Evaluating Correlation and Factor Analysis of Morphological Traits in Potato Cultivars in Fall Cultivation of Jiroft Area

Hamed Felenji, Saeed Aharizad, Gholam Reza Afsharmanesh and Mostafa Ahmadizadeh

Abstract: In order to evaluate and classify morphological traits of Potato cultivars in fall cultivation of jiroft area, 22 Potato cultivars and experiment in randomized complete block design with three replications, was done in Jiroft Agricultural Research Center. Correlation coefficient showed that tuber weight and harvest index have positive and significant correlation with tuber yield. Factor analysis based on principal component analysis method and varimax rotation indicated that three important factors accounted for about 80.05 percent of the total variation among traits. The first factor assigned 33.29 percent of total variation between traits and was significantly related with tuber yield. Therefore, this factor was regarded as tuber yield factor. Other factors accounted for 30.48 and 16.28 percent of variation between traits and were entitled as stolon length factor and negative factor for diagonal height, respectively.

Key words: Potato • Correlations traits • Varimax rotation • Fall cultivation • Tuber yield

INTRODUCTION

Agricultural potato (Solanum tuberosum L.) is an auto-tetraploid and heterozygous plant. It is from the north hemisphere and its origin is the heights of Andes mountain range in South America [1]. Potato is the fifth agricultural crop in the world after wheat, rice, maize and barely. The cultivated area of this plant in the world reached to 20 million hectares in 2005 and its production reached to 324.49 million tons [2]. Potato cultivated area in Iran was about 189670 hectares in 2004 and its production was 4830000 tons with yield about equal to 25763 kg/hectare [1]. Determining tuber weight or the marketable yield is influenced by two major factors such as tuber size and number of produced tubers in per unit. Tuber size is a more important index of marketable yield compared to the number of tubers. Therefore, number of tubers plant density is depends [3]. Tuber yield in potato is influenced by number of produced tubers in each plant and the weight of each tuber. Number of produced tubers in each plant is 3 to 10 tubers and each rhizome produces about 3 tubers. Number of tubers has a high correlation with number of produced stem, while there is a negative relation between the number of peduncles in each plant and the number of tubers in each stem [4]. The weight of each tuber depends on stolon position and its age [5]. The cultivars which start their own tuber generation with a large number of tubers have also a high dry matter percent. On the other hand, in the cultivars which have more stems, dry weight of tuber increases from tuber generation time to harvest time [6]. Number of tubers in each potato bush has a positive correlation with the number of stem and the more the number of stem in each plant, more number of formed tubers will be [7]. Lopez et al. [8] observed that plant height has a positive and significant correlation with the number of tubers and tuber yield has the same correlation with tuber average weight and there is a negative and significant correlation between tuber average weight and the number of tubers. Haverkort et al. [9] stated that there is a high correlation between the number of stolon and the number of tubers. Adeli [10] stated in his study that tuber creation data and the number of stem have a positive and significant correlation with the number of tubers in potato. Gunel et al. [11] reported that negative and significant correlations between small tuber percentage and tuber...
yield. Kaminski [12] concluded that some traits of potato such as growth period length, the number of stem, leaf area have a positive and significant correlation with tuber average weight.

Morphological characterization has been used for various purposes including identification of duplications, studying the patterns of genetic diversity and correlating them with characteristics of agronomic importance [13]. Yildirim et al. [14] observed that both yield components (tuber number and tuber weight) were associated with tuber yield, but they indicated that tuber numbers were important than average tuber weight. Fataei et al. [15] studied correlation coefficients calculation among the traits and showed that there is a positive and significant correlation between number of tubers in a plant, number of stems, tuber creation data with yield in 1% possibility level in three cultivars such as Agria, Auola, and Kariz. Rezazadeh [16] showed that the yield had a significant correlation with number of tubers in 1% possibility level. Er [17] reported that there is a positive and significant correlation between main stems/plant and small tuber percentage. These findings are in accordance with the results of present study except small tuber percentage.

In other words, multivariable analysis like stepwise regression and factor analysis is used to explain existing relations between traits and to group them on the basis of these relations. So, in this way the most important traits influencing yield and also unknown factors were identified which result in appearing particular structure of covariance matrix among traits and variables which had the most intergroup correlation and showed the minimum correlation to other groups. Consequently, it can improve different traits simultaneously, which influenced by different factors and in order to achieve ideal yield, we could strengthen or weaken one or more unknown factors with the hope that these traits can be influenced by each one of the unknown factors [18]. Factor analysis on the base of analyzing method to major factors, which has been explained by Harman, accompanies to factorial load extraction [19]. Cooperation and variance amount that have been justified by the factors have been estimated by means of the most correlation coefficient [20] and the number factors can be estimated by means of some methods such as analyzing to major factors, maximum likelihood and another methods. Temporary factors rotation and transforming their into rotated factors can be used by means of varimax method which is a orthogonal rotation. It is due to transformation of each factor to series of independent variables [21]. Rotated matrix factorial loads, justified variation percent by means of each factor and cooperation scale of each variable in extracted factors can be estimated too [22]. Bartos and Sarvari [23] used factor analysis in one study to consider the effects of ecologic variables on potato. Tai and Misener [24] did factor analysis by means of the traits related to the tubers. In this research, the first factor showed a negative structural relation among the interior membrane parts and the second factor was an indicator of a positive relation among width indices and tuber length.

Khayatnezhad et al. [25] in his studies on durum wheat cultivars showed that performing factor analysis, through analysis, principal 4 components 77.19 percent of total operating changes were justified and the results indicated the importance of factor coefficients characteristics of total and fertile tillers, main spike length, 1000-seed weight and yield selected genotypes is desirable for dry conditions. Gholamin et al. [26] showed that performing factor analysis through analysis, principal 5 components 82.58 percent of total operating changes were justified. The results indicated that the importance of factor coefficients characteristics of fertile tillers, grain weight original lavender, seed weight and harvest index selected genotypes is desirable for dry conditions.

The aim of this research is studying the relations of different traits in Jiroft climate condition and also identifying effective factors in yield improvement in potato cultivars.

**MATERIALS AND METHODS**

Field trial was carried out during 2008 in Agricultural Research Centre, Jiroft which has warm and almost dry climate. Soil texture of the experiment place was sandy-loamy with an EC 2.7 dS/m and pH 7.6. The results of soil analysis which has been done on the soil sample by soil laboratory in Jiroft agricultural studies centre have been stated in Table 1. To get the cultivar or cultivars which have high yield and are compatible to be cultivated in autumn in Jiroft, 22 potato cultivars were evaluated. Tubers of these cultivars were provided from Agricultural Research Centre. The experimented cultivars were Kofi jiboti, Raja, Mlina, Picasso, Almera, Casmos, Odsa, Atlas, Dayta, Sante, Licaria, Arcola, Auola, Moren, Agria, Auax, Maradona, Condor, Satina, Spanta, Diamond and Vergo.
Table 1: Soil features of experiment place in 2008

<table>
<thead>
<tr>
<th>Total nitrogen (%)</th>
<th>Available phosphorus (ppm)</th>
<th>Available potassium (ppm)</th>
<th>Soil texture</th>
<th>EC (dS/m)</th>
<th>pH</th>
<th>Soil depth cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.004</td>
<td>8.5</td>
<td>210</td>
<td>sandy - loamy</td>
<td>2.7</td>
<td>7.6</td>
<td>30.0</td>
</tr>
</tbody>
</table>

The experiment was laid out in the form of randomize complete blocks design with three repetitions. In each experimental unit, there were four lines of cultivation with five meters length with distance 75 cm, 25 cm plant spacing in the row and the distance between repetitions of the 1.5 m were considered. Land preparation was done in October that included plow and disk. Then the action was taken to make rows according to the cultivation plan. According the results of soil test, 250 kg h⁻¹ nitrogen was used and 150 kg h⁻¹ of ammonium phosphate was consumed and kg h⁻¹ of potassium sulphate was used. Nitrogen fertilizer was used in two stages: 1.2 stage when 75% of the bushes were green and 1.2 before flowering. The cultivation was done on 25 October 2008. It was done manually and by means of the tubers that had passed sleeping period and had buds. They were cultivated in the depth of 20 cm. When the leaves got dry and yellow and it was assured that the tubers were completely ripe, harvesting operation was done in January on February. Measuring the traits was done from two lines from the middle and by taking away 0.5 meters from the beginning and 0.5 meters from the end of the line. In each experimental unit, 5 bushes were selected to be measured from the considered traits points of views. The studied traits were measured on the average base of five bushes. It must be mentioned that drying the organs was done by means of oven and in 75°C for 72 hours. Mean repetition was on the data and the means were used in calculations.

Table 2: Correlation coefficients among the studied traits in 22 potato cultivars

<table>
<thead>
<tr>
<th>Trait</th>
<th>Biological yield</th>
<th>Yield</th>
<th>Tuber weight</th>
<th>Stolon length</th>
<th>No. tubers</th>
<th>Dry matter percent</th>
<th>No. stems</th>
<th>Plant height</th>
<th>Harvest Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield</td>
<td>0.512*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuber weight</td>
<td>0.702**</td>
<td>0.804**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stolon length</td>
<td>0.2</td>
<td>-0.118</td>
<td>0.053</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. tubers</td>
<td>-0.117</td>
<td>0.347</td>
<td>-0.157</td>
<td>-0.070</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry matter percent</td>
<td>0.691**</td>
<td>0.416</td>
<td>0.476*</td>
<td>0.515*</td>
<td>0.286</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. stems</td>
<td>-0.122</td>
<td>0.243</td>
<td>-0.120</td>
<td>-0.160</td>
<td>0.761**</td>
<td>0.257</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant height</td>
<td>0.152</td>
<td>0.178</td>
<td>0.135</td>
<td>-0.020</td>
<td>0.118</td>
<td>0.353</td>
<td>0.518*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harvest index</td>
<td>0.382</td>
<td>0.899**</td>
<td>0.663**</td>
<td>0.076</td>
<td>0.543**</td>
<td>0.629**</td>
<td>0.447*</td>
<td>0.316</td>
<td></td>
</tr>
<tr>
<td>Stem diagonal</td>
<td>0.248</td>
<td>0.022</td>
<td>0.401</td>
<td>0.018</td>
<td>-0.629**</td>
<td>-0.106</td>
<td>-0.760**</td>
<td>-0.321</td>
<td>-0.168</td>
</tr>
</tbody>
</table>

** and * significant at 1%, 5% level of probability, respectively

RESULTS AND DISCUSSION

Studied the correlation coefficient among different traits makes it possible to decide more precisely about selected indirect selection indices and removing ineffective traits. On the other hand, using multivariable factorial analysis has a great importance on identifying the independent factors which are effective on plant important traits separately and it expands every day. By means of varimax rotation which maximizes the variance among the factors, the factors which justify more percentage of variations among the traits have had more importance and must be studied. So, the effective traits on each factor are identified and the factors are named according to the most effective traits. This method makes genetic improvement of factors possible by means of related traits to them [19, 22, 27]. The results of studied correlation among the traits analysis have been presented in table 2. As it is considered, tuber weight and harvest index in 1% possibility level and the biologic yield in 5% possibility level had a positive and significant correlation with tuber yield. It corresponded to the results gotten
by Parvizi [28] and Nazirzadeh [29]. Therefore, it can be stated that the cultivars which have more average tuber weight, have higher tuber yield too. The number of tubers in plant and the percent of dry matter percent had a positive and significant correlation with tuber yield. Shook et al. [30] and Hosseinzadeh-Mogbeli [31] did not observe a significant correlation between the number of tubers in each plant and tuber yield either. The lack of significant correlation between the number of tubers and tuber yield can be a result of this fact that the more the number of tubers in plant, the less the average weight of the tuber was and it neutralized their effects. Tuber weight had a positive and significant correlation with dry matter percent and harvest index and it had a negative and insignificant correlation with the number of tubers in plant. Negative relation exists between the number and weight tuber has been reported by Siyadat et al. [32].

Also, negative and significant correlation between the tuber weight and the number of tubers in plant has been reported by [30], Islam et al. [33] and Tsegaye et al. [34] according to the correlation analysis showed that sweet-potato yield is related to many traits.

Number of tubers per plant had a positive and significant correlation with the number of stem and harvest index and it also had a negative and significant correlation in 1% possibility level with stem diagonal. A positive and significant correlation was observed between dry matter percent and harvest index. Number of stems had a positive and significant correlation with plant height and harvest index and it had a negative and significant correlation with stem diagonal (Table 2). Therefore, it can be declared that more number of stems, lower diameter growth will be.

**Factor Analysis:** With due attention to the complex relations of the traits with each other the final judgment cannot be done on the basis of simple correlation coefficients and it is necessary to use multivariable statistical methods in order to perceive deeply the reactions among the traits. In the meantime factor analysis is an effective statistical method in decreasing the volume of data and getting results of the data which showed a high correlation among the primary variables [35]. Selecting factors number was done on the basis of roots number larger than 1 and the number of used primary variables in factor analysis was equal to 10, according to formula $F<(P+1)/2$ (in which $P$ and $F$ refer to number of variables and number of factors, respectively) selection of three factors was compatible with the presented principles [36]. This method had been used effectively for perceiving the relations and structure of yield components and some traits of cultivated plants [37, 38].

In factor analysis by means of major factors analysis and on the base of specific numbers larger than 1, three factors were identified and they all together justify 80.05 percent of existent variations among the traits (Table 3). The importance of each factor is observed in Fig. 1. The first factor posses 33.29 percent of the variance among the traits and played an important role in justifying yield variations changes, Tuber weight, harvest index and biological yield. So, the existent coefficients indicate that this factor was an effective factor in increasing yield for the cultivars. The second factor justified 38.48 percent of
the variance and had high positive coefficients for the traits such as the number of tubers and the number of stem and it had negative coefficient with stem diagonal. In selecting the cultivars by means of the second major factor, the mentioned traits will have high importance, so the second factor was named as a negative factor for the stem diagonal. The third factor owned 16.28 percent of the variations and it played an important role in justifying traits variation such as stolon length variation and dry matter percent. This factor was called as stolon length factor (Table 4).

Various researchers have been done by means of factor analysis and considering different traits in potato cultivars. In this case we can mention that researches which have been done by some researchers including Sharma [39] who did factor analysing using 40 genotypes and considering the related traits to plant. Three important factors were identified and were respectively introduced as' the size and weight of the fruit', 'the number of fruit and seeds' and 'the number of fruit in each stem'. Rabiee et al. [40] also analysed the factors in normal and drought stress on potato cultivars and identified two important factors. In non-stress condition the first factor was ' leaf area ' and the second factor was 'structural state'. In stress condition the first factor was ' photosynthetic level' and the second was 'structural state'.

REFERENCES

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