Evaluation of seed characteristics in three lentil (Lens culinaris Medik) genotypes

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Abstract

The purpose of this study was to investigate some physical traits of three lentil genotypes. The present study was done based on a randomized complete block design with five replications. For this work some physical traits including 100 seed weight, seed volume, bulk density, true density, grain turgidity, turgidity index, water absorption capacity, water absorption index and grain porosity were examined in the laboratory in 2011. The results showed that 100 seed weight and bulk density had the highest (32.2%) and lowest (5.15%) coefficient of variation respectively. All traits except seed true density had the significant difference. Quvin cultivar with higher 100 seed weight 3.89 g, seed volume 25.2 μl/seed, turgidity 25.4 μl/seed, water absorption capacity 28.2 mg/seed, water absorption index 1.01 and porosity 47.8% had a significant difference with two other genotypes. 100 seed weight had positive and negative significant correlation with seed volume, turgidity, water absorption capacity traits and water absorption capacity index, respectively. Turgidity index trait had no significant correlation with any of the traits. The results showed that in general, selection of 100 seed weight, seed volume and seed turgidity in macrospema and the bulk density of microspema lentils can help to improve these traits.

Key words: genetic variability, physical properties, lentil, selection, traits correlation

Introduction

Due to its cheap prices, good taste and protein in compare with animal protein, lentil has taken a very important role in the human diet (Ozer and Kaya, 2010). Lentil (Lens culinarisMedik) is divided into two sub-species including macroperma (broad and large seeds with a diameter of 9-6 mm) and microperma (concave shaped tiny seeds with a diameter of 6-2 mm) (Rathore, 2002). Merging these two subspecies (macroperma and microperma) the resultant hybrid plants are perfectly fertile. Freshly harvested seeds of lentils may show about 3 or 4 weeks dormancy. In this research work, the variation between different genotypes of lentil has been observed. When the seeds having no dormancy are placed in desired temperature humid soil or water, they absorb water quickly and the maximum water absorbance is completed within 12 hours. Tiny seeds of lentil absorb water with a quantity of 85% of their dry weight. Far as improper use of post-harvesting facilities and inappropriate processing of this plant in Iran, waste of lentil has increased and production efficiency has been reduced. Therefore, achieving basic scientific information about the physicochemical properties that have a crucial role in designing required equipment of cultivation, harvesting, transportation, storage and processing of this product is necessary. Some physical properties of seeds such as seed weight, seed volume and seed size are the main characteristics for designing transportation equipment of agricultural products (Peleg, 1985). According to a study involving 10 lentil genotypes in Turkey, indicated that there were significant differences between these genotypes in terms of 1000 seed weight and this trait had a heritability of 98 percent (Tuba and Sakar, 2010). Weight of 100 seed is one of the important performance indicators and represents the size, quality and density of seeds which are also affected by environment and genetic factors (ICARDA, 2004). In order to determine some physical properties such as 1000 seed weight, bulk density and porosity, the results of a study on two lentil cultivars showed that there is a significant difference between the two cultivars (Szot et al., 2003). In a study on 245 lentil genotypes, significant differences for 100 seed weight were reported and high heritability for this trait was observed (Singh et al., 2012). In a study on two lentil cultivars grown in Turkey, it was reported that Seyran-96 cultivar with the true density of 1409 kilograms per cubic meter had more density than the Firat-87 cultivar with a density of 1395 kg per cubic meter and these two cultivars had a low mean standard error (Gursoy and Guzel, 2010). Dursun and Dursun (2005) believed that bulk density and porosity are important...
parameters in the design of drying systems and storing seeds. Also Altuntas et al. (2005) reported seed porosity, is important for designing storage and transportation equipment. In a study on physical properties of two lentil cultivars, the significant differences for the seed turgidity were observed that might be caused by the difference of the seed coat, skin and cellular characteristics of the two cultivars (Szot et al., 2003). In study, researchers found a mathematical relationship between the true density, seed length and width in changing moisture conditions of seeds (Ahmadi and Mollazade, 2009). Urena et al. (2002) reported that the 1000 seed weight, seed size, seed density, true seed porosity in storage systems, transportation and separation of seed from straw, were helpful. In a study on the physical characteristics and geometric properties of different sunflower seed cultivars, significant difference for traits such as 1000 seed weight and sectional area of the seed, seed size, seed bulk density and true porosity was observed (Jafari et al., 2011). The results showed considerable variation for measured traits. In a study on 80 bean genotypes to estimate the phenotypic and genotypic variance of some physicochemical properties, significant differences between phenotypic and genetic variance were reported and heritability for various traits was high (Adewale et al., 2010). Physical characteristics play important role in equipment design for plant culture, harvest, translocation and yield production therefore it seems to achieve these basic scientific information about these characteristics is necessary. The purpose of this study is investigating the physical properties of the three lentil genotypes.

Materials and Methods

In order to investigate the physical properties of three lentil genotypes, this study was conducted in a research laboratory, Faculty of Agriculture, Shahrekord University, Iran in 2011. This work was done in a randomized complete block design with five replicates. For this purpose lentil genotype local cultivars of Qazvin (a local population of Iran), L-3685 (macronutrient type: origin Iran) and LC-74 (macronutrient type: origin India) were used. Cultivars were chosen because of the extent of cultivation in Iran. Seed characteristics like 100 seed weight, seed volume, true density, bulk density, seed turgidity, turgidity index, water absorption capacity, water absorption index and seed porosity was measured. For determination of seed volume, 100 seeds were put into a measuring cylinder containing with adequate quantity of water that could completely cover all the seeds. Seed volume (µl/seed) was recorded as (final reading – initial reading)/100 (Mohsenin, 1986). To measure the true density, seed weight was divided by its volume and it was expressed as g/µl. To measure bulk density, a certain amount of seed weight was divided by its volume and it was expressed based on g/cm³ (Khattak et al., 2006). To calculate the water absorption capacity, 100 seeds from each replication were weighted, soaked in water and maintained at a temperature of 22°C for 12 hours. The seeds were then removed from water and the excess moisture on the seed surface was removed with filter paper and weighted. Water absorption capacity in terms of grams per seeds was obtained by dividing the difference between these two values multiplied by 100 (Mohsenin, 1986). Water absorption index was obtained by dividing the water absorption capacity of the main seed size (g) (a single seed) (Williams et al., 1983). Seed turgidity (µl/seed) was obtained by calculating the differences in moisture conditions of seeds (Ahmadi and Mollazade, 2009). Seed turgidity index was calculated as the ratio between the seed turgidity and the seed volume and obtained by dividing seed turgidity on seed volume (Bishnoi and Khotarpaul, 1993). To obtain the seed porosity percent, first the bulk density (ρb) and the true density (ρt) of each replication were calculated, and then seed porosity percent was obtained using the following formula (Singh and Goswami, 1996):

\[ e = \left(1 - \frac{\rho_b}{\rho_t}\right) \times 100 \]

Data were analyzed using SAS 9.1 and Minitab statistical software and correlation and variation coefficients were calculated from measuring different physical properties.

Table 1. Descriptive statistics of physical properties of lentil seeds at three different genotypes (Qazvin, L-3685 and LC-74)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>minimum</th>
<th>maximum</th>
<th>mean</th>
<th>standard deviation</th>
<th>variance</th>
<th>coefficient of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 seed weight (g)</td>
<td>2</td>
<td>4.47</td>
<td>2.79</td>
<td>0.9</td>
<td>0.8</td>
<td>32.2</td>
</tr>
<tr>
<td>seed volume (µl/seed)</td>
<td>14</td>
<td>26</td>
<td>19.8</td>
<td>4.49</td>
<td>20.1</td>
<td>22.6</td>
</tr>
<tr>
<td>true density (g/µl)</td>
<td>1.18</td>
<td>1.84</td>
<td>1.39</td>
<td>0.2</td>
<td>0.04</td>
<td>14.7</td>
</tr>
<tr>
<td>bulk density (g/cm³)</td>
<td>0.75</td>
<td>0.88</td>
<td>0.82</td>
<td>0.04</td>
<td>0.001</td>
<td>5.15</td>
</tr>
<tr>
<td>turgidity (µl/seed)</td>
<td>15</td>
<td>26.3</td>
<td>21.2</td>
<td>4.29</td>
<td>18.3</td>
<td>20.1</td>
</tr>
<tr>
<td>turgidity index</td>
<td>0.94</td>
<td>1.18</td>
<td>1.07</td>
<td>0.08</td>
<td>0.006</td>
<td>7.65</td>
</tr>
<tr>
<td>water absorption capacity (g/seed)</td>
<td>20.7</td>
<td>28.4</td>
<td>25</td>
<td>3.33</td>
<td>11.1</td>
<td>13.3</td>
</tr>
<tr>
<td>water absorption index</td>
<td>0.63</td>
<td>1.1</td>
<td>0.94</td>
<td>0.16</td>
<td>0.02</td>
<td>17.9</td>
</tr>
<tr>
<td>porosity (%)</td>
<td>31.1</td>
<td>56.9</td>
<td>40.1</td>
<td>8.04</td>
<td>64.6</td>
<td>20</td>
</tr>
</tbody>
</table>

Descriptive statistics of physical properties of lentil seeds at three different genotypes.
Table 2. Analysis of variance for physical traits of lentil genotypes

<table>
<thead>
<tr>
<th>S.V</th>
<th>df</th>
<th>MS 100 seed weight (g)</th>
<th>seed volume (μl/seed)</th>
<th>true density (g/μl)</th>
<th>bulk density (g/cm³)</th>
<th>turgidity (μl/seed)</th>
<th>turgidity index</th>
<th>water absorption capacity (g/seed)</th>
<th>water absorption index (%)</th>
<th>porosity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genotyp</td>
<td>2</td>
<td>2.86**</td>
<td>78.8**</td>
<td>1.87ns</td>
<td>0.005*</td>
<td>71.1**</td>
<td>0.03**</td>
<td>43.5**</td>
<td>0.09*</td>
<td>167.9**</td>
</tr>
<tr>
<td>Repeat</td>
<td>4</td>
<td>0.1ns</td>
<td>0.61ns</td>
<td>0.91ns</td>
<td>0.0001ns</td>
<td>0.2ns</td>
<td>0.003ns</td>
<td>2.42ns</td>
<td>0.0007ns</td>
<td>1.32ns</td>
</tr>
<tr>
<td>Error</td>
<td>8</td>
<td>0.13</td>
<td>0.71</td>
<td>0.03</td>
<td>0.0005</td>
<td>1.22</td>
<td>0.002</td>
<td>0.2</td>
<td>0.007</td>
<td>13.4</td>
</tr>
</tbody>
</table>

Table 3. Results of comparison of the mean and standard error of the physical properties of lentil genotypes

<table>
<thead>
<tr>
<th>traits/genotyp</th>
<th>100 seed weight (g)</th>
<th>seed volume (μl/seed)</th>
<th>true density (g/μl)</th>
<th>bulk density (g/cm³)</th>
<th>turgidity (μl/seed)</th>
<th>turgidity index</th>
<th>water absorption capacity (g/seed)</th>
<th>water absorption index (%)</th>
<th>porosity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line-LC74</td>
<td>2.43b</td>
<td>19.3b</td>
<td>1.25a</td>
<td>0.79b</td>
<td>22.5b</td>
<td>1.16a</td>
<td>26b</td>
<td>1.07a</td>
<td>36.5b</td>
</tr>
<tr>
<td>Line-LC3685</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>Qazvin</td>
<td>0.02</td>
<td>0.49</td>
<td>0.06</td>
<td>0.006</td>
<td>0.52</td>
<td>0.03</td>
<td>0.05</td>
<td>0.01</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>3.89a</td>
<td>25.2a</td>
<td>1.55a</td>
<td>0.79b</td>
<td>25.4a</td>
<td>1.01b</td>
<td>28.2a</td>
<td>1.01a</td>
<td>47.8a</td>
</tr>
<tr>
<td></td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td></td>
<td>0.35</td>
<td>0.06</td>
<td>0.17</td>
<td>0.01</td>
<td>0.46</td>
<td>0.03</td>
<td>0.16</td>
<td>0.06</td>
<td>3.02</td>
</tr>
</tbody>
</table>

Difference between the values shown with the same letter on the same column in the table is insignificant according to 0.05 confidence limit.

Table 4. Results of correlation analysis of physical properties of lentil genotypes

<table>
<thead>
<tr>
<th>traits</th>
<th>100 seed weight (g)</th>
<th>seed volume (μl/seed)</th>
<th>true density (g/μl)</th>
<th>bulk density (g/cm³)</th>
<th>turgidity (μl/seed)</th>
<th>turgidity index</th>
<th>water absorption capacity (g/seed)</th>
<th>water absorption index (%)</th>
<th>porosity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 seed weight (g)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed volume (μl/seed)</td>
<td>0.86**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>True density (g/μl)</td>
<td>0.74*</td>
<td>-0.75*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bulk density (g/cm³)</td>
<td>-0.51**</td>
<td>0.31**</td>
<td>0.04**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turgidity (μl/seed)</td>
<td>0.81**</td>
<td>0.92**</td>
<td>0.29ns</td>
<td>-0.83**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turgidity index</td>
<td>-0.35**</td>
<td>-0.37**</td>
<td>-0.18**</td>
<td>-0.04**</td>
<td>-0.03**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water absorption capacity (g/seed)</td>
<td>0.8**</td>
<td>0.92**</td>
<td>0.28**</td>
<td>-0.86**</td>
<td>0.96**</td>
<td>-0.09**</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water absorption index (%)</td>
<td>-0.93**</td>
<td>-0.72**</td>
<td>-0.82**</td>
<td>0.26**</td>
<td>-0.59**</td>
<td>0.52**</td>
<td>-0.56**</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Water absorption index (%)</td>
<td>0.86**</td>
<td>0.54**</td>
<td>0.93**</td>
<td>-0.32**</td>
<td>0.53**</td>
<td>-0.18**</td>
<td>0.55**</td>
<td>-0.86**</td>
<td>1</td>
</tr>
</tbody>
</table>

Results and Discussion

Results of descriptive statistics related to the physical properties of studied lentil genotypes are presented as minimum, maximum, mean, standard deviation, variance and coefficient of variation are shown in Table 1. The results showed the maximum and the minimum value of the coefficient of variation was dedicated to 100 seed weight (32.2%) and bulk density (5.1%) respectively. Because lentil genotypes were selected from two different types, a large difference in terms of the coefficient of variation was observed between different traits. In a study on six lentil genotypes and the resulting generations of their crosses, wide differences were reported for physicochemical characteristics that the maximum value of the coefficient of variation was dedicated to the seed turgidity trait with 49.1% (Solanki et al., 1999). In another study on the different pea cultivars, wide differences were reported for physicochemical characteristics such as 100 seed weight, seed volume, water absorption capacity, water absorption capacity index, turgidity and turgidity index among these cultivars (Malik et al., 2011). Results of analysis of variance physical properties of lentil seeds are shown in Table 2. The results showed that there were among the genotypes significant differences for bulk density, turgidity index and the water absorption index at 5% level and for 100 seed weight, seed volume, seed turgidity, porosity and seed water absorption capacity at 1% level statistically. True density trait had no considerable difference among the genotypes. The
results of mean comparison of physical properties of lentil seeds indicated that Qazvin cultivar had higher value of 100 seed weight (3.89 g, P<0.01) and had significant difference from two other cultivars, but those two other genotypes had no significant difference among themselves for this trait (Table 3). Since the Qazvin cultivar was selected from macrosperma, it had larger seeds than the other two cultivars and these results were predictable. The results of means comparison for the water absorption capacity trait showed that Qazvin cultivar had higher water absorption capacity than the other two genotypes, because this cultivar had more cells, larger cells and more space between the cells leading to absorb more water and having the highest rate of water absorption after 12 hours. Qazvin cultivar with a water absorption capacity of 28.2 mg/seed had more water absorption capacity than LC-74 cultivar and L-3685 cultivar with the rate of 26 mg/seed and 20.8 mg/seed, respectively. L-3685 had the lowest water absorption capacity. Since microsperma type of lentil had seeds with diameter from 2 to 6 mm and a variable weight and had less weight than macrosperma type, most physical and geometrical characteristics of microsperma were less than macrosperma type. In a study on physiochemical properties of red lentils seeds, it was reported that increasing moisture range led to an increase in porosity percent and bulk density (Gharibzahedi et al., 2011). Based on the results, the Qazvin cultivar with a volume of 25.2 μL/seed had the largest seed size so that it was superior to LC-74 and L-3685 with a rate of 19.3 μL/seed and 15 μL/seed respectively (Table 3). L-3685 had the lowest seed size among the three genotypes and just had a significant difference with Qazvin cultivar. From density trait viewpoint, L-3685 with a mass density of 0.87 g/cm³ had significant differences with two other genotypes at 5% level; because microsperma seeds were more compact than macrosperma ones. For this trait (density), Qazvin and LC-74 genotypes had no significant differences (Table 3). The physical properties such as 100 seed weight, seed volume, bulk density and porosity percent has also been studied for seeds of various crops such as cotton (Ozarslan, 2002) pea (Yalcin et al., 2007) bean (Rich and Teixeira, 2005) and pigeon pea (Baryeh and Mangope, 2002). Results of analysis of variance for seed turgidity showed that there were significant differences among the three genotypes at 1% level (Table 2). Since Qazvin cultivar had the maximum seed volume, even after absorbing water and turgidity, it had the highest turgidity (25.4 μL/seed) among the three studied genotypes. L-3685 also had the lowest seed turgidity (15.9 ml/seed) (Table 3). Genetic variation in the turgidity trait is caused by stretching seed coat due to maintenance of the absorbed water in cells and the intercellular spaces. Since the seed cells became larger due to absorbed water, the seed volume increased in this case leading to increase of turgidity value. In various cultivars, water absorption and stretching seed coat is different because of absorbed water. Results of mean comparison of three lentil genotypes for water absorption index trait are shown in Table 3. Water absorption index demonstrated the relationship between water absorption capacity and seed weight. The results showed that LC-74 and Qazvin had significant differences with L-3685 at 5% level. The LC-74 had the lowest value of the water absorption index (0.73) among the three genotypes. Seed porosity in storage, packaging and determining the stability of seed mass against the airflow is important. Porosity of Qazvin was higher than LC-74 and L-3685 with the rate of 36.5% and 36.1% respectively. Results of comparing three genotypes for seed porosity trait showed that Qazvin had the maximum value (47.8%) among the three genotypes and had a significant difference with the other two ones. L-3685 had lower porosity than Qazvin according to great mass density to the true density ratio and it is justified based on porosity formula. In a study on sunflower cultivars, it was reported that the effect of cultivar on seed porosity was highly significant(Gupta1 and Das, 1997). In a study on physical properties of two pea cultivars, it was reported that effect of 1000 seed weight, bulk density and seed porosity percent had highly significant differences with each other (Al-Husseini et al., 2012). The results showed that the studied genotypes had significant differences at 5% level for this trait and LC-74 with a maximum value of turgidity index had significant differences with Qazvin. L-3685 with a turgidity index of 1.06 had no significant difference with the other two genotypes. The difference in values of the obtained physical parameters in the three studied genotypes was caused by the difference in axial dimensions, mass and specific shape of tested genotypes which was due to differences in their genome. The correlation index is used for measurement and determination of mutual relationship between changes of two random variables. This index shows strength or weakness and direction of changes of two variables towards each other's. The results of correlation analysis showed that there is a positive and significant correlation between 100 seed weight and seed volume traits, seed turgidity, water absorption capacity and seed porosity at 1% level (Table 4). True density and 100 seed weight had positive and significant correlation at 5% level. Thistrait also had a negative significant correlation with water absorption index trait (-0.82). In a study on pea cultivars, high positive correlation between 100 seed weight and seed volume, grain turgidity capacity and water absorption was reported (Malik et al., 2011). There was an strong and positive correlation between seed volume and water absorption capacity representing an increase inseed volume after 12 hours being in water compared with initial volume. In other studies, the relationship between seed volume and water absorption capacity was reported positive and significant (Khattak et al., 2006; Nizakat et al., 2006). True density had positive correlation with seed porosity (0.93) at 1% level. The results were predictable because seed porosity was obtained using the two ratio of the true density and bulk density. The results obtained in this study are contrary to the results of physical traits of pea cultivars (Pandey et al., 2007) which could be caused by differences in lentil and pea. Bulk density had an extremely and negative correlation with seed turgidity and water absorption capacity but had no correlation with other traits (Table 4). The correlation between turgidity and seed water absorption capacity traits was positive and significant among the three genotypes at 1% level (0.96). The correlation coefficient for porosity and seed water absorption index traits (-0.86) shows the inverse correlation between the two traits.
Conclusions

According to the obtained results, it is concluded that the Qazvin cultivar compared to the other two genotypes had the highest 100 seed weight, seed volume, true density, turbidity, porosity and water absorption capacity generally. Selection based on high 100 seed weight, seed volume, turbidity, water absorption capacity, water absorption index and porosity of the macrospora lentil and bulk density of the microspora lentil, these types of traits can be improved in this plant.

References