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Effect of water stress on gland function and some qualitative traits of commercial cultivars and promising potato clones

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ABSTRACT

In order to evaluate the effect of water stress on gland function and some of qualitative traits of commercial cultivars and potato clone, the experiment was performed as split-plot design based on randomized complete blocks with 3 replications in agricultural research and education station and natural resources of Ardabil in 2015. In order to determine the tolerance of cultivars and clone against water stress, susceptibility indexes and tolerance against water stress were used. The results of analysis of variance showed that the traits of total gland function, gland protein function, and percentage of dry matter of the gland, under the effect of irrigation levels and all traits of interest, became significant under the main effect of genotype. Also, the interaction of irrigation levels and cultivar was significant for the percentage of the dry matter of the gland. In this study, substituting moderate water stress for normal irrigation lead to about 27% saving on irrigation water consumption. Agria and Marfona cultivars produced highest percentage and function of protein and gland methionine. Clone 397008-9 showed the highest function of total gland and according to GMP, MP, and SSI indexes, had higher tolerance threshold relative to water stress. Also, Agria and Spirit cultivars had highest percentage of dry matter in severe and moderate water stress, respectively. STI showed significant superiority in identifying resistant genotypes.

KEY WORDS: TOLERANCE INDEX, PROTEIN FUNCTION, DRY MATTER, METHIONINE

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INTRODUCTION

Potato (*Solanum tuberosum* L.) is a one-year plant from Solananceae family and after corn, rice, and wheat, is in the fourth place in global scale. In this scale, Iran is in the twelfth place regarding potato production and in the Asia, is in the third place, so that the cultivation area of this product during 92-93 was 159000 hectares (FAQ, 2014). Since the provision of food necessitates maximum utilization of limited resources, therefore, awareness of factors that influence the function of each plant and its effect on increased agricultural plants function is very important. Also, its provision is an important factor in increasing the quality and quantity of crops, especially potato. Water stress is one of the most important factors that limits crops production (Passioura, 2007). Numerous studies have shown that potato has high susceptibility to water stress in all stages (Rezazadeh et al., 2015; Shock et al., 2013, Li et al., 2016).

The results of studies by Haghighi et al. (2015) showed that the effect of water stress treatments on gland function is significant and with increased irrigation water, the function increases. Water stress has a direct effect on proteinizaton process and water shortage in plant, in addition to hydrolyzing the available proteins, stops synthesis of new proteins (Kazemi, 1994). Since the function of crops under stress condition, due to genotype and environmental effects, is not considered as a suitable benchmark to select genotypes resistant against drought, various indexes are proposed to select plants based on function. In investigating the tolerance of water deficit under in vitro and in vivo conditions, Hasanpanah (2010), based on MP, GMP, STI, and MSTI, selected Kaiser as the superior cultivar under normal and water stress conditions. Since a major part of lands are under arid and semi-arid conditions and rainfall are decreased in recent years, potato production has been faced by numerous problems. Therefore, accurate analysis as well as qualitative and quantitative assessments and determining to tolerance and susceptibility against water in different growth stages constitute one of the most important methods to decrease concerning effects of water deficit. Therefore, this study aimed to use tolerance and susceptibility against water stress in farm conditions.

MATERIAL AND METHODS

This study was conducted during 2014-2015 in agricultural research and education station and natural resources of Ardabil. Ardabil province has moderate and semi-temperate climate with very cool winters and springs and moderate summers. Average maximum and minimum annual temperature and maximum regional temperature were 19.8, 15.18, and 21.58, respectively. Also, average rainfall has been reported as 310 mm (Unknown, 2016). Soil properties of the area are presented in Table (1).

The experiment was performed as split-plot design based on randomized complete blocks with 3 replications. Irrigation as the main plot was considered with three levels including provision of 100% water needs (control treatment), moderate water stress, and severe water stress. Also, cultivar was considered as the minor plot at six levels including Agria , Spirit, Marfona , Luca, Hermes, and promising clone. In the autumn of 2014, land preparation operation was performed as deep plowing, disc cutting, and land levelling the farm. At the beginning of May, stacking and plotting operation was performed and glands were cultivated. Treatments were implemented in experimental plots with the area of 22.5 square meter consisted of four 6-meter lines with the distances of 75 cm between two rows and 25 cm between two bushes. To prevent water penetration from adjacent plots, 3 m and 1.5 m were considered between the main plot and the minor plots as margin. To control Colorado beetle pest, confidorous pesticide (250 ml) was used before flowering of potato. Also, to prevent whippery, mancozeb was used (1 kg/ha) before flowering stage. According to the results of soli analysis in the area of interest, 150 kg/ha ammonium phosphate was used in two turns (50% while cultivation and 50% in gland formation), urea (350 kg/ha) in three turns (25% while cultivation, 50% while emergence, and 25% immediately after gland formation), and potassium sulfate (150 kg) in one turn (cultivation). Weed practices were performed in two turns before gland formation in all experimental plots. In Ardabil and neighborhood areas, water stress mainly occurs in July and August and for this reason, the purpose is to identify cultivars that are resistant against stress in the final tension of the season. The implementation of irrigation treatments was as follow:

Normal irrigation treatment was initiated one day after gland cultivation (Juan 6) and continued until October, 2 (harvesting) that was accompanied by two irrigations (5-7 days) with providing 100% water needs of the plant. In the plots under this treatment, irrigation times from cultivation to harvesting, included 11 times and water volume and applied water were 10950 and 11638 cubic meter, respectively.

Moderate water stress treatment was initiated one day after gland cultivation (Juan 6) and continued until July, 2 with irrigation period of 5-7 days and provision of 100% water need. Then, the irrigation operation stopped after 15 days (two times of irrigation). After this period, irrigation operation followed normal condition until October, 2 with the provision of 100% water need.

Therefore, in the plots of this treatment, the number of irrigations until cultivation was 9 and water volume and applied water were estimated as 8040 and 8728 cubic meter, respectively. Severe water stress was initiated one day after cultivation (Juan 6) and continued until July, 2 with the provision of 100% water need and irrigation period of 5-7 days in normal condition. Then, the irrigation operation continued until October, 2 win normal condition and provision of 100% water need. Therefore, in the plots of this treatment, the number of irrigations was 7 and irrigation water and applied water were 6600 and 7288 cubic meter, respectively.

The initiation of irrigation in the farm of interest in climatic condition of Ardabil was estimated based on evaporation of 28 mm water from pan evaporation surface (40% humidity discharge of available water). In other words, to estimate water in experimental plots, data related to evaporation from pan evaporation (Class A) were used. Also, Relationship (1) was used to estimate the required water for normal irrigation treatment (provision of 100% required water).

Relationship 1: $S \times EP \times 8/0 = IW$

Here, IW is required water (cubic meter), 0.8 is pan coefficient (Moradi et al., 2000), EP is evaporation from pan evaporation (mm), and S is the area of experimental plot (square meter). Then, in each irrigation turn, the required water for plots was estimated and directed to the plots of interests. Irrigation operation was performed for all plots until 75 days after cultivation and after that, moderate and severe water stresses were implemented. To measure daily precipitation, rainfall meter device was installed at the pan evaporation and each day in certain time (12 PM), measurements were performed. Comparison of the water required for each treatment and rainfall has been presented in Table (2).

Harvesting was performed by Octoer, 2. For this purpose, by the end of the season, to measure gland function, sampling was done for 2 central row in each plot (5 m) and to remove marginal effects, to marginal rows were removed. Then, the harvested glands from each surface (5 ×1.5m) were weighted and the resulted number was determined as the total gland function at the surface level (hectares). To determine the dry matter percentage of the glands, first, 10 glands were randomly selected and from each samples, 200g was sliced and after placing them within paper envelopes, they were placed inside the oven for 48h at the temperature of 72 C (Hasanpanah & Hoseinzadeh, 2007). After this period, samples were weighted by digital balance and the dry matter percentage was estimated using Relationship (2):

Relationship 2: dry matter percentage – (gland weight after drying/initial weight of glands) ×100

The multiplication of gland dry matter percentage and gland function has been considered as the gland dry matter function in hectares. To determine the weight of gland protein, Bradford method (1976) was used and to estimate protein function, relationship (3) was used:

Relationship 3: gland function×100/gland protein percentage – protein function. Also, methionine function (having data related to gland protein percentage and function) was estimated using Relationship (4):Relationship 4: methionine function - protein function×gland methionine percentage/100

In this study, after harvesting and estimating genotypes in both stress and normal conditions, five main indexes were used to determine tolerance and susceptibility of genotypes against water stress. To define different indexes, following terms have been used:

Yp: potential function of each genotype in stress-free environment
Ys: potential function of each genotype in stress environment
$\bar{Y}p$: average function of all genotypes in stress-free environment
$\bar{Y}s$: average function of all genotypes in stress environment

Stress Susceptibility Index (SSI) was proposed by Fischer and Mourer (1978) as follow:

Relationship 5: $SSI = [1- (Ys /Yp)] /SI$

In this relationship, SI is estimated as follow:

$SI = 1- (\bar{Y}s/\bar{Y}p)$

In genotype assessment using SSI, higher value of the index shows genotype susceptibility to stress. Therefore, genotype selection should be based on low SSI values.

Tolerance index (TOL) was defined Roseili and Hambline (1981) as function disorder in stress and stress-free environments:

Relationship 6: $TOL = Yp – Ys$

In genotype assessment using this index, higher index value shows susceptibility to stress; therefore, genotype selection should be based on low value of TOL.

Mean Productivity (MP) that was proposed by Rosielle and Hamblin (1981) as follow:

Relationship (7): $MP = (YS + YP)/2$

This index in the mean of genotype utilization in stress and stress-free conditions and selects genotypes that have high function in desirable conditions, but are in undesirable condition in term of function. Therefore,

selection based in MP index is efficient for genotypes with high potential.

Stress tolerance Index (STI) is estimated by Relationship (8) and Geometric Mean Productivity (GMP) is estimated by Relationship (9):

$$\text{Relationship (8): } STI=\frac{yp \times ys}{(\bar{y}p)^2}$$

$$\text{Relationship (9): } GMP=\sqrt{(Yp)(Ys)}$$

To perform statistical analyses and data estimations such as analysis of variance, correlation coefficient between assessment characteristics, and estimating tolerance indexes, SAS 9.1 was used. Also, to compare means, LSD test at the probability level of 5% was used.

Table 1. Soil test results at the depth of 0 to 30 cm

Soil texture	Saturated moisture content	Electrical conductivity	pH	Organic carbon percentage	Total percentage of neutralizing material	Total nitrogen percentage	Zinc (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Copper (mg/kg)	Absorbable potassium (mg/kg)	Absorbable phosphorus (mg/kg)
Lumi	43	0.874	0.797	1.03	6.5	0.1	10.1	5.18	16.2	7.52	318	5.8

Table 2. Comparing irrigation water volume of experimental plots

Treatment	Irrigation rounds (day)	Number of irrigations	Irrigation volume (cubic meter/ha)	Rainfall		Effective rainfall (cubic meter/ha)	Applied water volume (cubic meter/ha)
				mm	Cubic meter/ha		
Normal irrigation	5-7	11	10950	86	860	688	11638
Moderate stress	5-7	9	8040	86	860	688	8728
Severe stress	5-7	7	6600	86	860	688	7288

Table 3. Rainfall statistics of the area in 2015

Month	Rainfall (mm)	Month	Rainfall (mm)
April	35.7	October	58.3
May	26.5	November	46.6
Juan	7	December	13.9
July	3.6	January	6.4
August	0	February	24.9
September	48.9	March	36.7

RESULTS AND DISCUSSION

TOTAL GLAND FUNCTION

The results of analysis of variance for this trait showed that there is a significant difference between irrigation levels and cultivars at the probability levels of 5% and 1% while the interaction of these two factors did not show any significant difference (Table 4). Comparison of total gland function at different irrigation levels showed that normal irrigation treatment has highest function at the surface level (31290 kg/ha). Also, moderate water stress was placed in mutual statistical group and showed a significant difference with severe water stress treatment (Table 5).

According to the economic importance of gland function as well as difference in two irrigation rounds between normal irrigation and moderate water stress, it seems that the implementation of moderate water stress in potato farms and replacing it by normal irrigation method, in addition to obtaining suitable total function, leads to relative saving on water consumption. Significance of the difference between genotypes shows the variety of genetic materials for the trait of interest, so that the promising clone 397008-9 with including Agria, Spirit, Marfona, Luca, and Hermes shows the highest gland function mean and significant different with other cultivars. Also, Spirit and Hermes cultivars produced minimum total mean of gland function (Table 6).

Correlation coefficient table showed that total gland function has a positive and significant correlation with most of traits (Table 8). In moderate and severe water stress, a significant and positive correlation was observed between total gland function and gland protein function (Tables 9 and 10). Also, a significant and positive correlation was observed between gland dry matter and total gland function under moderate water stress. Also, in moderate water stress, MP and GMP, in addition to having significant and positive correlation with each other, showed the same correlation with STI (Table 11).

Table 4. Square mean of traits in potato cultivars and irrigation levels

Change sources	Degree of freedom	Total gland function	Gland protein percentage	Gland protein function	Gland dry matter percentage	Gland dry matter function	Gland methionine value
Replication	2	206.37	0.0003	2959.44	0.69	8.72	0.002
Irrigation levels	2	118.34*	0.00794**	619.92**	22.14**	1.02ns	0.00032ns
False	4	31.94	0.00017	330.04	0.43	1.11	0.002
Genotype	5	316.87**	0.01003**	4471.16**	26.32**	18.82**	0.032**
Cultivars × irrigation levels	10	35.83ns	0.00014ns	471.88ns	3.46**	1.36ns	0.001ns
False	30	41.15	0.0002	584.72	0.53	1.44	0.003
Change percentage (%)		22.59	3.99	23.38	3.75	21.59	29.10

Table 5. Comparing the mean of irrigation levels on some of potato traits

Irrigation levels	Gland protein function (kg/ha)		Gland protein percentage (%)		Gland total function (kg/ha)	
Normal irrigation	190.01	b	3.4	b	31290	a
Moderate stress	205.71	a	3.76	a	27590	ab
Severe stress	192.14	b	3.7	a	26320	b

Table 6. Comparing the mean of cultivar on some of potato traits

Cultivars	Gland methionine (microgram/mg)		Gland dry matter function (kg/ha)		Gland protein function (kg/ha)		Gland protein percentage (%)		Gland function (kg/ha)	
Agria	0.25	a	6240	a	253.21	a	4	a	29647	a
Marfona	0.25	a	6930	a	252.46	a	4	a	32403	a
Luca	0.16	b	6370	a	230.81	a	3.6	b	33100	a
Spirit	0.12	b	3900	b	146.65	b	3.2	d	22790	b
Hermes	0.14	b	3540	b	119.95	b	3.4	c	19303	b
Clone 379008-9	0.23	a	6360	a	229.21	a	3.6	b	33110	a

In severe water stress, MP and GMP showed a significant and positive correlation at the probability level of 5% with STI and under these circumstances and probability level of 1%, a significant and positive relationship was observed between MP and GMP (Table 12). According to the table of simple coefficients between indexes, correlation between potential function and stress in moderate stress (r=0.893) and severe stress (r=0.937) was significant (Table 13 and 14). The function of genotypes in stress-free environment showed a positive correlation with STI, MP, and GMP. Also, correlation between the function of genotypes under moderate water stress and STI, MP, and GMP as well as under severe water stress with STI, MP, GMP, and TOL was positive. High correlation between STI and genotype function in stress and stress-free environments shows superiority of this index relative to the indexes of interest in the assessment of genetic variety and screening tolerant genotypes as well as estimation of function resistance. Maralian et al. (2014) investigated the effect of low irrigation of gland function of different potato genotypes and found that 60% provision of water leads to decreased gland function of potato genotypes from 754 g to 640 g (17.7%).

GLAND PROTEIN PERCENTAGE

The results of analysis of variance showed that there is a significant difference between different irrigation levels and cultivars at the probability level of 1% while no significant difference was observed in the interaction of these two factors for the traits of interest (Table 4). Comparing gland protein percentage at irrigation levels showed that moderate and severe water stress treatment have highest mean of gland protein percentage and

showed a significant difference with normal irrigation (Table 5). It seems that high values of protein in water stress treatments is the result of low gland function. Significance of the difference between genotypes showed genetic variation for traits, so that Agria and marfona cultivars showed highest percentage of gland protein (4%) and significant difference with other cultivars. Also, the lowest gland protein percentage mean belonged to Spirit (Table 6). Correlation coefficients between assessment characteristics in normal irrigation showed that protein percentage has a significant and positive correlation with most of traits (Table 8). Also, although no positive and significant correlation was observed with other traits, under severe water stress, methionine level and gland dry matter percentage showed significant and positive correlation at the probability levels of 1% and 5% with traits (Tables 9 and 10). With increased water stress severity, protein percentage increases; therefore, change in protein structure or its destruction is one of the metabolic stages that may be influenced by water stress (Ommen, 1999).

GLAND PROTEIN FUNCTION

The results of analysis of variance for this trait showed that there is a significant relationship between irrigation levels and cultivars at the probability level of 1% while no significant relationship was observed in the interaction between these factors (Table 4). According to the comparison between protein function mean at the irrigation level, moderate water stress showed the highest gland protein function (205.71 kg/ha) and showed a significant difference with normal irrigation and severe water stress. Lowest gland protein function was observed under normal irrigation condition and severe water stress (Table 5). In other words, by replacing moderate water stress with normal irrigation, about 27% of water consumption was saved. Significant difference between genotypes showed genetic variety between cultivars. Comparing the effect of genotype on gland protein function showed that the highest mean of gland protein function is related to Agria , Marfona , Luca, and promising clone 379008-9. Lowest mean of protein function at the surface level belonged to Spirit and Hermes (Table 6). Correlation coefficient table about traits in normal irrigation showed that gland protein function has a significant and positive relationship with most of traits (Table 8). Also, under moderate and severe stress conditions, significant and positive correlation was observed between this trait and gland function. Moreover, the trait and gland dry matter function in moderate and severe water stress conditions showed significant and positive correlation at the probability levels of 5% and 1% (Tables 9 and 10).

GLAND DRY MATTER PERCENTAGE

The results of analysis of variance showed that there is a significant different between different moisture contents, cultivars, and interaction between irrigation lev-

Table 7. Gland dry matter percentage of potato cultivars at different irrigation levels

Irrigation treatments	Clone 397008-9		Hermes		Luca		Spirit		Marfona		Agria	
Normal irrigation	19	bcd	16.25	bcd	16.67	bcd	16.82	bcd	18.65	bcd	19.76	abc
Moderate water stress	18.85	bcd	19.02	bcd	17.34	bcd	21.75	a	20.59	ab	21.42	ab
Severe water stress	19.86	bcd	19.57	bcd	17.32	bcd	19.54	bcd	19.19	bcd	22.88	a

Table 8. Correlation coefficient between traits in normal irrigation conditions

	Methionine level	Protein function	Protein percentage	Gland dry matter function	Gland dry matter percentage	Gland total function
Gland function						-
Gland dry matter percentage					-	0.79*
Gland dry matter function				-	0.90**	0.97**
Protein percentage			-	0.96**	0.91**	0.96**
Protein function		-	0.96**	0.94**	0.80*	0.94**
Methionine	-	0.81*	0.92	0.90**	0.99**	0.78*

Table 9. Correlation coefficients between traits under moderate water stress

	Methionine level	Protein function	Protein percentage	Gland dry matter function	Gland dry matter percentage	Gland function
Gland function						-
Gland dry matter percentage					-	0.34
Gland dry matter function				-	0.76	0.87*
Protein percentage			-	0.38	0.51	0.19
Protein function		-	0.34	0.84*	0.37	0.95**
Methionine level	-	0.41	0.49	0.78	0.99**	0.37

Table 10. Correlation coefficients between traits under severe water stress

	Methionine level	Protein function	Protein percentage	Gland dry matter function	Gland dry matter percentage	Gland function
Gland function						-
Gland dry matter percentage					-	0.26
Gland dry matter function				-		0.80
Protein percentage			-	0.75	0.99**	0.26
Protein function		-	0.61	0.95**	0.32	0.98**
Methionine level	-	0.31	0.80*	0.55	0.83*	0.55

Table 11. Estimating tolerance and susceptibility of cultivars and clone to water stress by indexes in moderate water stress

Cultivars and clone	MP	SSI	STI	GMP	TOL	YS	YP
Agria	31070	2.16	0.684	30520	11650	26810	36890
Marfona	34530	2.15	0.807	34330	7380	28150	38220
Spirit	34330	0.51	0.954	34320	1610	30630	35140
Luca	22220	0.62	0.944	22210	1280	23930	22860
Hermes	34620	0.09	-17.28	17340	50	23080	17440
397008-9	35670	0.09	-14.00	21670	7670	33000	37000

Table 12. Estimating tolerance and susceptibility of cultivars and clone to water stress by indexes in severe water stress

Cultivars and clone	MP	SSI	STI	GMP	TOL	YS	YP
Agria	31850	2.29	0.727	31450	10090	25240	36890
Marfona	33800	6.72	0.736	32800	10070	30840	38220
Spirit	32890	3.27	0.872	32810	4500	33530	35140
Luca	23400	-1.19	1.047	23390	1070-	21580	22860
Hermes	20260	-8.23	1.323	20060	5630-	17390	17440
397008-9	35000	2.76	0.892	34940	4000	29330	37000

Table 13. Correlation coefficients between susceptibility indexes and tolerance to drought and function in moderate water stress

	YP	YS	TOL	GMP	STI	SSI	MP
YP	1						
YS	0.893	1					
TOL	-0.051	-0.496	1				
GMP	0.964	0.980	-0.315	1			
STI	0.952	0.988	-0.353	0.999*	1		
SSI	0.319	-0.712	0.963	-0.559*	-0.593	1	
MP	0.969	0.977	-0.297	1*	0.998*	-0.544	1

els and cultivars at the probability level of 1% (Table 4). Comparing the effect of irrigation levels on gland dry matter percentage showed that the highest mean of gland dry matter is related to moderate and severe water stress conditions and these treatments were at the highest level of statistical group and showed a significant difference with normal irrigation treatment (Table 5). It seems that increased dry matter percentage of potato under water stress is resulted from low level of gland function. According to considering water stress treatments in the same group and necessity for savings on water consumption, moderate water stress is recommended for nutritional goals and potato processing (chips, franchise, etc.). Significant difference between genotypes showed the existence of genetic variation between cultivars. Comparing the effect of this cultivar on this trait showed that Agria and Spirit have the highest mean of gland dry matter and showed a significant difference compared with other cultivars. Hermes with the lowest mean of gland dry matter was at the lowest position of the statistical group (Table 6).

Comparing the mean of interaction between irrigation levels and cultivar for this trait showed that Agria and Spirit have the highest percentage of gland dry matter under severe (22.8%) and moderate (21.75%) water stress conditions and it seems that it can be used as a suitable mixture to produce fried products and use in processing industry to save water consumption in agriculture. Correlation coefficient table showed that gland dry matter percentage has a significant and positive correlation with most of traits (Table 8). Also, this trait under moderate water stress showed a significant and positive correlation with methionine level and under severe stress condition, showed a significant and positive correlation with methionine and gland protein percentage (Tables 9 and 10).

GLAND DRY MATTER FUNCTION

The results of analysis of variance for this trait showed that there is a significant difference between cultivars at the probability level of 1% while irrigation levels and interaction between these factors did not show any significant difference (Table 4). Significant difference between genotypes shows the variety of genetic substance of cultivars for the trait. Comparing the effect of cultivar on this trait showed that Marfona wit Luca, clone 397008-9, and Agria have the highest gland dry function mean and showed a significant difference with other cultivars. In this study, Spirit and Hermes showed the lowest mean of gland dry matter function at the surface level (Table 6). Correlation coefficient table between traits in normal irrigation condition showed that gland dry matter percentage has a significant and positive correlation with most of traits (Table 8). Also, this trait under moderate water stress showed a significant and

Table 14. Correlation coefficient between susceptibility indexes and tolerance to drought and function in severe water stress

	YP	YS	TOL	GMP	STI	SSI	MP
YP	1						
YS	0.937	1					
TOL	-0.528	0.792	1				
GMP	0.973	0.992	-0.710	1			
STI	0.960	0.997*	-0.745	0.999*	1		
SSI	0.289	-0.972	0.912	-0.936**	-0.953*	1	
MP	0.978	0.989	0.695	1**	0.997*	-0.928	1

positive correlation with gland and protein function (Tables 9 and 10). The results of studies by Kumar et al. (2007) with different irrigation treatments showed that increased water stress decreases gland dry matter function.

GLAND METHIONINE LEVEL

Analysis of variance for the trait of interest showed that there is not any significant difference between different irrigation levels and interaction between irrigation and cultivar levels while cultivars for this trait showed a significant difference at the probability level of 1% (Table 4). Significant difference between genotypes showed the variety of genetic substances for the trait of interest. Comparing the mean of the effect of cultivar on this trait showed that the highest methionine level belongs to Agria , Marfona , and clone 3977008-9 and showed a significant difference with other cultivars. Luca, Hermes, and Spirit produced lowest level of gland methionine (Table 6). Correlation coefficient table between traits in normal irrigation condition showed that gland methionine has a significant and positive correlation with most of traits (Table 8). Also, this trait, under moderate water stress, showed a significant and positive correlation with gland dry matter percentage and under severe water stress, showed a significant and positive correlation with gland dry matter percentage and gland protein percentage (Tables 9 and 10). Muttucumaru et al. (2015) by investigating 5 cultivars of potato resistant and susceptible to drought found out that cultivars were significantly different in terms of methionine concentration. Also, methionine concentration of cultivars resistant to drought is higher than cases sensitive to drought.

CONCLUSION

Moderate water stress lead to the production of suitable gland function. Also, the highest percentage of gland protein (3.76%), gland protein function, and highest dry matter percentage (19.83) belonged to this treatment. Therefore, due to the economic importance of gland function and decreased levels of water consumption (2910 cubic meter) compared with normal treatment, the implementation of moderate stress and replacing it with normal irrigation seems more economic. Agria and Marfona produced the highest protein percentage (4%) and gland methionine. Also, Agria and Spirit in severe (22.88%) and moderate (21.75%) water stress conditions showed highest gland dry matter percentage and it seems that it can be introduced as a suitable treatment. The highest values of gland protein function belonged to Agria and Marfona . Clone 397008-9 produced the highest gland function mean ((33100 kg/ha) and according to MP indexes (severe and moderate water stress), SSI (moderate water stress), and GMP (severe water stress) showed higher tolerance compared with water stress and it can be used for commercial purposes. High correlation between STI and genotype functions in stress and stress-free environments showed the superiority of this index in screening tolerant genotypes and function tolerance estimation.

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