Nondestructive germinability assessment of radish seeds by near infrared spectroscopy

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Introduction

Near infrared (NIR) spectroscopy is widely used today as a quantitative technique for predicting the chemical composition of various agricultural products. Nowadays NIR spectroscopy has been used to measure protein, fat, sugar and fibre content of many crops, such as wheat, oats, rice, rye, corn, millet and so on on a single grain or whole grain basis. However, few applications exist for seed quality assessment, especially for seed germinability. Previous works in germinability testing have usually focused on biochemical tests such as tetrazolium(TZ) or conductivity tests. The terazolium test was based on the relative respiration rate, at the hydrate state, for the viable and dead tissues of the embryo. This test showed the activity of dehydrogenase enzymes as an index to the respiration rate and seed viability. The conductivity test was based on the premise that the cell membranes become less rigid and more water-permeable, allowing the cell contents to escape into water solution and increasing its electrical conductivity as seed deterioration progressed. However, these tests have experienced some difficulty and necessary experience to interpret and need bulk testing. The sinapine or amino acid leakage method recently developed was used to test seed viability as a single seed base from *Brassica* seeds, but the seeds should be pretreated before evaluation. Therefore, the purpose of this study is to show the possible application of NIR spectroscopy as a nondestructive germinability test on radish (*Raphanus sativus* L) seeds in a single seed base without any pretreatment.

Materials and methods

The radish seeds (cultivar, Chung Su Gung Jung, Nong woo Bio Co. Ltd, Korea) harvested in 1993 was used in this experiment. NIR spectral measurements were carried out on the flat side of the seed surface of a single grain kernel using an NIRSystems 5000 (Foss NIRSystems, Silver Springs, Maryland, USA). Each seed was scanned, in the NIR reflectance mode, from 1100 to 2500 nm at 2 mm increments in a sample hole (4 mm diameter) of seed holder plate. The WinISI II program (Foss NIRSystems, Infrasoft, International, LLC.) was used to process the data. The seeds, after spectral measurement, were planted on a blotter individually and germination was observed. The seeds were characterised into non-germination and germination, then grouped again into normal and abnormal germination by the rules of the Association of Official Seed Analysts (AOSA) and then compared with that of NIR spectra. Figure 1 illustrates the normal, abnormal and non-germination of radish seeds according to the rules of AOSA.

Results and discussions

A total of 571 seeds were planted after NIR scanning. 300 germinated with 25 outliers and 226 non-germinated with 20 outlier seeds were observed and outliers were excluded in interpreting the

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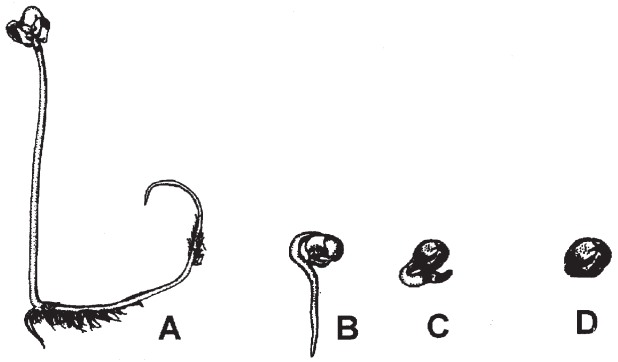

Figure 1. Normal (a), abnormal (b, c) and dead radish seeds (d) evaluated after germination.

NIR spectra. 261 out of 300 germinated seeds were classified as normal and 39 seeds were classified as abnormal. Figure 2 shows a PC scores plot for radish seeds which has been classified either as 'germinated seeds' or 'non-germinated seeds'. The plot represents the three PCs that explain the large variation in the spectral data with respect to the 'germinated' and 'non-germinated' characteristics of radish seeds.

Figure 3, using PC score plots, demonstrates how the characteristics of normal germinated radish seeds differ from those of abnormal germinated seeds. It shows a clear difference in pattern of the distribution of the spectra of normal from abnormal germination.

The 3D plots from Figures 2 and 3 showed that the application of principle component analysis (PCA) for the spectral data could be successfully performed to characterise germination to non- germination and normal to abnormal germination of radish seeds. Therefore, the PCA of NIR reflectance spectra for the radish seeds of germination and non-germination and normal and abnormal germina-

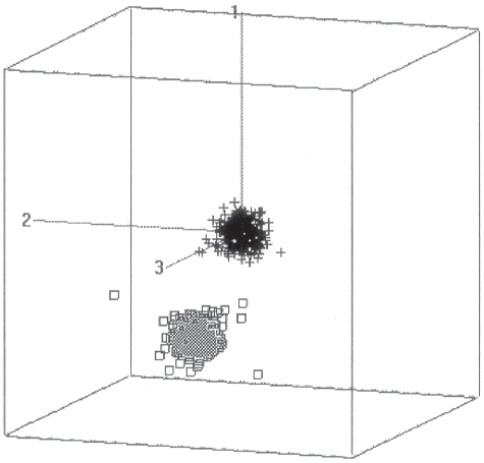

Figure 2. 3D PC scores plot for 'germinated' and 'non-germinated' radish seed characteristics. The symbol + denotes spectra from 'germinated seeds' and □ denotes the spectra from 'non-germinated seeds'.

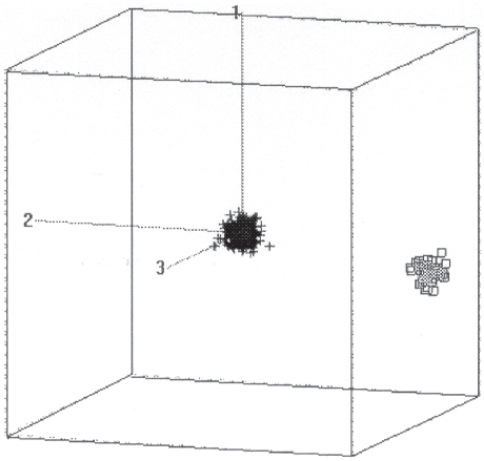

Figure 3. PC scores plot showing 'normal' and 'abnormal' germinated radish see characteristics. The symbol + denotes spectra from 'normal' and □ denotes the spectra from 'abnormal' germinated seeds.

tion showed quite different patterns for each group and the results suggest that NIR spectra could be applicable to separate radish seeds on the germinability.

Conclusion

Analysis of NIR spectra on radish seeds was clearly characterised into non-germination (non- viable) and germination (viable) groups, which were, in turn, grouped into normal and abnormal germination. The results indicated that the NIR technique could be used as a means of discriminating physiological seed quality.

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