 0.893$ ).

**Table 1.** Correlation coefficients ( $r$ ) for *Tagetes patula* 'Little Devil Flame' using means of variables that indicate seed vigor level.

	Radicle length (mm)	Standard germination (%)	Emergence (%)
Radicle length	1.000	0.893	0.997
Germination*	0.893	1.000	0.924
Emergence**	0.997	0.924	1.000

\*  $R^2 = 0.797$  where  $y = 1.02 + 0.01x$  when radicle length is regressed against germination.

\*\*  $R^2 = 0.995$  where  $y = 1.17 + 0.01x$  when radicle length is regressed against seedling emergence.

It has been established that radicle length can be used for marigold as an accurate, economical, reproducible seed vigor indicator. When the petri dish assay protocol is established, using digital analysis as a indicator of seed vigor will meet all the criteria for a reliable and efficient test and the potential for this technology in the seed industry can be fully realized.

#### LITERATURE CITED

- Bingham, I.J., A. Harris, and L. Macdonald.** 1994. A comparative study of radicle and coleoptile extension in maize seedlings from aged and unaged seed. *Seed Sci. Technol.* 22:127-139.
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