ISBN: 978-81-972400-8-9

7. Seed Image Analysis and Its Importance in Seed Industry

K. P. Vaghasiya

Assistant Professor,
School of Agriculture, Dr. Subhash University,
Junagadh, Gujarat, India.

J. R. Sondarva

Assistant Professor, Department of Seed Science and Technology,
College of Agriculture, Junagadh Agricultural University,
Gujarat, India.

Abstract:

Image analysis is a state-of-the-art technique for seed quality testing. This tool provides vast usage in evaluation of various physiological and morphological characteristics of the seed with a more comprehensive perception. It is based on the extraction of numerical data from a captured image for characteristics like color, size, shape of seed and seedlings and their subsequent processing with the help of suitable computer software. Speedy analyses, cost-effectiveness, automatic nature and user-friendly environment for work are some important advantages of Image Analysis over other conventional techniques. Numerous software has been developed for application in different fields of seed science research like germination studies, vigour estimation, varietal identification and purity testing etc. and most of these showed their potential adoption in the future as such or with some required transformations

Keywords:

Image analysis, Image analysis parameters, ImageJ, Features, Seeds, Seed morphology

7.1 Introduction:

7.1.1 Image Analysis:

The primary criteria for defining the seed quality are purity, germination, moisture and freedom from diseases and insect. The assessment of varietal identity and purity is also contributed by the seed certification procedures. For the proper implementation of PVP and PBR programs in India, DUS characters play a crucial role. Seed image analysis has potential use in determining the cultivar identity of seed lots and testing of the distinctness of new cultivars for the award of breeders' right and cultivar registration. Image-based measurements are fast and easy to achieve the desired objective and thus can provide data correlating with genetic properties of germination and growth performance of seedling.

(Kapadia et al., 2017) The term "image analysis" refers to the extraction of numerical data from an acquired image. Machine Vision System is basically a computerized apparatus designed for Image Analysis (IA) which functions similar to the human observations. Fundamental approach in this technique is acquisition of data (shape, size, colour etc.) via a video or still camera followed by analysis of these data using suitable computer software. (Satya srii and sanam, 2022)

Image analysis technique (machine vision system) is among such systems that offer the prospect that researchers will be able to study seed morphology, its anatomical activity during germination and growth of germinated seedlings more closely and hence, increase accuracy in studying various processes related to the seed. The term "image analysis" refers to the extraction of numerical data from an acquired image. Machine Vision System is basically a computerized apparatus designed for Image Analysis (IA) which functions similar to the human observations. Fundamental approach in this technique is acquisition of data (shape, size, colour etc.) via a video or still camera followed by analysis of these data using suitable computer software. (Dell'Aquila A. 2004)

Image Analysis shows many important advantages over manual techniques. It provides rapid analysis as compared to any of the conventional methods. Seeds are not subjected to any kind of treatment or damage. Once the system that works has been designed then the whole process can be automated. Imaging software provides an increasingly interactive and user-friendly environment to work. After the initial outlay for equipment and research unlike other systems, IA has very few additional costs. (Hemender et al., 2018)

The Image Analysis System Consists of Two Sets of Components:

a. An environmental system, which includes a thermostatic cell, a timer controlled transilluminator and a Petri dish containing the imbibition medium and seeds.
b. A computer imaging unit, which comprises a CCD-camera, a commercial computer and a software package that is able to capture time-lapsed seed images and perform related size and shape measurements. (Dell'Aquila A. 2004)

Standardization of IA programs for characterization of variety is initiated with the measurement of seed, proceeded in sequence to plant organs, to an extent where the analyst feels capable in varietal distinctness. IA is well suited to the acquisition of large amounts of quantitative data concerning seed/plant morphology and this information could be used to support that a variety is new in context of proposed variety licensing and registration.

Why Image Analysis?

Image Analysis shows many important advantages over manual techniques. It provides rapid analysis as compared to any of the conventional methods. Seeds are not subjected to any kind of treatment or damage. Once the system that works has been designed then the whole process can be automated. Imaging software provides an increasingly interactive and user-friendly environment to work. After the initial outlay for equipment and research unlike other systems, image analysis has very few additional costs. (Satya srii and sanam, 2022)

Application of Seed Image Analysis in Seed Science Research:

- Characterization- Ex: Sunflower, Lucerne
- Identification of cultivars –Ex: Wheat, Barley, Faba bean,
- Grading - Ex: Raisin, Potato, Tomato, Lentil
- Automated vigor testing – Ex: Lettuce, Cabbage
- Detection of Kernel Quality Factors - Ex: Soybean, Maize
- Detection of Color and Surface Defects – Ex: Maize
- Monitoring the imbibition process – Ex: White Cabbage, Sunflower

Table 7.1: Image Analysis Parameters

Parameter	Unit	Definition
Seed area	mm^2	The area of the polygon that defines the seed's outline.
Seed perimeter	mm	The length of outline of each seed.
Seed length	mm	The diameter along the major axis of the seed.
Seed width	mm	The diameter along the minor axis of the seed.
Radicle length	mm	The distance between the point of the seed coat in which radicle protrusion occurs and the radicle tip.
Roundness factor	-	Circularity of the seed, calculated by the formula: $\text{Perimeter}^2 / 4\Pi\ \text{Area}$
Aspect Ratio	-	The ratio between the major axis and the minor axis of the ellipse equivalent to the object (i.e., having similar area of the seed).

7.2 Characterization & Identification:

Bean landrace from Italy that uses an image analysis technique. This study aims to examine aspects related to the form and overall color of the bean seed, such as seed size, shape, color, and texture. Method could be applied in germplasm banks or ex-situ conservation, and it could aid in the cataloging, preservation, and improvement of the bean genus. (Venora et al. 2009).

Using image analysis, the high throughput phenol typing software Smart Grain measures the morphology of rice seeds. Seed parameters including length, width, and area are automatically recognized using seed recognition software based on digital photographs. The Japonica cultivars Kishihikari and Nippobare were crossed in a BIL, and the results of their QTL analysis revealed a few minor variations in the seed morphology (Tanabata et al. 2012).

Using color features, four hybrid maize seeds were identified for purity. According to the experiment's findings, maize seed purity may be accurately identified by the k-mean method, which is based on one directional space obtained using Fisher Discriminant Theory. Its recognition rate exceeds 93.75% (Yan et al. 2010).

7.2.1 Sorting & Grading:

Using frequency domain image analysis, corn kernel stress cracks can be found. The pre-processed images were subjected to a quick fourier transform method, with the outcome being a reduction in size into signatures of seed characteristics that indicate morphological features that are invariant to changes in position or orientation. Stress fractures are internal fissures that an x-ray inspection can detect in kernels (Han et al. 2006).

Texture and shape neural network for four different types of paddies. Four different types of paddy grains were classified using the texture and shape neural network, and the most appropriate feature from the four correct classifications was determined. The shape feature set produced the most satisfactory results, while the texture feature set saved were more accurate than all the other sets (Chaugule & Mali 2014).

7.2.2 Physiological Testing:

Automated evaluation of lettuce seed vigor. The results show that the imaging method accurately evaluated seed vigor to produce repeatable, objective vigor assessment for seedlings cultivated for three days in the dark (Sako et al. 2001)

Automated method for measuring electrical conductivity and seedling vigor in SVIS sun hemp seeds. Three days following seeding, assessments were carried out, and information on the vigor index, length, and consistency of seedling growth was gathered. varied sunhemp seed lots can have varied levels of vigor, which can be detected using the SVIS seedling and electrical conductivity measurement at 4 or 8 hours (Silva et al. 2012).

Self-created method for identifying the visual vigor index of vegetable seeds. Using a self-developed SVI system, this is done manually. A comparative investigation of four vegetable seeds revealed improved reorganization accuracy; the derivations were 4.32%, 4.90%, 5.95%, and 3.22%, respectively, and within an acceptable range (Li et al. 2016).

7.2.3 Detection of Mechanical, Insect & Diseases Damage:

Using an x-ray image analysis technique, the mechanical and stink bug damage to the soybean cultivar BRS-184 was assessed. After being sorted by x-ray test, seed from several batches of the BRS184 cultivar was tested for germination. The outcome demonstrated how well the x-ray image analysis method worked to identify mechanical and stink insect damage in soybean seeds (Pinto et al. 2009). X-ray analysis to evaluate the relationship between germination and vigor and mechanical damage in sweet corn seeds. They concluded that the x-ray test is effective in detecting mechanical damage in sweet corn seed, enabling the correlation between its occurrence and germination and vigor losses (Francisco & Silvio 2012).

A survey on the identification and detection of soybean seed-borne illnesses by image processing. A seed lot's ability to contain pathogenic propagules is essential because contaminated seed may not germinate or may infect seedlings and growing plants. Among the problems are Image processing for the identification and detection of soybean seed-borne illnesses (Kinnikar et al. 2015).

Imaging analysis and physiological quality evaluation of pumpkin plant seed produced by seqush mosaic virus (SqMV) infection. When compared to healthy seeds, they discovered that the proportion of aberrant plants and the appearance of infected seeds shown a considerable decline in performance. The contaminated seeds also had lower averages for seed emergence and vigor (Alencar et al. 2016).

Winter triticale (*Tritico secale* Wittm. & Camus) and winter wheat (*Triticum aestivum* L.) variety separation and seed health assessment. The intriguing outcome of this investigation was the ability to discriminate between the contaminated and uncontaminated areas of the seed surface. The study also shown the ability to differentiate between kinds. These elements could be combined in future research to create a sorting model by merging information from multispectral photography (Vresak et al. 2016).

7.2.4 Color & Surface Detection:

Computer image analysis to classify varieties of flax together. Based on the findings, they suggest that more meaningful continuous quantitative seed descriptors that can be obtained at a cheap cost from dried flax seeds might be added to the current qualitative sensorical seed descriptors that are frequently employed for cultivar characterisation (Dana et al. 2008).

Size projection of many species of legume seeds using image analysis derived from model data. For beans, the estimated specific surface area varied from (5.1 to 5.8) cm^2/g, and for lentil varieties, it was between (11.57 and 11.55) cm^2/g. It offered quick and precise values for key technological characteristics of legumes, including surface area, volume, and geometric factors (Durmas et al. 2010).

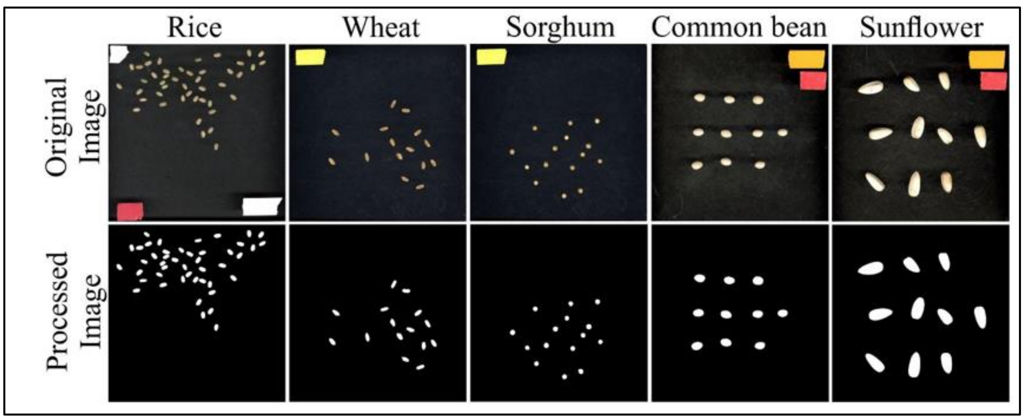

Figure 7.1: Colour & Surface Detection

7.3 Advantages of SIA:

- It is simple to operate, and the basic principles are readily understood.
- It is non-destructive method of assessing the seed quality.
- Stages of development and extent of damage by insects in seeds can be assessed quickly.
- The data acquired by IA were satisfactory and could be used in the preparation of morphological variety descriptions.
- IA is a speed potential to measure new characters used for the electronic storage and transmission of the data.

7.4 Limitations of SIA:

- The procedure described is essentially oriented at analyzing just one specimen or a small number of seeds at a time though it can do this at very high speed.
- No information is gained on the detailed chemistry, especially biochemistry of the seed.
- For vigour assessment software, developed for a particular crop species can't be used for the vigour assessment of the other crops.
- It is not possible to distinguish a variety with 100% accuracy level.

7.5 In the seed industry, seed image analysis is essential, particularly for breeding and quality control initiatives. Examining the significance of seed image analysis in more detail:

A. Quality Control:

- **Uniformity:** Analyzing seed images makes it possible to evaluate how uniformly sized, shaped, and colored the seeds are. For a steady harvest, uniform seeds are necessary.
- **Purity:** It makes it possible to identify contaminants, ensuring that farmers receive only high-quality seeds.

B. Germination Prediction:

- **Viability:** Understanding the viability of seeds can be gained by analyzing seed image. In order to help farmers estimate the best seeding rates for improved crop establishment, this is essential for predicting germination rates.

C. Breeding Programs:

- **Trait Identification:** Trait Identification: Seed image analysis helps to measure and identify specific characteristics like morphology, size, and color. In breeding programs designed to produce crops with desired traits, this is essential.
- **Efficiency:** Breeders are able to make better choices and improve the breeding process by using automated image analysis tools to quickly evaluate a large number of seeds.

D. Disease Detection:

- **Disease Identifying:** Image analysis can be useful in identifying variations or diseases in seeds at an early stage. Maintaining the overall health of crops and preventing the spread of diseases require early identification.

E. Research and Development:

- **Data-driven Decisions:** Analysis of seed images provides useful information for studies. This data can be used by researchers to analyze seed development processes, explain genetic variations, and make data-driven choices in agricultural research.

F. Precision agriculture:

- **Optimized Planting:** Farmers can ensure that seeds are sown at the proper depth and spacing for maximum growth by evaluating seed images to optimize planting techniques.

G. Cost Efficiency:

- **Reduced Wastage:** Precise analysis ensures that only viable seeds are planted, hence minimizing the potential of crop failure. This helps reduce wastage.

7.6 Conclusion:

A lot of work is being done on image processing for a variety of applications in the agriculture and seed industries, with an emphasis on varietal quality and identification. like maize, beans, faba beans, and paddy. It is straightforward and precise to evaluate the vigor of sun hemp seeds by integrating the SVIS and electrical conductivity measurements of the seed imbibitions. Image processing helps extract low-level properties like color, texture, and form for the purpose of detecting and classifying seeds. like flax, beans, and lentils. The identification of female parent self and cross seeds of maize is aided by seed image analysis. Research on seed image analysis aids in the identification of internal infections carried by seeds, insect, pests, and mechanical damage from whole seeds.

To sum up, seed image analysis is an effective technique that improves the precision, quality, and efficiency of activities related to seeds in the agriculture sector. In the end, it helps researchers, farmers, and breeders make wise decisions that lead to increased crop yields and sustainable agriculture.

7.5 Future Thrust:

A significant amount of research is required in the field of seed image analysis for central processing and sensory aspects of computing technology. Significant advancements in this technology are required to reduce human error. It is necessary to build hardware and software that will lower costs and improve return on investment.

To improve the robustness and accuracy of decisions, future computer vision applications should incorporate new developments in pattern recognition and huge data processing. Additionally, in order for seed industries to handle huge quantities of seeds, work must be done on online sorting and grading systems.

7.7 References:

1. Alencar, N. E., Figueira, A. R, Santos, H. O, & Duarte, P. S. G. (2016). Image analysis and physiological quality assessment of seeds produced in pumpkin plants infected with the squash mosaic virus (SqMV). *Research Journal of Seed Science, 9*(1), 14-21.
2. Chaugule, A. & Mali, S. N. (2014). Evaluation of texture and shape features for classification of four paddy varieties. *Journal of Engineering*' Article ID 617263: 1-8.
3. Dana, W., & Ivo, W. (2008). Computer image analysis of seed shape and seed color for flax cultivar description. *Journal of Food Engineering, 61*(2), 126-135.
4. Dell'Aquila A. (2004). Application of a computer-aided image analysis system to evaluate seed germination under different environmental conditions. *Italian Journal of Agronomy, 8*(1), 51–62.
5. Durmus, E. F., Sarka, E., Bubnik, Z., Schejbal, J., & Kadlec, P. (2010). Size properties of legume seeds of different varieties using image analysis. *Journal of Food Engineering 99*(4), 445-451.
6. Francisco, G. G. J., & Silvio, M. C. (2012). X-Ray analysis to assess mechanical damage in sweet corn seeds. *Revista Brasileira de Sementes*, *34*(1), 78- 85.
7. Han, Y. J., Feng,Y., & Weller, C. L. (2006). Biological Systems Engineering. Papers and Publications. *12*(4), 487-492.
8. Hemender, T., Sushma, S., Virender, M., & Axay, B. (2018). Image Analysis: A Modern Approach to Seed Quality Testing. *Current Journal of Applied Science and Technology, 27*(1), 1-11.
9. Kapadia, V., Sasidharan, N., & Kalyanrao, P. (2017). Seed Image Analysis and Its Application in Seed Science Research. *Advances in Biotechnology and Microbiology, 7*(2), 555709. DOI:10.19080/AIBM.2017.07.555709
10. Kinnikar, A., Desai, P., & Jahagirdar, S. (2015). Identification and Detection of Seed Borne Diseases of Soybean Using Image Processing -A Survey. *International Journal of Emerging Technology in Computer Science & Electronics, 14*(2), 363-368.
11. Li, Z., Wang, X., Liao, T., Feng, Q., & Zhang, D. (2016). A self-developed system for visual detection of vegetable seed vigor index. *International Journal of Agriculture & Biology, 18*(1), 86-91.
12. Pinto, T. L. F., Cicero, S. M., França, N. J. B., & Forti, V. A. (2009). An assessment of mechanical and stink bug damage in soybean seed using X-ray analysis test. *Seed Science & Technololy, 37*(1), 110-120.
13. Sako, Y., McDonald, M. B., Fujimura, K., Evans, A. F., & Bennett, M. A. (2001). A System for Automated Seed Vigor Assessment. The Ohio State University, Columbus, USA.
14. Satya Srii, V., & Sanam, T. (2022). Application of Digital Image Analysis in Seed Science. *Just Agriculture, multidisciplinary e-newsletter, 3*(2), 1-4.
15. Silva, C. B., Lopes, M. M., Filho, J. M., & Vieira, R. D. (2012). Automated system of seedling image analysis (SVIS) and electrical conductivity to assess sun hemp seed vigor. *Revista Brasileira de Sementes, 34*(1), 55-60.

16. Tanabata, T., Shibaya, T., Hori, K., Ebana, K., & Yano, M. (2012). Smart Grain: High-Throughput Phenotyping Software for Measuring Seed Shape through Image Analysis. *Plant Physiology, 160*(4), 1871-1880.
17. Venora, G., Grillo O., Ravalli C., & Cremonini R. (2009). Identification of Italian landraces of bean (*Phaseolus vulgaris* L.) using an image analysis system. *Scientia Horticulturae, 121*(4), 410-418.
18. Vresak, M., Olesen, M. H., Gislum, R., Bavec, F., & Jorgensen, J. R. (2016). The use of image-spectroscopy technology as a diagnostic method for seed health testing and variety identification. *PLoS One, 11*(3), e0152011.
19. Yan, X., Wang, J., Liu, S., & Zhang, C. (2010). Purity identification of maize seed based on color characteristics. 4th Conference on Computer and Computing Technologies in Agriculture (CCTA). DOI: 10.1007/978-3-642-18354-6_73