Shape analysis of common bean (*Phaseolus vulgaris* L.) seeds using image analysis

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**Abstract**

Morphological features of common bean (*Phaseolus vulgaris* L.) seeds were measured in five bean cultivars (Akhtar, Ks21189, Ks31169, G11867 and khomein) using digital image analysis. The images of seeds were captured using digital camera (Canon G7). The images were analyzed using image processing toolbox of MATLAB ver. 7.6 software. Morphological features including Area, Perimeter, Major and Minor Axis Length, Eccentricity, Convex Area, Extent, Compactness, Aspectratio, Feret Diameter, Roundness and Elongation were extracted on binary image. The bean cultivars which used in this study showed significant difference in all features. It was concluded that morphological features are powerful tool which could separates the seed cultivars. More numerical results described in the paper.

**Keywords:** Common bean; Morphological features; Image analysis.

**Introduction**

The varieties of plants showed significant differences visually and different morphological features of cultivars as well as their necessary options made identification of varieties in simplest way crucial. Harper et al. (1970) emphasized the heritability of morphological characters in nature. Measurement of some characters such as color, texture, or some of morphological features are simple, but the information which get in this way is subjective and so is not reliable. Therefore, searching a method which solves this problem is necessary. Digital image analysis is using image analysis software; with accurate, rapid and objective potential is much reliable method which gets a lot of information from a digital image. Also, reviewing the literatures supported the importance of this technique in agricultural research. Zayas et al. (1986) used some of shape parameters for identification of wheat varieties. Recognition of cultivars seeds using imaging program was reported by Travis and Draper (1985). Neuman et al., (1987) discriminated durum wheat cultivars with accuracy of 96%. Symons and Fulcher (1988) calculated the morphological features of Canadian wheat cultivars. Automatic discrimination of autumn cereals including oats, rye, barley and weed species was reported by Westerlind (1988). Afshari behbahanizadeh et al. (2011) used image processing technique to indicate different physical properties in various plant densities. Common bean (*Phaseolus vulgaris* L.) is one of the most important crops which widely grown in different regions of the world. According to Iranian Ministry of Agriculture in 2005, different cultivars of common bean are grown in more than 105000 ha annually in Iran. Modarres Najafabadi and Farahani (2012) discriminate some cultivars of common bean using linear discriminant analysis. This discrimination was done based on morphological features of bean in their digital images.

According the importance of precise calculation of morphological features of bean seeds in separation of different cultivars, the present study was conducted to extract these features in five cultivars of common bean and estimation of features diversity in these cultivars.

**Material and Methods**
The bean seeds including Akhtar, Ks31169, Ks21189, G11867 and Khomein (Fig. 1) were obtained from the National Station of Bean Research in Khomein (Markazi province, Iran). The seeds were cleaned manually to remove any unexpected dusts. A digital camera (Canon G7) was used for image acquisition. In order to reduce the noise of image and shadow effect, the white background was used for Ks31169 and Akhtar, and the black background was used for the others. Then the images transferred to personal computer for image analysis. The images were analyzed using image processing toolbox of MATLAB programming language. In image analysis, at first, the input image is converted to gray level one. The seeds in image which named Region Of Interest (ROI) were segmented using edge function and based on Laplacian of Gaussian (log) method which resulted the binary image (Fig. 2). Then the ROI was labeled in Binary image and morphological features of seeds including Area, Perimeter, Major Axis Length, Minor Axis Length, Eccentricity, ConvexArea, Solidity, Extent were calculated using regionprops function. Then Compactness, Aspectratio, Feret Diameter, Roundness and Elangation were measured using the following equations. The collected data were subjected to analysis of variance using SAS ver. 9 software and the means were separated using Duncan Multiple Range test at ($P<0.05$).

\[
\text{Roundness} = \frac{4\pi \times \text{Area}}{\text{Perimeter}^2} \tag{1}
\]

\[
\text{Aspect Ratio} = \frac{\text{Major Axis}}{\text{Minor Axis}} \tag{2}
\]

\[
\text{Compactness} = \frac{\text{Perimeter}^2}{\text{Area}} \tag{3}
\]

\[
\text{Elangation} = \frac{\text{Minor Axis}}{\text{Major Axis}} \tag{4}
\]

\[
\text{Feret Diameter} = \sqrt{4 \times \frac{\text{Area}}{\pi}} \tag{5}
\]

Figure 1. Different of common bean cultivar seeds.

Figure 2. Binary images of Akhtar seeds for extraction of morphological features.
Results and Discussion

Not specifying the sensitivity threshold for the Laplacian of Gaussian method made it to choose the threshold value automatically, so recognition in this way is robust and intelligence. The analysis of variance showed significant different among the cultivar seeds in all studied features. Data on the mean, error and coefficient of variation of all the features are presented (Table 1).

The results indicated that there were significant differences between the cultivars in morphological features which measured. Area was the highest and lowest for Akhtar and khomein, respectively (Fig 3A). Perimeter was the highest and lowest for Akhtar and khomein, respectively. Also, Ks21189 and G11867 had no statistical difference in perimeter (Fig 3B). Major axis length was the highest in Akhtar and the lowest in Ks21189 (Fig 3C). But the minor axis length was the lowest for Khomein cultivar (Fig 3D).

Table 1. Analysis of variance of morphological features (mean square) of bean cultivar seeds

<table>
<thead>
<tr>
<th>Feature</th>
<th>Mean</th>
<th>C.V.</th>
<th>Error</th>
<th>Cultivar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (pixels)</td>
<td>292.15</td>
<td>17.41</td>
<td>2589.4</td>
<td>947876.1</td>
</tr>
<tr>
<td>Perimeter (pixels)</td>
<td>63.88</td>
<td>11.32</td>
<td>52.39</td>
<td>11618.6</td>
</tr>
<tr>
<td>Major Axis Length (pixels)</td>
<td>24.54</td>
<td>11.61</td>
<td>8.12</td>
<td>1846.16</td>
</tr>
<tr>
<td>Minor Axis Length (pixels)</td>
<td>15.05</td>
<td>8.07</td>
<td>1.47</td>
<td>635.60</td>
</tr>
<tr>
<td>Eccentricity</td>
<td>0.77</td>
<td>4.9</td>
<td>0.001</td>
<td>0.46</td>
</tr>
<tr>
<td>Compactness</td>
<td>14.24</td>
<td>8.4</td>
<td>1.43</td>
<td>21.12</td>
</tr>
<tr>
<td>Aspect Ratio</td>
<td>1.63</td>
<td>8.4</td>
<td>0.01</td>
<td>3.59</td>
</tr>
<tr>
<td>Elangation</td>
<td>0.61</td>
<td>7.5</td>
<td>0.002</td>
<td>0.6</td>
</tr>
<tr>
<td>Roundness</td>
<td>0.88</td>
<td>5.5</td>
<td>0.002</td>
<td>0.8</td>
</tr>
<tr>
<td>Feret Diameter</td>
<td>19.07</td>
<td>8.23</td>
<td>2.4</td>
<td>921.2</td>
</tr>
<tr>
<td>Convex Area</td>
<td>301.76</td>
<td>19.05</td>
<td>3307.3</td>
<td>1003404.8</td>
</tr>
<tr>
<td>Extent</td>
<td>0.72</td>
<td>8.08</td>
<td>0.003</td>
<td>0.02</td>
</tr>
</tbody>
</table>

significant at 1% probability.

Common Bean Cultivars

Figure 3. Area (A), Perimeter (B), Major Axis Length (C) and Minor Axis Length (D) of common bean cultivar seeds. The cultivars with the same letter don’t differ according to Duncan’s Multiple Rang test ($P<0.05$).
Eccentricity was the highest in Akhtar and G11867. Khomein, Ks31169 and Ks21189 were in the next groups (Fig 4A). Compactness was the highest in Akhtar and there was no significant different in Ks21189 and Ks31169 in compactness (Fig 4B).

Common Bean Cultivars
Figure 4. Eccentricity (A), Compactness (B), Aspect Ratio (C), elongation (D), Roundness (E) and Feret Diameter (F) of cultivars of been seeds. The cultivars with the same letter don't differ according to Duncan's Multiple Rang test ($P<0.05$).

Akhtar had the highest value of Aspect Ratio and G11867 and khomein are in the next and same group (Fig 4C). Ks21189 had the highest value of elongation, whereas Akhtar was the least and G11867 and Khomein with no significant difference were in the same group (Fig 4D). Roundness was the highest in Ks21189 and Ks1169 and the lowest in Akhtar (Fig 4E). Feret Diameter was the highest in Akhtar and the lowest in khomein (Fig 4F).
Common Bean Cultivars

Figure 5. Convex Area (A) and Extent (B) of cultivars of bean seeds. The cultivars with the same letter don’t differ according to Duncan’s Multiple Rang test (P<0.05).

Convex Area was the highest in Akhtar, but the lowest was seen in Khomein (Fig 5A). Extent was the lowest amount in Akhtar and the highest in Ks21189 (Fig 5B). All of these results indicated that there was high diversity in morphological features of seeds in different cultivars of bean. Similar results were reported by Shouche et al. (2001) who quantified morphological features including geometric features, shape factors, Moments and invariant moments for 15 varieties of Indian grains. These results emphasized that the features extracted by image analysis could facilitate many agricultural programs such as application of them in automated detections in machine vision systems, discrimination of cultivar seeds from each other. Studies on correlation of morphological features of seeds with other parts of plant and finally the correlation of these features with physiological characters of plant could recommend.

Reference


