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Evaluating Yield and Some Traits of Potato Cultivars in Fall Cultivation of Jiroft Area

Hamed Felenji[1] and Mostafa Ahmadizadeh[2*]

[1.] Payam Noor University of Jiroft, Iran.
[2.] Young Researchers Club, Jiroft Branch, Islamic Azad University, Jiroft, Iran.

ABSTRACT

In order to finding cultivars with high yield and compatible with potato in the form of fall cultivation in jiroft area, an experiment in randomized complete block design with three replication, was done in Jiroft agricultural research center in 2008. In this experiment diagonal height, shrub height, the number of stems, stolon length, the number of shrub tuber, average tuber weight, percent of dry matter, harvest index and biologic yield were examined. Analysis of variance data represent significant statistical differences between examined cultivars, for most of the traits and only in term of the number of tuber in shrub and biologic yield between cultivar no difference was shown. The result mean comparison shows that sante, vergo and satina cultivars have the most tuber yield. Moren cultivar has the least yield. Path analysis with regression stepwise shows that tuber numbers in shrub, average tuber weight and percent of dry matter are effective traits on yield.

KEY WORDS: Component yield, path analysis, potato, fall cultivation.

INTRODUCTION

Potato is one year old plant and its scientific name is *Solanum tuberosum* L. and is from tomato family (*Solanaceae*) and autotetraploid with 48 chromosomes [1]. Potato, due to having high nutritional value, is considered as a very important crop in feeding the developing countries of the world. In Iran due attention to the growth of population all over the country, food preparation for 65 million people at present and 120 million people in two future decades must be considered totally all the time. Therefore, increasing efficiency and more profitability of the strategic crops such as potatoes seems necessary to create nutritional health. To get this goal, performance increase in per unit considering the effective parameters on it has always devoted to apart of the researches related to potato. Potatoes yield against cereal yield (grain dry weight per unit area) are expressed wet weight per unit area [2]. Potato yield is very high in per unit area and it has been in the second place after maize from cultivation level extension point of view and it is the second simple nutritional source after egg [3]. Potato is the fifth agricultural product in the world after wheat, rice, maize and barely. The cultivated area of this plant in the world reached to about 2 million hectares and its production reached to 324.49 million tons [4]. Potato cultivated area in Iran was about 189670 hectares in 2005 and its production was 4830000 tons with a yield equal to 25763kg h^{-1} [5]. It must be mentioned that more than 100 countries out of the total number stand in tropical and semitropical areas. However the most production is focused in temperate zones of industrial countries. With due attention to climate variety in Iran, there is a lot of potential to plant this crop. More than 82% of the produced crop is presented to the markets in August, September, October and November which is produced in cold and temperate areas and the rest of it is produced in tropical and semitropical zones which are distributed at the end of winter and the beginning of spring. Since tropical areas like Jiroft have the capability to be cultivated out of the season, like September or October, harvesting them in winter can reduce its shortage [6]. Potato cultivation in the cold areas of the Iran such as Hamedan, Ardabil and etc with the specific traits of the mentioned areas has been a stable cultivation for the farmers, while in the southern areas of the country in which they plant this crop in August, September and October to continue its production, there are specific conditions which oppose the conditions of cold areas. For example in cold areas, after cultivation the days are gradually warmer and longer but in tropical areas after cultivation the days become hot and difficult conditions appear because the days get colder and shorter little by little. Autumn cultivation of potato is done in January, February and March in order to fill market loss. Also less storage costs and fresh crop are the factors that can be gotten in autumn cultivation. Annual cultivation of 165000 hectares of potato in Iran and reaching to nutritional health and avoiding crop price vacillation necessitates that in all seasons and in all cultivable areas, a proper seed of compatible species of the same area is available [6].

***Correspondence Author:** Mostafa Ahmadizadeh, Young Researchers Club, Jiroft Branch, Islamic Azad University, Jiroft, Iran. Cell Phone: +989194457655 Email address: ahmadizadeh.mostafa@yahoo.com

Alavi-Shahri and Zahedi-Aval [7] and Alavi-Shahri [8] advised Vital and Marphola species in 1995 and then Arinda species in 2008 with an average yield of 386 $tonh^{-1}$ as a precocious species and he suggested Picasso with an average amount of 40 tons as a semi-late species to be cultivated in Khorasan (the east of Iran). Genetic variability studies are important in the selection of parents for hybridization [9] because crop improvement depends upon the magnitude of genetic variability in the base population [10]. Once genetic variability has been ascertained in a crop, improvement is possible through the use of appropriate selection method. Planned plant introduction therefore becomes inevitable whenever the genetic base of a germplasm is narrow for important desirable traits. However, for the effective utilization of the introductions, germplasm evaluation is an essential and preliminary step [11]. About natural science, the relationship among some variables must be considered. The general goal of multivariable analysis is considering several variables simultaneously that are related to each other and all variables have the same importance degree [12].

Regression analysis is a method that is used to estimate the value of quantitative variables regarding its relation with one or some other quantitative variables. This relation is such a relation that it is possible to predict other changes using one variable. Stage regression method is used to determine the role of yield components in increasing the yield and increasing selection efficiency by means of few traits as the effective indicators to obtain breeding aims [13]. With the aid of stepwise regression analysis, we could omit ineffective or low-effective traits on yield in the regression model and we could just evaluate traits which had justified yield alterations significantly. We could also analyze genetic diversity on the basis of morphological and biochemical data by multivariable statistical methods with considering several measurements, simultaneously [14]. Shamsi et al. [15] Expressed that stepwise regression analysis in wheat shows that the most important yield component was number of grains per spike followed by number of spikes per unit area, then, by 1000 grain weight and path analysis showed that, in overall, given direct and indirect effects of yield components on grain yields, number of grain per spike had the largest effect on grain yield.

Path analysis showed direct and indirect effects of cause variables on effect variables. In this method, correlation coefficient between two traits is separated into the components which measure the direct and indirect effects [13-16]. Multivariable analysis has a wide usage in the studies related to potato [17-18-19-20-21-22]. Fahem [23] declared that in Mediterranean areas, potato yield is more in spring cultivation compared to autumn cultivation. In qualitative and qualitative studies in order to find the proper potato cultivar to be cultivated in autumn in Jiroft, Khozestan and Iranshahr, Sante cultivar has been identified as the best cultivar in two years time in all studied areas. This cultivar has shown its superiority in cold areas experiments (spring cultivation) and winter cultivation compared to other cultivars [24]. Ifenkwe and Allen [25] did some experiments during two years on two cultivars of Maris and Desire, they found out that there are some differences among the cultivars from the number of tubers formed in each bush point of view. Gueler and Kolsarice [26] studied the effect of height from the sea (altitude) on potato cultivars yield and qualitative traits. They stated that there is a significant difference among the cultivars so that Marphona and Osiyana cultivars had the most efficiency respectively in low and high areas.

With the attention to the limited potato cultivated areas in the country and also more need for nutrients, one of the possible ways to meet this need is to introduce the cultivars which have high yield and this study has been performed to obtain this goal.

MATERIALS AND METHODS

The experiment was carried out in 2008 in the field of agricultural research centre of Jiroft which has warm and almost dry climate (Tables 1 & 2). Soil texture of the experiment place was sandy - loamy with an EC equal to about 2.7 ds/meter and its PH was equal to 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 3. 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.

Table1. Monthly rain and relative humidity amount during potato growth season in Jiroft in 2008 (Jiroft weather forecast statistics).

month	Jul-Oct	Oct-Nov	Nov-Dec	Dec-Jan	Jan-Feb	Feb-Mar
rain (mm)	0	0	12.6	1.7	14.7	0
Relative humidity (%)	36	41	59	56	55	40

Table 2. Monthly maximum, minimum and mean temperature during potato growth season in Jiroft in 2008 (Jiroft weather forecast statistics).

month	Jul-Oct	Oct-Nov	Nov-Dec	Dec-Jan	Jan-Feb	Feb-Mar
maximum temperature (0^C)	4.40	35.4	27.4	26/8	25.6	34
minimum temperature (0^C)	16	4	0/8	0	3/2	5
mean temperature(0^C)	28.7	20.8	14.5	13.5	15	21

The experiment was done in the form of random complete blocks design with three repetitions. In each experiment 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 sulfate 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 20cm. 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 5 bushes. It must be mentioned that drying the organs was done by means of oven and in 75^0 c for 72 hours. To do the statistical analysis of the resulted data, MSTAT_C, SPSS and Path Analysis software's were used.

Table 3. Soil features of experiment place in 2008.

total nitrogen (%)	absorbable (ppm) phosphorus	absorbable (ppm) potasium	Soil texture	EC (ds/m)	pH	depth(cm)
0.004	8.5	210	sandy - loamy	2.7	7.6	30-0

RESULTS AND DISCUSSION

The results of analysis of variance the studied traits, according to random complete blocks have been shown in table 4. The studied species had a significant difference from bush height, the number of stems, stem diagonal, stolon length, dry matter percent, harvest index and yield points of views in possibility level of 1%. They had a significant difference from the tuber weight in 5% possibility level. It is an indicator of genetic variety existence for these traits among the cultivars. There was no significant difference from the number of tuber in each bush and biologic yield points of views among the species. Coefficient of variation was vacillating between 6.11% to 34.86%. Among the studied traits, stolon length and the number of tuber in each bush had the most coefficient of variation (34.86% and 28.86% respectively) and harvest index and dry matter percent had the least coefficient of variation (6.11% and 8.29% respectively). Coefficient of variation is a standard factor and shows that the scale of traits value can be repeated. The accepted scale of coefficient of variation is different dependant on experiment control degree, the studied traits inheritance scale and other factors.

Table 4. Variance analysis of evaluated traits in the studied potato cultivars.

S.O.V	D.F.	Mean Square									
		Height	No. Stems	Stem Diagonal	Stolon Length	Biological Yield	Dry Matter Percent	Harvest Index	Tuber Weight	No. Tuber	Yield
Replication	2	80.59^{ns}	0.077^{ns}	1.01^{ns}	20.1^{ns}	1.47^{ns}	0.26^{ns}	32.5*	473.6^{ns}	2.4^{ns}	1.8^{ns}
Genotype	21	299.27**	0.843**	6.05**	18.9**	1.95^{ns}	6.91**	277.1**	549.6*	2.1^{ns}	90.5**
Error	42	109.15	0.224	2.126	6.375	2.549	1.081	8.22	249.6	4.28	19.3
CV	%	21.5	23.75	14.81	34.86	19.51	8.29	6.11	19.36	4.28	14.4

**, * and ns, significant at 1%, 5% level of probability and non-significant, respectively.

Mean comparisons

The obtained results of the mean comparisons have been inserted in table 5 by means of Duncan's multiple range tests in the possibility level of 5%. Vergo had the most height. Raja, Odsa, Atlas, Auola and Dayta had the least height and they did not have a significant difference with some species. Vergo and Maradona had the most no. of stems compared to the other studied cultivars. Sante, Dayta, Casmos, and Licaria had the most stem diagonal. Diamond had the most stolon length. This cultivar did not have a significant difference with Condor, Sante, Atlas, Mlina, Arcola, Moren, Spanta, Agria, Auax and Auola from stolon length point of view.The amount of dry matter percent in potato cultivars is one of the important traits after yield. Spanta had the most dry matter percent. No significant difference was observed among these cultivars with Moren, Sante, Vergo, Diamond, Satina, Condor, Auola, Auax and Agria dry matter percent amount point of view. Dayta, Mlina, Atlas, Almera, Kofi jiboti, Raja, Odsa, Casmos and Licaria had the least dry matter percent. According to Darabi [27] evaluation, Sante produced the most and Picasso produced the least dry matter percent. Ifenkwe and Allen [25] have reported a difference existence of dry matter percent in potato cultivars. Parvizi [28] reported that among precocious, Frsco and Arinda had the most and Binla cultivars had the least dry matter percent. In this experiment, Auax and Sante cultivars were average from dry matter percent point of view. Among late maturing cultivars, Corase and Diamond had the most dry matter percent which showed a significant difference in the possibility level of 5% with all late cultivars. Sante and Vergo had the most and Moren, Casmos, and Atlas had the least harvest index amount.However some researchers know the number of tuber more effective than its weight [29-30], it must be considered that the number of tuber also affects tuber yield by means of weight, and it means so. However the number of glands has a great effect on the yield, this effect is exerted by means of tuber weight. Sante had the most tuber weight. These cultivars had not a significant difference with Diamond and Licaria from average weight of the tuber point of view. Shekari [31] stated that the most average weight of tuber belonged to the real seed of Kara cultivar. After that the real seed of Picasso, Saina, Caiser, and Roster had a high average weight of tuber and their difference with the real seed of Kara was not significant and the least average weight of tuber was produced by the real seed of Dlicat.

Table 5. Mean values of studied traits, measured from 22 potato cultivars in fall cultivation of Jiroft area

No	Cultivar	Height	No. of Stems	Stem Diagonal	Stolon Length	Dry matter (%)	Harvest Index	Tuber Weight	Yield
1	Condor	46.1 b-e	1.86 c	9 b-d	6.73 a-f	13.4 a-e	50.13 d	88.5 b-d	33.6 b-d
2	Sante	42.9 c-e	1.46 c	13.33 a	9.16 a-e	14.6 a-c	69.13 a	120.7 a	44.11 a
3	Maradona	55.7 a-e	3.06 ab	9 b-d	6.26 c-f	12.6 c-g	51.17 cd	85.2 b-d	32.8 b-e
4	Atlas	37.37 e	1.60 c	10.67 bc	7.96 a-e	10.53 h	38.1 eg	76.4 b-d	24.7 e-g
5	Kofi jiboti	45.4 b-e	2.26 bc	8.66 cd	5.8 d-f	11.1 gh	42.17 e	63.97 cd	27.6 d-g
6	Mlina	51.3 a-e	1.73 c	9.66 b-d	8.6 a-e	10.37 h	39.9 ef	59.9 d	27.0 d-g
7	Casmos	40.1 d-e	1.53 c	11.67 ab	4.8 ef	11.5 e-h	36.7 fg	74.7 b-d	26.7 d-g
8	Arcola	42.4 c-e	2.06 c	10 b-d	10.9 a-c	12.9 b-g	43.23 e	66.47 cd	25.2 d-g
9	Odsa	36.93 e	1.40 c	10.67 bc	5.3 ef	11.3 f-h	42.9 e	86.0 b-d	31.45 c-f
10	Picasso	48.6 a-e	1.93 c	10.3 b-d	4.8 ef	11.8 e-h	39.93 f	72.1 b-d	23.67 fg
11	Vergo	68.37 a	3.53 a	7.66 d	2.83 f	14.1 a-d	68.97 a	86.0 b-d	40.17 ab
12	Moren	59.6 a-d	1.73 c	10.67 bc	9.3 a-e	14.63 ab	33.7 g	72.6 b-d	20.78 g
13	Raja	36.33 e	2.33 bc	8.33 cd	4.76 ef	11.2 gh	39.63 ef	71.8 b-d	28.3 d-g
14	Spanta	42.2 c-e	1.93 c	9 b-d	11.23 ab	15.17 a	56.97 b	87.6 b-d	33.5 b-d
15	Agria	52.4 a-e	2.33 bc	7.66 d	8.5 a-e	13.2 a-f	53.3 b-d	84.3 b-d	31.5 c-f
16	Auax	65.6 a-b	2.26 bc	8.33 cd	8.6 a-e	13.27 a-f	50.8 cd	72.4 b-d	28.5 d-g
17	Dayta	39 e	1.40 c	11.67 ab	4.53 ef	10.37 h	40.03 ef	78.1 b-d	27.6 d-g
18	Satina	44.5 c-e	1.80 c	10 b-d	6.4 b-f	13.4 a-e	56.0 bc	91.7 b-d	37.7 a-c
19	Auola	37.47 e	1.86 c	9.66 b-d	10.6 a-d	13.3 a-e	41.27 ef	76.1 b-d	27.0 d-g
20	Diamond	61.8 a-e	2.26 bc	9.66 b-d	11.53 a	14.07 a-d	51.7 cd	95.3 a-c	32.28 b-f
21	Almera	52.3 a-e	2.06 c	9.33 b-d	5.3 ef	10.53 h	43.43 e	83.7 b-d	32.3 b-f
22	Licaria	62.2 a-c	1.40 c	11.67 ab	5.4 ef	12.1 d-h	42.7 e	101.8 ab	32.7 b-e

Values with the same superscript letters are non significantly different at P < 0.05.

Cultivars yield was variable from 20.78 to 44.11 tons. Sante, Vergo and Satina had the most yield. The yield of these cultivars was more than 37 ton h^{-1} and they can be selected for the primary experiments of yield. Darabi [27] stated that Sante produces the maximum total yield. Total yield of the mentioned cultivar had an increase compared to Arinda and Picasso yield. This increase was respectively 5.8% and 11.5%. It was significant compared to Picasso in 1% of possibility level. Darabi [12] stated that in autumn cultivation Sante produced the maximum total yield and it was marketable. It was superior to other cultivar in the level of 1%.

Analysing the tuber segments yield showed that one of the important factors of Sante yield increase has been high average weight of tuber in this cultivar so that the mentioned cultivar was superior to the others from this trait point of view. It must be mentioned that this cultivar was in the superior group from some traits points of views such as stem diagonal, dry matter percent and harvest index. There is a possibility that Vergo superiority from yield point of view was more related to the superiority of the mentioned cultivar from height, the number of stems, dry matter percent and harvest index and it must be stated that this cultivar did not have a high average weight of tuber (Table 5). With due attention to the high yield of Sante and Vergo cultivar and also from dry matter percent point of view, these cultivar were categorized in the superior group. The mentioned cultivars were suitable to be used in preparing industry of mashed potatoes, potato peel and chips.

Multiple regression analysis and path analysis

To select the traits which have more important role in yield justification, step by step regression was used. The number of tuber, tuber weight and dry matter percent in the final regression model remained and they were accounted as the major and effective factors on yield segments (Table 6). The number of R^2 model ($R^2 = 0.907$) was an indicator of stating more than 90% total variations yield by means of the number of tuber in a bush, tuber weight and dry matter percent. Multiple regression analysis is a good tool to study the individual contribution of many traits (independent traits) to the performance of a trait (dependent trait). This was demonstrated by Stathers et al. [32] who identified marketable and unmarketable root weight and total number of roots as good yield components that could be used to improve the genotypes they evaluated. Therefore, the objectives of this work were to determine the extent of agro-morphological variability existing among potato genotypes, to determine the relationships existing between yield and other traits so as to identify few traits that could serve as good yield components using multivariate tools to improve yield, and the heritability of the traits for the effective utilization of the genotypes for breeding purposes. Although correlation coefficient was important to determine, traits that directly affect grain yield could not determine indirect effects of these traits on yield. Yield traits that occurred at a different growing stage could affect each other and were explicitly studied using path coefficient analysis [33]. And the results of these studies were used in studies related to the yield characteristics of methods for causality effects on yield traits and interface between the traits. With the help of this method we could analysis the correlation between yield and its components and also we could identify the direct and indirect effects of these traits [34-35-36-37].

Table 6. Stepwise regression on the yield (dependent variables) and other traits (independent variables).

traits	Regression coefficient	t
No. Tuber	0.405	11.431**
Tuber Weight	3.716	7.071**
Dry Matter Percent	-0.801	-2.46*
Width from base point	-19.23	-4.176
**** and *, significant at 1%, 5% level of probability, respectively.**		907 0. R^2=

Table 7. Path analysis of yield and effective traits on yield.

traits	Direct effect	Indirect effect			correlation coefficient with yield
		Tuber Weight	No. Tuber	Dry Matter Percent	
Tuber Weight	0.998	—	-0.089	-0.105	0.804
No. Tuber	0.567	-0.157	—	-0.063	0.347
Dry Matter Percent	-0.221	0.475	0.162	—	0.416
Remained effect	0.305				

In path analysis, yield was considered as a dependent variable and the tuber weight, number of tuber and dry matter percent were considered as effective variables. The obtained results of path analysis of yield have been shown in table 7. Tuber weight had the most direct effect on yield. As it was already mentioned, yield had a positive and significant correlation with the tuber weight and this result corresponds to the finding of this analysis. Vishwakarma et al. [38] reported that multiple regression analysis serves an effective solution for improvement of yield through some adequate models. Rabiei et al. [22] did step by step regression for all traits and found out that peduncle length, the number of peduncle and small leaf width had an important and determinative role on performance in stress condition. Also in stress condition, some traits such as stem length, number of stem and small leaf length were entered into regression model.

REFERENCES

1. Khajehpour, M.R., 2004. Industrial plants. Publication of Jehad University of industrial unit of Isfahan, Iran.

2. Imani, A. and M. Rasooli, 2006. Effects of seed tuber size on growth and yield of potato cultivar Moron. Journal of Agricultural Sciences Islamic Azad University. 12(1): 165-172.

3. Wiersema, S.G., 1985. Physiological development of potato seed tubers. Technical Information Bulletin 20 . International Potato Center. Lima, Peru, p. 16.

4. FAO. 2007. WWW.FAO.ORG.

5. Roodbar-Shojaei, T., N.A. Sepahvand, M. Omidi, A. Mohammadi and H.R. Abdi, 2008. Response of four commercial potato cultivars to different combination of plant growth regulators in meristem culture and production of virus free plantlets. Irania Journal of Crop Sciences. 9 (4): 332-344.

6. Anonymous, 2002. Brief consideration on agriculture of Jiroft and Kahnoj state, Jehad Agriculure Organization of Jiroft and Kahnoj.

7. Alavi-Shahri, H. and M. Zahedi-Aval, 1995. Investigate and compare the performance of potato cultivars. Agricultural Research Center, Khorasan, Iran.

8. Alavi-Shahri, H., 1999. Research report of potato research projects. Agricultural Research Center, Khorasan, Iran.

9. Chaudhary, V.S. and B.B. Singh, 1982. Heterosis and genetic variability in relation to genetic diversity in soybean. Indian J. Genet., 42: 324-328.

10. Adebisi, M.A., O.J. Ariyo and O.B. Kehinde, 2001. Variation and correlation studies in quantitative characteristics in soybean. Proceedings of the 35th Annual Conference of the Agricultural Society of Nigeria held at the University of Agriculture, Abeokuta, Sept. 16-20, pp. 121-125.

11. Afuape, S.O., P.I. Okocha and D. Njoku, 2011. Multivariate assessment of the agromorphological variability and yield components among sweetpotato (*Ipomoea batatas* (L.) Lam) landraces. African Journal of Plant Science, 5(2): 123-132.

12. Darabi, A., 2007b. Effect of Autumn and Winter planting and temperature stress on total yield, marketable yield and yield components of some potato cultivars in Behbahan. Seed and Plant Improvement Journal, 23(3): 386-373.

13. Farshadfar, E., 2004. Multivariate principles and procedures of statistics. Taghbostan publication.

14. Mollasadeghi, V., A.A. Imani, R. Shahryari, M. Khayatnezhad, 2011. Classifying bread wheat genotypes by multivariable statistical analysis to achieve high yield under after anthesis drought. Middle-East Journal of Scientific Research, 7(2): 217-220.

15. Shamsi, K., M. petrosyan, G. Noor-mohammadi, A. Haghparast, S. Kobraee and B. Rasekhi, 2011. Differential agronomic responses of bread wheat cultivars to drought stress in the west of Iran. African Journal of Biotechnology, 10(14): 2708-2715.

16. Zakizadeh, M., M. Esmaeilzadeh and D. Kahrizi, 2010. Study on genetic variation and relationship between plant characteristics and grain yield in long spike bread wheat (*Triticum aestivum* L.) genotypes-using multivariate analysis. Iranian Journal of Crop Sciences 12 (2):18-30.

17. Alvarez, M.D. and W. Canet, 2000. Principal component analysis to study the effect of temperature fluctuations during storage of frozen potato. Eur. Food Res. and Technol. 211(6): 415-421.

18. Bartos, A., A. Fekete and B. Sarvari, 1985. Study of some factors affecting potato yield using factor analysis. Novenytermeles, 34(6): 467-474.

19. Cardi, T., 1998. Multivariate analysis of variation among Solanum commersonii (+) S. tuberosum somatic hybrids with different ploidy levels. Euphytica, 99: 35-41.

20. Cardi, T., M. Mazzei and L. Frusciante, 2002. Field variation of tetraploid progeny derived by selfing a Solanum commersonii (+) S. tuberosum somatic hybrid: A multivariate analysis. Euphytica, 124(1): 111-119.

21. Segnini, S., P. Dejmek and R. Oste, 1999. Relationship between instrumental and sensory analysis of texture and color of potato chips. J. Texture Stud, 30(6): 677-690.

22. Rabiei, K., M. KHodambashi and A. Rezaei, 2009. Detection of traits affecting potato yield under drought stress and non-stress conditions by multivariate analyses. Journal of Science and Technology of Agriculture and Natural Resources, Water and Soil Science, 12(46): 131-140.

23. Fahem, M., 1993. Effect of seed tuber treatment and variation in environmental conditions on the growth of potato. Potato Research, 35: 81-87.

24. Mirzaei, E. and H. Hassan-Abadi, 2002. Evaluating the depth of planting on yield and agricultural features of 6 potato cultivars on continuous planning in Jiroft state. The summary of articles of seventh congress of agricultural science and reforming plants of Karaj, Iran. September 2-4, p 397.

25. Ifenkwe, O.P. and E.G. Allen, 1978. Effect of row width and planting density on growth and yield of two main crop potato varieties, number of tubers, total and graded yields and their relationships with above ground stem densities. Journal of Agricultural Science, 91: 279-289.

26. Gueler, A. and O. Kolsarice, 1995. Effect of altitudes on morphology, Physiology, yield and quality charactors of some potato cultivars grown in different location. Turkish Journal of Agriculture and Forestry, 19(5): 385-389.

27. Darabi, A., 2007a. Effects of planting density and harvesting data on total yield and yield components of some potato cultivars in Behbahan. Seed and Plant Improvement Journal, 23(2): 233-244.

28. Parvizi, Kh., 2008. Evaluation of quantitative and qualitative traits of late and early ripening advanced potato cultivars. Pajouhesh & Sazandegi, 79: 80-90.

29. Birhman, R.K. and G.S. Kang, 1993. Analysis of variation and interrelation ship in potato germplasm. Euphytica, 68: 17-26.

30. Logh, R.C., J.M. Varrieur and R.E. Velleax, 2001. Selection in herent in monoploid derivation mechanisms for potato. Theor. Appl. Genet. ,103(1): 178-184.

31. Shekari, B., 2007. Evaluation drought tolerance in real tuber of 8 potato cultivars in germination and mature stage. Master of Science thesis, Plant breeding, Islamic Azad University Ardabil Branch, Iran.

32. Stathers, T.E., D. Rees, S. Kabi, L. Mbilingyi, N. Smit, H. Joizya, S. Jeremiah, A. Nyango and D. Jeffries, 2003. Sweetpotato infestation by Cylas spp. In East Africa: I. Cultivar differences in field manifestation and the role of plant factors. Int. J. Pest Manage, 49:131-140.

33. Asadi, A.A. and B. Naserian-Khiabani, 2007. Evaluation of salt tolerance based on morphological and yield traits in wheat cultivars and mutants. Int J. Agri Biol., 9(5): 693–700.

34. Manifesto, M.M., A.R. Schlatter, H.E. Hopp, E.Y. Suarez and J. Dubcovsky, 2001. Quantitative evaluation of genetic diversity in wheat germplasm using molecular markers. Crop Breeding Genetics and Cytol, 41: 682-690.

35. Kirigwi, F.M., M. Van-Ginkel, R.G. Trethowan, R.G. Sears, S. Rajaram and G.M. Paulsen, 2004. Evaluation of selection strategies for wheat adaptation across water regimes. Euphytica, 135: 361-371.

36. Khayatnezhad, M., M. Zaefizadeh, R. Gholamin and S. jamaati-e- Somarin, 2010. Study of genetic diversity and path analysis for yield in durum wheat genotypes under water and dry conditions. World Applied Sciences Journal, 9(6): 655-665.

37. Ahmadizadeh, M., H. Shahbazi, M. Valizadeh and M. Zaefizadeh, 2011. Genetic diversity of durum wheat landraces using multivariate analysis under normal irrigation and drought stress conditions. African Journal of Agricultural Research, 6(10): 2294-2302.

38. Vishwakarma, G., H.L. Sharma and P. Kumar, 2002. Multiple regression analysis for yield improvement in wheat. 9th Int Conf Forum for Interdisciplinary Mathematics on Statistics Combinatorics and Related Areas. December 21-23.