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Analysis of Genetical Diversity of Some of the Tetraploides Potato Cultivars Grown in Iran

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ABSTRACT

The genetical diversity of potato, *Solanum tuberosum* was assessed using morphological traits. To verify, how this diversity is distributed among the main potato varieties grown in Iran. A total of eleven potato varieties, Ramose, Sante, Shepody, Marfona, Maradona, Milova, Santana, Boren, Cosima, Granola and Agria, were evaluated *under vivo* and *situ* experimental conditions in Isfahan, conditions, Iran. Seven phenological, floral and morphological vegetative aerial descriptors, Growth Rate = CGR, Net Assimilation Rate = NAR, Leaf Area Duration = LAD, Leaf Area Ratio = LAR and specific Leaf Area = SLA were recorded. The descriptors were evaluated by SAS Software and their means comparison by DMRT test. Certain defined groups were observed, indicating that the diversity of the cultivars are structured with a considerable morphological variation in between the varieties with a very high significant growth indices.

Keywords: Potato; Genetic; Phenology; Morphology; Varieties

1. Introduction

Potato (*Solanum tuberosum*) is one of the main and strategic products and stands in fourth position after wheat, rice and corn. It has also a special role in feeding people of under developed countries. Thus, for making secure feeding, increasing efficiency of this strategic product seems necessary. Potato is from the family of Solanaceae with 26 genus and 2800 species. Most of its species are from tropical and southern parts of America. Potato is belonged to big and varied *Solanum* genus; with 2000 species. Cultivated potatoes are belonged to *S. tuberosum* with 180 varieties, which produce tubers [1].

Most commercial varieties of *S. tuberosum* are tetraploid. There are two subspecies: *tubersum* and *andigena* whereas, *tubersum* is with world distribution expended. Root system of *S. tuberosum* is relatively weak and it is expanded easily in light soil with sandy clay texture. Methods of propagation of potato are asexual with tubers division and, sexual with true potato seed culture [1].

In propagation with tuber, the adventurous roots are formed from the base of divided tubers primarily, and then root and stem are initiated from top of underground nodes of tubers. In case of true potato seed sowing, plant will have a tiny tap root and stolons with lateral branches, and some replicates roots initiated from stolen. The stem in *S. tuberosum* is green, herbaceous, and already thick. It's thickness is already 2 - 2.25 Cm. Stem also has some trichomes. Plants which are formed from true seed has main stem with lateral branches but, plants from tuber seed has many main and lateral stems [2].

The leaves are compound pinnate. That is; a leaflet can be seen on the top of the main petiole. The main petiole is herbaceous and has light green color with 7 - 9 leaflets. The leaflets are ovate, irregular, entire margin and little lobed with dark green color. The veins of leaflets are clear with light green color. The leaflets have trichomes on both the sides with very short petiole [3].

The flowers of *S. tuberosum* are two types; actinomorph and zygomorph. There are five sepals, soft or corky and with green, red, or purple color and different length. The petioles are also different in length size. The corolla are star shape, rectangular, or circular. In case of color, most of them are white but, they are clear in red, purple, blue, yellow, and pink type [1].

The stamens are 5 and most of them have long and column anther with yellow or orange color. They show related groups which are individual or divergent. The pollen grains are expended from the top of anther. The fruit is inform of burry epigenous with two carpels and 5 - 8 mm thickness. Tiny seeds are spread in berry fruit. Modified stem, tuber is the main reserving organ in potato [3].

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The size of tuber is depending on the kind of variety, soil properties, and also climatic conditions. The potato is commonly circular—elliptical and or oval. The skin of tuber is soft, hard or nettled. The color of the tuber skin is white, and, purple and also pink or yellow. The tuber contains; 75% or 80% water, 12% starch, 1.5% and or 2% protein, 2% or 3% fiber, salts and also vitamin C [4]. Some lateral stems are horizontally grown on buds of underground stems. The lengths of them are varied and also are the main factor to recognize varieties. *S. tuberosum* can be produced in different ecological areas, in tropical, subtropical, desert, mountainous, and temperate areas. *S. tuberosum* is used for feeding herd and human. It contains vitamin C, potassium, calcium, family of vitamin B and a little sodium.

There is no any coherent study on this subject. So, because of the importance of the subject, any types of such studies is unavoidable. This study was carried out on eleven varieties of potato which are under cultivation in both greenhouse and field conditions, for verification of phenological and morphological diversity differentiation.

2. Material and Method

For the genetic analaysis phenological and morphological analysis and also testing varieties in field and green house conditions, these experiments were done based on classic method in Isfahan. The treatments were composed of eleven commercial varieties of *S. tuberosum* growing mainly in Iran; Ramose, Sante, Shepody, Marfona, Maradona, Milova, Santana, Granola, Boren, Cosima, Agria (**Table 1**). Experimental treatments were based a randomized block design using 4 replicates in the field and 5 replicates in green house.

For preparation of the soil, 20 t/ha farm yard manures were added into the field soil on January 2010 before plowing. Then, 300 kg/ha potassium sulfate, 200 kg/ha Super triple phosphate and 350 kg/ha ammonium sulfate in the form of chemical fertilizers were added proportionately into the field soil. At the end, the field was divided into 4 replications. There was one raw with 3 meters length and 75 cm distance. Also, for preparing pots soil, the ratio of 1:1:1 of sand, manure and clay mixed together for the glass house. The pots were sterilized and sufficient NPK was added accordingly [5].

Each variety was sown in a raw. The tubers in the density of 5.33 plants (clons) per square meter were sown with the distance of 20 Cm plant to plant. To avoid soil diseases, tubers were disinfected by fungicide for 3 minutes in a suspension and each variety was sown in 45 pots. The depth of sowing tubers was 10 cm. In green house, also tubers were disinfected by fungicide for 3 minutes. Watering in the field and green house was based on the temperature and moisture of the soil. For avoiding and controlling early blight disease the fungicides, RTS 2/1000 and Daconil 3/1000 were used. And, for mite pest, the pesticide Neuron 1/1000 and larvin 0.5/1000 were used. For aphid pest, Kenfidor 0.5/1000, and for *Bemisia*, Diazinon 1/1000 was used [6].

A month after sowing, 150 kg/ha Ammonium sulfate in each pot was used. Sampling for determination of understudied factors in the field and green house were done repeatedly, after every two weeks. Varieties; Ramose, Sante, Shepody, Marfona, Maradona in the field and green house were sampled 6 and 5 times respectively. Santana, Maradona, Milova, Boren varieties were sampled 7 times in the field and 6 times in the green house. Also, for Granola, Cosima, Agria the sampling was done 8 times in the field and 7 times in the green house. In

Table 1. The Characteristics of the varieties for analysis of genetical diversity of some of the tetraploides potato.

Characteristics	Agria	Ramose	Granola	Sante	Shepody	Marfona	Sanata	Maradona	Milova	Burren	Cosima
Maturity	ME - ML	Lo	Low	ME - ML	E	ME - ML	ME - ML	ML	Me	ME-ML	ME - ML
Dormancy	Lo	Me	V Lo	Me Lo - Lo	Me	Lo	Me Lo	Lo	Me	Me	Lo - V Lo
Foliage development	G	G	Low	Fa G	G	G	G to Fa G	G	Me	G	G
Colour of skin	Y	FaY - OpY	W - Y	Y	C	Y	Y	C	W - Y	W - Y	W - Y
Colour of flesh	Y	FaY - PY	Y	PY	C	PY	PY	Y	C - Y	FaY	Y
Shape of tubers	Lo - Ov	Lo - Ov	Ov - R	Ov - R- Ov	L	R - Ov	Lo - Ov	R - Ov	Ov	R Flat	R Ov - R
Shallowness of eyes	Sh	Sh	Sh - M	Ra Sh	Sh - Me	Ra Sh	VSh	Ra Sh	Ra Sh	Sh	Sh - Me
Size of tubers	L	L	Me - L	L	Lo	VL	L	L	L	L	L
Yield	VH	G - Me	Me - H	H	Me	VH	G - Me	VH	H	H	Me - H
Dry matter content	G	Fa firm - Fl	Me - H	Me - G	Me	V low - Low	G - H	H	Me	Me - H	Me - H
Suitable for	Ff	Ff	F, Ch, Ff	F Ch	F, Ff	F, Ch	F ,Ch, Ff	F	F ,Ff	F, Ff	F, Ff

C = Cream, Ch = Chips, E = Early, F = Fresh, Fa = Fairly, Fl = Floury, Ff = French fries, G = Good, H = High, I = Intermediate, L = Large, La = Late, Li = Light, Lo = Long, Me = Medium, ME = Mid Early, ML = Mid Late, Op = Opale, Ov = Oval, P = Pale, R = Round, Ra = Rather, Sh = Shallow, V = Very, W = White, Y = Yellow.

every step of field sampling, four plants (clone) from every varieties in each replicate were analyzed. Whereas, in green house sampling, 5 pots were analyzed accordingly [7].

The samples were transferred into the lab, and the total fresh and dry weights were measured by drying for 48 h, at 75˚C. For determining understudies factors, the following factors were measured for both the field and green house [2,8,9].

1) Crop growth rate (CGR)

$$\mathrm{CGR} = (\mathrm{W2} - \mathrm{W1})(\mathrm{T2} - \mathrm{T1}) \times \mathrm{GA}$$

CGR is calculated based on gr/m^2.

W1 and W2 are the total dry weight in the first and second sampling. T1 and T2 are the times of sampling and GA is the sampling level based on square meter.

2) Net assimilation rate (NAR)

$$\mathrm{NAR} = 1/\mathrm{LA} \times \mathrm{dw}/\mathrm{dt}$$

NAR is the speed of photosynthesis based on gr/m^2 of LA, LA is the leaf area and dw/dt is the changes of dry weight of plant × time.

3) Leaf area index (LAI)

$$\mathrm{LAI} = \mathrm{LA}/\mathrm{P}$$

LAI is the leaf area of one side, which occupies the land. LA is the leaf area and P is the surface of sampled land based on square meter.

4) Leaf area duration (LAD)

$$\mathrm{LAD} = (\mathrm{LA2} + \mathrm{LA1}) \times (\mathrm{T2} - \mathrm{T1})/2$$

LAD is the largeness and leaf area based on growing time of product.

LA1 and LA2 are leaf area of plant in the first and second sampling. T1 and T2 are times of first and second sampling.

5) Relative growth rate (RGR)

$$1/\mathrm{W} \times \mathrm{DW}/\mathrm{DT}$$

RGR is based on the changes of dry plant per day, W is the weight of dry plant, and DW/DT is the changes of dry weight of plant × time.

6) Leaf area ratio (LAR)

$$\mathrm{LAR} = \mathrm{LA}/\mathrm{W}$$

LAR is the relationship between photosynthesis tissue and the total weight of plant. LA is the leaf area and W is the total weight of plant.

7) Specific leaf area (SLA)

$$\mathrm{SLA} = \mathrm{LA}/\mathrm{LW}$$

SLA is the leaf area and LW is the weight of leaves. For determining the height of plants at the time of harvesting. In each replication five plants (clones) were chosen randomly and the height of each was measured separetely. Then, the average was calculated. Also the same was with green house for 5 pots at the time.

On harvesting time, based on maturity, the varieties Ramose, Santeh, Shepody, Marfona in green house and field took placed on 28th of May and 10th of June 2010. Also, varieties like; Maradona, Milova, Santana, Boren were harvested on 8th of June and 24th of June2010. Agria, Granola, Cosima were harvested on 24th of June and 9th of July 2010. In harvesting time, the average of stem height and the length of root varieties were calculated. Also, the average of fresh and dry of stem and the root weights were calculated accordingly [10].

The data were subjected to statistical analysis by SAS software. Their averages were compared by danken multiple text ranges (DMRT). Also, the comparison and differences for variations were shown graphically [2].

Harvested tubers were classified based on into 3 tubers sizes, mini, medium and big respectively. The yield average and the number of tubers in every plant (clone) were calculated separately [11].

3. Result and Discussion

The results of phenological and morphological analysis of the varieties in field and green house are summarized in the following tables and figures, which are presented and discussed with the results of the other reporter as fallows accordingly.

3.1. Leaf Area Index (LAI)

The total leaf area of a bush based on the occupied land surface (LAI) had a great effect on plant growth and the final yield of dried material (**Table 2**, **Figures 1** and **2**) (P = 0.01). The highest and lowest LAI in the field were related to varieties Cosima, Sante and the lowest one was related to Ramose. For varieties, Ramose, Sante, Shepody and Marfona, the highest of LAI was calculated before flowering period in the field and green house. But, for varieties, Santana, Maradona, Milova and Boren, the highest of LAI in field and green house was before flowering period. For varieties, Cosima, Granola, and Agria, was calculated at the end and at the beginning of the flowering periods. The highest LAI was observed in the field, because of the sufficient space for growing and also the large number of lateral stems. The average of LAI for understudied factors in field and green house were 3.23 and 1.37 for early maturing, 1.5 and 5.19 for mid maturing, and 6.12 and 1.9 for late maturing varieties respectively. All of the analysis showed positive coefficient among the highest LAI level of varieties (P = 0.01). These results agreed with the findings of Kawakami and Gremew, which reports that, the growth factors including stems and leaf area are having positive correlation with yield measures [2,9].

Table 2. The average factors of potato varieties in the field and greenhouse conditions.

Cultivars	RGR		NAR		CGR		SLA		LAR		LAD		LAI	
	F	G	F	G	F	G	F	G	F	G	F	G	F	G
Ramose	0.0671d	7.76d	6.97d	7.76e	16.93g	8.2f	17.03i	13.23b	105f	82.6b	16.23e	5.66g	3.25ef	1.3d
Sante	0.0676c	7.98d	6.44f	7.98d	16.16h	9.15e	18.04h	11.66c	125e	71.6d	15.27f	5.85f	3.07g	1.31d
Shepody	0.0681b	8.33bc	7.99a	8.33bc	16.9g	8.28f	22.36e	13b	129d	77.6c	15.32f	5.89e	3.19f	1.35cd
Marfona	0.0681b	6.96e	7.97a	6.96e	18.08e	9e	19.02g	11.76c	130d	87.4a	16.6e	5.78f	3.43e	1.4c
Santana	0.0676c	9.12a	6.76e	9.12a	22.8c	9.93cd	27a	13.25b	140c	70.6d	28.21c	8.54c	5.17d	1.45b
Maradona	0.0674d	8.33bc	6.77e	8.33bc	22.11d	11.07a	20.05f	11.78c	100g	62.2g	27.2d	8.16d	5.14d	1.5b
Milova	0.0673d	8.44b	7.06c	8.44b	23.45b	10.4b	17.32i	13.25b	141c	65f	27.27cd	8.14d	5.23d	1.48b
Boren	0.0687a	8.84a	7.43b	8.84a	24.26a	11.15a	25.53c	13.57b	167b	62g	27.27d	8.12d	5.2d	1.49b
Cosima	0.0640f	7.99d	5.58i	7.99d	17.12f	11.29a	25.52c	13.07b	131d	87a	39.39a	12.13a	6.23a	1.89a
Granola	0.0663e	8.48b	5.71h	8.48b	16.43gh	10.24bc	26.31b	14.86a	127e	82.6b	37.07b	12.13a	6c	1.89a
Agria	0.0674d	7.94d	6.08g	7.94d	17.85e	9.73d	24.64d	13.14b	170a	82.8b	39.28a	11.83b	6.13b	1.85a

Means followed by the same letter are not significantly different at the 0.01 level probability; F: Field, G: Greenhouse.

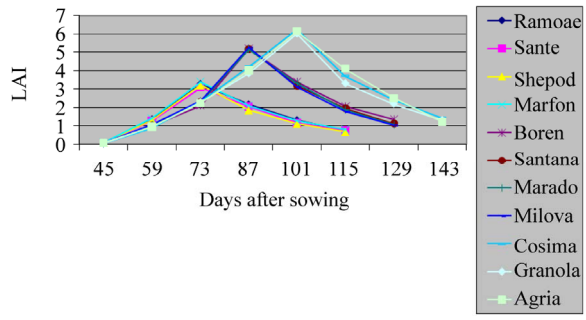

Figure 1. Shift of LAI in potato' varieties in field.

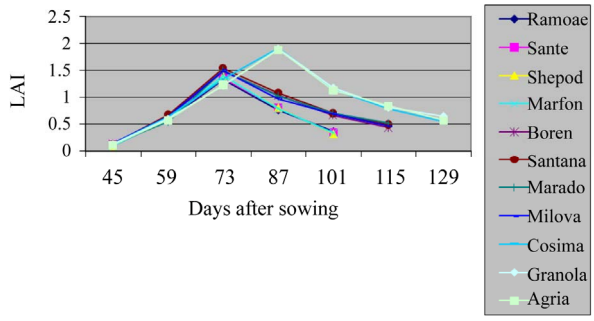

Figure 2. Shift of LAI in potato' varieties in greenhouse.

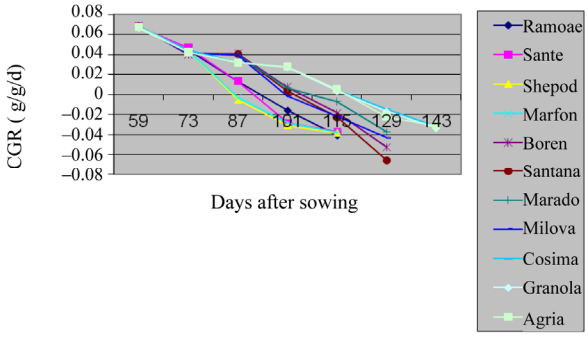

Figure 3. Shift of CGR in studied potato's varieties in field.

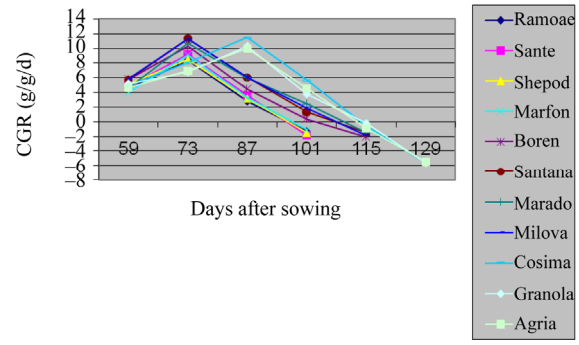

Figure 4. Shift of CGR in studied potato's varieties in greenhouse.

3.2. Crop Growth Rate (CGR)

There was a significant difference (in ratio of 1%) among potato varieties in the field and green house (**Table 2**, **Figures 3** and **4**) (P = 0.01). The maximum of CGR in the field was belonged to Boren and the minimum to Sante variety. And, in green house, the maximum level was of Cosima and the minimum to Ramose. According to the tables and figures, the CGR in the plant had a sigmoid trend. All the varieties in the field and green house had low trend at the early stages then, their trend were increased accordingly. Early maturing varieties, Ramose, Sante, Shepody, and Marfona reached their maximum CGR, before flowering in both the field and green house.

Mid-maturity varieties, Santana, Maradona, Milova, and Boren reached the maximum level of CGR at the beginning of flowering and in green house before flowering. For the late maturing varieties Cosima, Granola, Agria maximum level of CGR was at the end of flowering. At the Stages after this period, the CGR was slowed down, because of reduction of pure absorption and leaves falling [7,11,12]. The increase of structural tissues in comparison to active merystemic tissues, the age of leaves, the reduction of leaf area and pure absorption and shading of upper leaves over lower leaves were all factors effecting on CGR among *Solanum tuberosum* varieties in the field and green house [13].

3.3. Net Assimilation Rate (NAR)

The maximum level of NAR in the field was of to the beginning of the growth season, because of being small plant and the radiation of the sun over all leaves. But, over the time, the size of leafs area increased in Shepody, Marfona varieties and the minimum level was in Cosima (**Table 2**, **Figures 5** and **6**) (P = 0.01). Also, in green house the maximum of NAR was belonged to Santana and the minimum in Marfona. At the beginning of the growth season, the NAR was the highest, because of slow plant growth and the radiation of the sun over all the leaves. But, over the time, the size of leaves area were increased and, they made shadow over lower leaves and also, the aged leaves made lower photosynthesis process. At the end of growth the period, NAR becomes so low that, made the resulted factors negative. This was because of increasing temperature, leaf falling and the low level of photosynthesis. These results are in agreement with the analysis of the other workers [12].

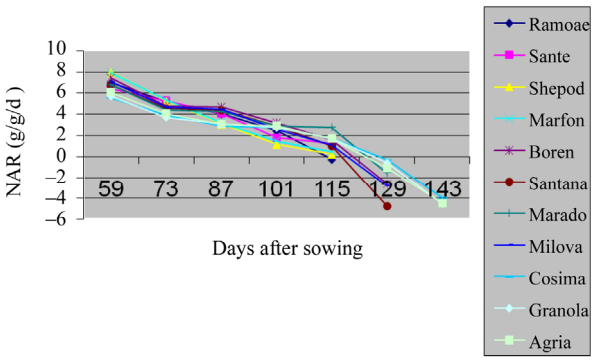

Figure 5. Shift of NAR potato varieties in the field.

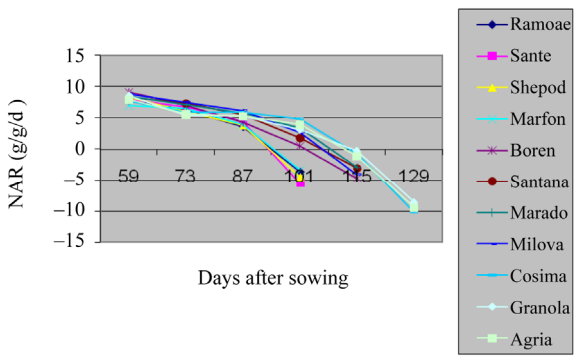

Figure 6. Shift of NAR in potato's varieties in greenhouse.

3.4. Leaf Area Ratio (LAR)

There was a significant difference among varieties in the field and green house (**Table 2**, **Figures 7** and **8**) (P = 0.01). The harvest LAR in field and green house was of Agria and Marfona whereas, the lowest was of Maradona and Boren. LAR is the largest of photosynthesis area in plant. There are certain reports indicating reduction of LAR in different *S. tuberosum* varieties showed this reality that, the growth of tuber consumed more photosynthesis materials of plant. This matter caused at the beginning of growth period. LAR had decreasing trend in all *S. tuberosum* varieties [13,14].

3.5. Specific Leaf Area (SLA)

The maximum level of SLA in the field and green house was of Santana and Granola respectively (**Table 2** and **Figures 9** and **10**) (P = 0.01). The lowest of SLA in the field and green house was of Ramose and Sante respectively. Actually, the total weight of any leaf was lower

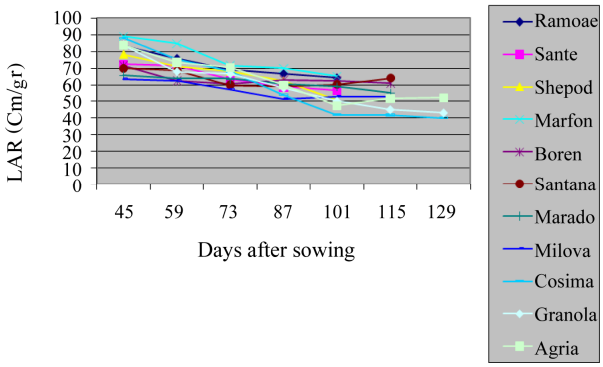

Figure 7. Shift of LAR in potato varieties in the field.

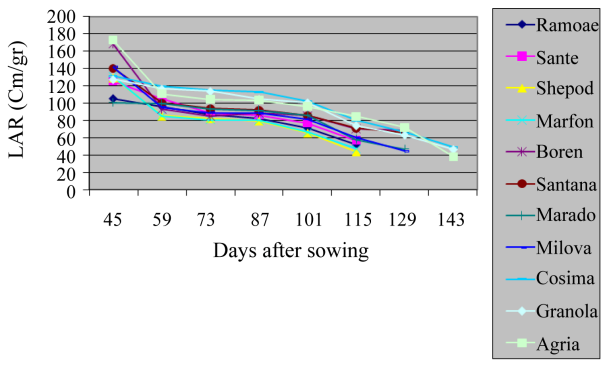

Figure 8. Shift of LAR in potato varieties in greenhouse.

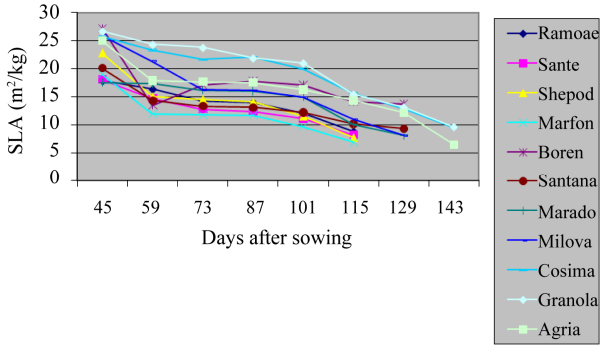

Figure 9. Shift of SLA in potato varieties in the field.

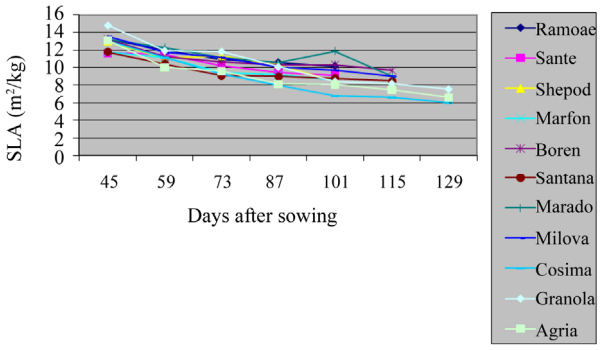

Figure 10. Shift of SLA in potato varieties in greenhouse.

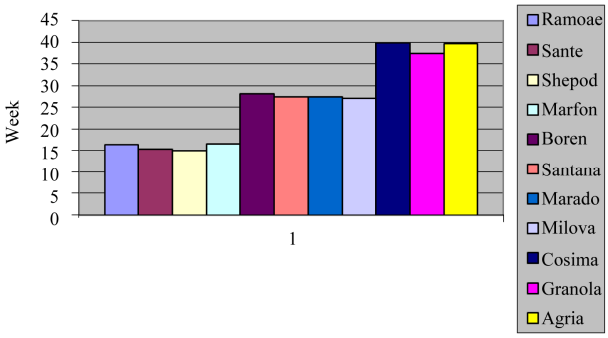

Figure 11. Shift of LAD in studied potato's varieties in field.

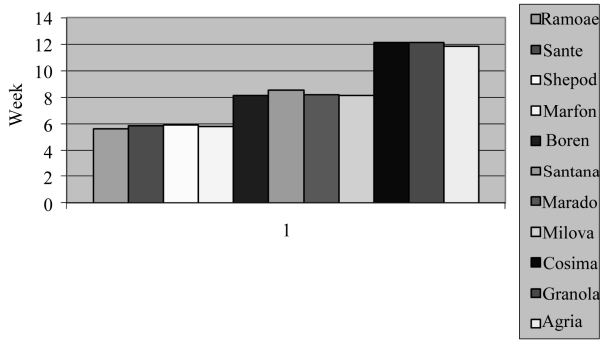

Figure 12. Shift of LAD in studied potato's varieties in greenhouse.

than the ratio of their specific leaf area at the beginning of the growth. But, during the growing period, the total weight of plant was increased, and it caused the reduction of SLA. The SLA of varieties in the field was significantly different from the varieties in green house (P = 0.01). As the result, the leaves of *S. tuberosum* varieties in green house were thicker than in the field, which agrees with other findings [13,14].

3.6. Leaf Area Duration (LAD)

The maximum level of LAD in the field and greenhouse was found in Cosima, Granola and, the lowest ones in Sante and Ramose respectively (**Table 2** and **Figures 11** and **12**) (P = 0.01). LAD of potato varieties in the field is more than green house which is in agreement with the other reporters [10,15,16].

3.7. The Effect of Varieties on the Number of Days from Sowing to Flowering Stage

The effect of varieties on the number of days was significant (P = 0.01) as shown in **Table 3**. Marfuna had the larger number of the days from sowing to germination, wheres Agria was reverse. Cosima had the larger number of days from sowing to tuberization and Ramose was reserve than that. Also, Cosima had the large number of days from calendar date to flowering whereas, Cosima was vice versa in both the field and green house. These differences among varieties were because of their genetic of late or early maturing and also their responses to the length of the days and the temperatures of the environment. There are reports indicating that, in the varieties, which had germination process lately, tuberization and flowering are happened early [6,17].

3.8. The Effect of Varieties on the Number and Length of Stems

A month after germination, the varieties had a significant effect on the number and the length of stems per plant (P = 0.01) (**Tables 3-5**). In the number of stems, Agria had the maximum density of stems and Sante with the lowest density. Agria had the longest and Ramose the shortest stem a month after germination. The rest of varieties had no any significant differences. The difference among varieties in the length of the main stem, was varying. That is because of their genetic differences that shows, the distance between nodes and the number of nodes in stem [18,19].

3.9. The Analysis of Yield Changes among Varieties in the Field

Among different varieties, in case of marketing performance, there was a significant difference probability

Table 3. Variance analysis of potato varieties factors in the field.

		Mean Square (MS)						
		The length of the longest (cm)		Number of stems in a bud		The number of days from calendar date to		
Source of variation (SV)	Degrees of freedom	Maturity	A month after germinat ion	Maturity	A month after germination	Flowering	Tuberization	Germination
Treatment	10	388.39**	215.17**	3.59**	2.61**	19.85**	26.04**	19.64**
Error	33	5.39	2.55	0.42	0.18	0.45	0.4	0.99
Total	43	-	-	-	-	-	-	-
CV%	-	2.48	2.05	13.14	13.97	0.99	0.99	4.2

**Significant at 0.01 level of probability.

Table 4. Variance analysis of potato varieties factors in the green house.

		Mean Square (MS)						
		The length of the longest (cm)		Number of stems in a bud		The number of days from calendar date to		
Source of variation (SV)	Degrees of freedom	Maturity	A month after germination	Maturity	Maturity	A month after germination	Maturity	Maturity
Treatment	10	137.92**	56.65**	4.15**	4.09**	26.01**	14.75**	13.37**
Error	44	4.09	2.29	0.48	0.54	0.61	0.59	0.63
Total	54	-	-	-	-	-	-	-
CV%	-	3.93	4.23	12.94	19.81	1.48	1.52	4.18

**Significant at 0.01 level of probability.

Table 5. The mean comparison of potato varieties factors in field and green house.

Cultivars	The length of the longest (cm)				Number of stems in a bud				The number of days from calendar date to					
	Maturity		A month after germination		Maturity		A month after germination		Flowering		Tuberization		Germination	
	F	G	F	G	F	G	F	G	F	G	F	G	F	G
Ramose	44c	87.5c	29.5c	4b	2.2b	4b	2.2b	2.25b	50c	64.5c	47c	60c	20a	25.5a
Sante	46.2c	89.25c	31.6c	3.8bc	2b	3.8b	2b	2b	50.6c	65.25c	48.2c	61.25c	20.6a	26.25a
Shepody	47c	90.25c	31c	4.25b	2.6b	4.25b	2.6b	2.25b	50.4c	64.7c	48c	61c	21.6a	27.25a
Marfona	48c	91.5c	30c	4.5b	2.6b	4.5b	2.6b	2.2b	50.6c	65c	47.8c	60.25c	21a	26.25a
Santana	50.8b	98b	34.6b	5.5ab	4a	5.5b	4a	3.5a	52.8b	67.25b	50.8b	65.75b	17.8b	21.25b
Maradona	51.2b	96.5b	35b	6a	4.8a	6a	4.8a	3.5a	52.6b	67.75b	51b	65b	17.8b	23.25b
Milova	50.6b	97b	34b	6a	4.4a	6a	4.4a	4a	53b	67b	51.4b	65.75b	18b	22.5b
Boren	50b	95b	33b	6.1a	4a	6.1a	4a	3.75a	52.2b	67.25b	50.6b	65.5b	17.8b	21.25b
Cosima	57.8a	105.75a	39.6a	6.25a	4.6a	6.25a	4.6a	3.5a	55.6a	71a	52.8a	68a	17.8b	22.25b
Granola	58.2 a	105.25a	38.6a	6.2a	4.2a	6.2a	4.2a	4a	55.4a	69.5a	52.6a	67.1a	18.6b	23.5b
Agria	58.6a	108.25a	39.8a	6.35a	5.1a	6.35a	5.1a	4.2a	55.4a	70a	52a	67.75a	17b	21b

Followed by the same letter are not significantly different at the 0.01 level of probability according to Duncan test. F: Field, G: Glasshouse.

(P = 0.01). **Tables 6** and **7** show that, the maximum marketing yield among *S. tuberosum* varieties was belonged to Agria and the lowest one to Sante. The maximum level of tuber production was of Maradona and the lowest one in Sante, which is in agreement with others reports [5,20].

3.10. Average Number and the Weight of Potato Tubers

The maximum tuber numbers were observed in Boren and Cosima in the field and Agria in green house respectively (**Tables 8** and **9**) (P = 0.01). The lowest tuber numbers per plant was of to Shepody in the field and Boren

Table 6. Variance analysis of potato varieties in the field.

Source of variation (SV)	Degrees of freedom	Mean square (MS)			
		Big size tubers	Medium tubers	Small tubers	Total yield
Treatment	10	64.63**	87.18**	8.85**	183.81**
Error	33	17.74	15.33	0.73	11.38
Total	43	-	-	-	-
CV%	-	64.51	20.18	28.47	8.82

**Significant at 0.01 level of probability.

Table 7. The comparison of yield average of varieties in the field.

Varieties	Big size tubers	Medium tubers	Seed tubers	Mini tuber	Total yield
Ramose	11.49ab	17.01cd	8.28bc	2.23b	39.02cd
Sante	1.66c	12.79d	9.05bc	2.13b	25.64de
Shepody	3.77bc	20.85bcd	6.38c	1.96b	32.98de
Marfona	5.76abc	15.41d	7.05bc	1.6b	29.82ef
Santana	11.46ab	14.26d	11.3abc	3.22b	40.19bcd
Maradona	12.61a	17.57bcd	6.62c	1.68b	38.49cd
Milova	2.68c	26.75a	11.87abc	3.13b	44.45abc
Boren	3.7c	25.55ab	8.39bc	2.54b	40.14bcd
Cosima	6.02abc	18.73abcd	16.21a	5.43a	46.4ab
Granola	2.23c	19.75abcd	10.74bc	3.11b	35.84de
Agria	4.07bc	24.73ab	12.43ab	6.13a	47.37a

Followed by the same letters are not significantly different at the 0.01 level of probability.

Table 8. Variance analysis of the yield factors in the field and green house.

Source of variation (SV)	Mean square (MS)					
	Degrees of freedom		Average No. of tubers per plant		Average weight of tubers per plant	
	G	G	F	F	G	F
Treatment	10	48.73**	480.75**	14.23**	73.48**	480.75**
Error	44	4.91	104.15	1.09	4.91	104.15
Total	54	-	-	-	-	-
CV%	-	10.75	12.44	11.6	10.75	12.44

**Significant at 0.01 level of probability; F: Field, G: Glasshouse.

Table 9. The comparison of yield factors in the field and green house.

Varieties	Average No. of tubers per plant		Average weight of tubers per plant (gr)	
	G	F	G	F
Ramose	1.8bc	8.35bc	14g	89.02ab
Sante	1.4c	6.95cd	24.5b	71.6b
Shepody	3.6b	8.35bc	20d	75.77b
Marfona	2.6bc	6.10d	21.48cd	93.32ab
Santana	2.2bc	9.45b	17.44e	80.52b
Maradona	3.2bc	6.80cd	17.04e	107.5a
Milova	1.4c	11.55a	17fg	72.7b
Boren	2.2bc	9.40b	21.96c	81.5b
Cosima	2.4bc	11.55a	26.2a	76.17b
Granola	2.2bc	9.35b	20.8cd	71.81b
Agria	5.4a	10.95a	25.67ab	82.25b

Followed by at least one same letter are not significantly different at the 0.01 level of probability according to Duncan test.

and Sante in green house. Also, the maximum average of tuber weight was found in Maradona in the field and Cosima green house. The minimum tuber weights in the field and green house was of Sante and Ramose varieties respectively. Which, confirmed the findings by other researchers [5,20,21].

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