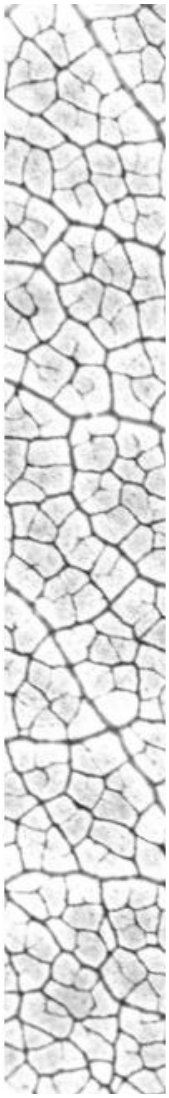

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Yield and water use efficiency of potato cultivars in autumn and spring cultivations of moderate and cold regions

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Abstract
A two years study was carried out during 2017-18 to investigate the effect of planting date and sowing depth on some qualitative traits, yield and water consumption efficiency of potato cultivars in autumn and spring cultivations in Ardebil, IRAN, as split factorial based on RCBD with three replicates. The main plots were sowing dates (1st of November and December and 30th of April) and factorial combination of potato cultivars (Esprit, Marfona, Savalan and Agria) and tuber sowing depths (10, 15, 20 and 25 cm) were considered as subplots. The results showed that iron content, tuber yield and water use efficiency affected by cropping date and nitrogen content, fat and fiber percentages and soluble sugars affected by sowing depths. Water consumption efficiency was higher by sowing Esprit cultivar in 1st of November and December at depths of 10, 15 and 25 cm.

Keywords: autumn cropping, potato, qualitative traits, water consumption efficiency

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INTRODUCTION

Potato is relatively psychrophilic plant and cold season vegetable (Darabi, 1392). The cultivation date depends on the weather conditions. Inappropriate cropping date result in the plant vegetative growth period encountered with unfavorable environmental conditions. Reducing of the growth period or encounter of plant sensitive periods to environmental unfavorable conditions can reduce vegetative growth, yield components, or even causing death of the plant. Potato sowing date plays an important role in its production. Also, planting depth play an important role in the formation of rhizomes and aerial stems, and by increasing cropping depth to 20 cm, the number of rhizomes and the yield is increased. Deep cultivation of potato tubers produces sparse and single stem plants on the farm, which this reduces required density in the farm, and lower cropping depth produces tubers on the soil surface, which will lead to sunburn in the produced tubers (Ezaazimi et al., 2009; Arzehgar et al., 2019). Hassanpanah et al. (2009) studied the effect of four planting dates from May 21 to June 4 on yield and agronomic characteristics of two Savalan and Agria cultivars in Ardabil and resulted that potato yield, especially the number of produced tubers depends heavily on planting depth and appropriate planting depth is one of the most important environmental factors in yield increasing, as Laei et al. (2012) emphasized on it. By increasing the depth of potato planting, the number of tubers per plant decreased and the tubers weight increased (Lalehgani-dezaki et al., 2007). Researchers such as Mortazavibak and Aminpoor (2003), Ali Mohammadi et al. (2004), Lalehgani-dezaki et al. (2007) and Pavek and Thornton (2009) reported that planting depth has a significant effect on potato tuber yield. Laie et al. (2012) reported that the highest tuber yield was obtained at planting depth of 15 cm, and as the depth of sowing increased, the number of tubers decreased and increased the tubers weight. The main objective of this study was to investigate the effect of sowing depth on qualitative characteristics, tuber yield and water use efficiency of potato cultivars in autumn and spring cultivations of moderate and cold regions.

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Table 1. Meteorological statistics of Ardabil area during 2017-18

Month	2017					2018				
	Rainfall (mm)	Mean temperature (°C)			Mean humidity (%)	Rainfall (mm)	Mean temperature (°C)			Mean humidity (%)
		Min.	Max.	Mean			Min.	Max.	Mean	
April	30.3	2.1	14.3	8.2	69	9.3	2.3	15.7	9	66
May	32.9	7.4	21.4	14.4	64	60.6	5.9	18.9	12.3	71
June	204	10	24.5	17.3	68	28.2	10	13.5	16.8	71
July	9.3	12.8	26.1	19.5	61	3.9	13.7	29.2	21.5	60
August	1.3	11.7	29.5	20.06	58	0.9	14.9	25.7	20.3	69
September	0.1	10.2	29.3	20	57					

Source: Ardebil Province Meteorological Organization

Table 2. Physicochemical properties of the soil and water of the experimental site

Analysis	Soil	Analysis	Water
Salinity	1.25ds/m	Salinity	1500 µs/m
pH	7.64	pH	7.66
Saturation (%)	29	Carbonate	0
Lime (%)	7.5	Bicarbonate (ppm)	382
Texture	Clay-loam	Sulfate (ppm)	155
Organic carbon	0.97	Chlorine (ppm)	195
Total nitrogen (%)	0.1	Sodium (ppm)	123.98
Absorbable P (ppm)	3.4	Calcium (ppm)	118
Absorbable potassium (ppm)	230	Magnesium (ppm)	44.2
Zinc (ppm)	1.22	SAR	2.46
Iron (ppm)	3.22	TDS (mg/l)	750
Copper (ppm)	3.2	Total hardness	480
Manganese (ppm)	4.2		

Table 3. Characteristics of the cultivars cultivated in the design

Cultivars	Growth period	Type of Use	Tuber flesh color	Tuber skin color
Esprit	Mid-late	Fresh consumption	yellow	yellow
Marfona	Mid-late	Fresh consumption	Light yellow	yellow
Savalan	Mid-late	Chips	yellow	yellow
Agria	Mid-late	French Fries	yellow	yellow

MATERIALS AND METHODS

This research was carried out at the farm of Ardebil Agricultural Research Station and Natural Resources, IRAN, that has temperate and semi-cold climate, the average rainfall is 310 mm with a slightly humid weather and the altitude of 1372 m. Some of the important meteorological parameters in the growth period of potato are presented in **Table 1** and **Table 2** shows some physical and chemical properties of the soil and water of the test site.

This study investigated the early and mid-late potato cultivars (**Table 3**) in different depths of planting in autumn and spring in three dates, by split factorial experiment based on randomized complete block design with three replicates in two years during 2017-2018. The main plots were sowing dates (1st of November and December and 30th of April) and factorial combination of potato cultivars (Esprit, Marfona, Savalan and Agria) and tuber sowing depths (10, 15, 20 and 25 cm) were considered as subplots. Fertilizers were applied based on soil test.

Planting site and each cultivar was cultivated on four hills of 5 meters in length with distance of 75 cm and with two plants spacing of 25 cm in autumn based on evaluated planting dates (Hassanpanah, 2016). Confider poison of 250 ml/ha was used twice to fight against Colorado beetle and carriers of viral diseases. On July 11, the plant was headed back by sickle. After 10 days, on 21th July, ten plants were selected from each plot and carefully the tubers of each plot were harvested and were transferred to the laboratory for measuring and necessary samplings (Khandan et al., 2011). In this study, water use efficiency was calculated as follows.

$$WUE = TY/TWU$$

WUE is water use efficiency (kg / m3), TY and TWU are Tuber Yield (kg/ha) and total water use (m3/ha), respectively

The amount of consuming water was used based on different steps of growth and plant requirement. To calculate the amount of irrigation water at each turn, and at each stage of potato growth, we need to the percentage of farm capacity (FC), Permanent Wilting Point (PWP), bulk density (Bd.D), available water (AW), and readily available Water (RAW). The soil bulk density is obtained from the ratio of dry soil mass to the unaltered soil volume in grams per cubic centimeter (Behnia, Borhan. 2007). The soil bulk density of the test site was calculated as follows: 1.29 g / cm3.

$$Bd.D = Ms - Vt$$

where Bd.D is soil bulk density (g/cm3), Ms is the mass of solid particles (g) obtained from the difference between the sample dry mass and the cylinder (g) and the cylinder mass (g), and Vt is the cylinder volume (cm3) equal to $Vt = (\pi/4) \times d2 \times h$, where d is the cylinder diameter and h is the cylinder height.

Table 4. Using water amount in different potato cultivations through surface irrigation with WSC-Flume type4

Year	cultivation	Number of irrigation	using water amount (Cubic meter per hectare)	Effective rain amount (Cubic meter per hectare)	* Practical water volume (Cubic meter per hectare)
2017	Autumn and winter	4	4015	441	4456
	Spring	13	13699	562	14261
2018	Autumn and winter	14	3950	696	4646
	Spring	12	13150	1017	14167

The amount of field capacity at the matrix potential of -0.3 bar and permanent wilting at the matrix potential of -15bar was obtained by using a pressure plate device. The field capacity was 29.1% (FC=29/1%) and the amount of permanent wilting was 14.6% (PWP = 14.6%) and the soil bulk density was 1.29 g/cm3. Maximum Allowable Depletion for potatoes is considered to be 0.35. Available water (AW) was calculated from the following equation.

AW = [(ΘFC - ΘPWP)/100] × Bd.D = [(29.1 – 14.6)/100] × 1.29 = 18.705%

Readily available water (RAW) was calculated from the following equation

RAW = AW × MAD = [(29.1 – 14.6)/100] × 1.29 × 0.35 = 6.547%

Soil moisture content was calculated to determine the irrigation start time by collecting amount of readily available water and permanent wilting. The soil moisture content was 21.147% for the irrigation start time. The soil moisture content of the test site during potato growth period was measured by using portable soil moisture meter PMS-714 made in Taiwan.

RAW + PWP = 6.547 + 14.6 = 21.147%

Flume WSC type 4 was used to measure the rate of passing flow through the creek in surface irrigation method. After installing the flume WSC at the entrance to the creek, the main creek was covered with nylon to prevent the water from falling into the creek. The rate of flow in the flume WSC type 4 was obtained from the following equation (Islamic, 1395).

Q4 = 0.0294 × H2.102

H: Height of water inside flume (measured by ruler mounted on flume body in cm)

Based on the performed measurements during the growth period of potato, the height of water was between 19 to 21 cm, and the water Flow rate was calculated to be 14.33- 17.687 liters / second.

Q4 =0.0294× (21)2.102=17.687 liters / second = 17.687× 3.6=63.673 Cubic meter per hour

Q4 =0.0294× (19)2.102=14.33 liters / second = 14.33× 3.6=51/588 Cubic meter per hour

The amount of using water in different potato cultivars by surface irrigation with WSC flume type 4 has been shown in (**Table 4**).

In this research, qualitative traits such as dry matter percentage (AOAC, 1990; khandan et al., 2011), starch percentage of tuber (Anthron's reagent method), fiber determination and reducing sugars were observed by di nitrofinyl method (Jones et al., 2001; Mostofi et al., 2005). Nitrogen percentage of tubers was measured by Kejeldal apparatus and percentage of protein was calculated from the product of multiplication of this percentage with constant coefficient of 6.25. Also, the amount of potassium, phosphorus, iron and zinc in the tuber was measured and evaluated by using method of Valinag et al. (1989) and Salovanone and Quivistinen, (1996). At the end of the growth season, the harvested tubers from each plot was weighed and turned into tons per hectare and were considered as the total tuber yield per hectare. After reviewing the data normalization and uniformity of the test error, compound analysis was performed based on the Statistical design of the split factorial and the comparison of the mean based on the LSD test at 5% probability level using SAS 9.1 software and the correlation between traits using Minitab.16 software and Drawing charts with Excel.

RESULTS AND DISCUSSION

The results of analysis of compound variance, effect of date and depth of planting on quantitative traits and tuber yield in two years of cultivation are presented in **Table 5**.

Nitrogen content of the tubers

The results of variance analysis of the nitrogen content of the tuber trait (**Table 5**) showed that the simple effect of planting depth at 5% probability level, cultivar and bilateral effect of the year× cultivar, planting date × cultivar and Triple effect of the year × planting date × cultivar at 1% probability level was significant. The effects of different planting depths on the nitrogen content of the tuber showed that there was no significant differences between sowing depths of 15, 20 and 25cm. They were in a statistical group and depth of 10cm had the lowest value (**Table 6**). Agria cultivar had the highest percentage of nitrogen by 23.2% in the first year in all three planting dates and in the second year in planting date of November and December. In the second year of planting in December, Esprite cultivar had an increase in nitrogen content to 23.2% nitrogen in the tuber and in the planting date of April, Savalan cultivar was at the highest level (**Table 7**). The relation of nitrogen percentage of the tuber to tuber starch percentage of the tuber, fiber percentage of the tuber and dry matter percentage of tuber was positive and significant and potassium percentage of the tuber, phosphorus percentage of the tuber, zinc percentage of the tuber was negative and significant (**Table 10**).

Table 5. Analysis of variance, effect of date and sowing depth on tuber yield and qualitative.traits in potato

S.O.V	df	Mean Of Square					
		Nitrogen of tuber	Potassium of tuber	Phosphorus of tuber	Iron of tuber	Zinc of tuber	Percentage fat of tuber
Year (A)	1	0.065 ^{ns}	15315.5 ^{ns}	166721.8 ^{ns}	85255.58*	107.385 ^{ns}	0.001 ^{ns}
Error 1	4	0.034	1648170.6	76856.029	8936.94	6200.816	0.001
Planting Date (B)	2	0.042 ^{ns}	2719081.9 ^{ns}	85101.6 ^{ns}	62624.8**	1469.47 ^{ns}	0.000161 ^{ns}
A × B	2	0.042 ^{ns}	2719081.8 ^{ns}	85101.6 ^{ns}	62623.7**	1469.402 ^{ns}	0.000148 ^{ns}
Error 2	8	0.034	1228394.5	33303.137	3741.26	5581.404	0.001
Planting Depth (C)	3	0.014*	780290.1 ^{ns}	32614.8 ^{ns}	22920.9 ^{ns}	3970.84 ^{ns}	0.003**
A × C	3	0.012 ^{ns}	772444.8 ^{ns}	37555.01 ^{ns}	20266.7 ^{ns}	1255.53 ^{ns}	0.001 ^{ns}
B × C	6	0.004 ^{ns}	662129.1 ^{ns}	72340.8 ^{ns}	5909.9 ^{ns}	6999.64 ^{ns}	0.000192 ^{ns}
A × B × C	6	0.004 ^{ns}	662129.1 ^{ns}	72340.82 ^{ns}	5910.03 ^{ns}	6999.61 ^{ns}	0.000284 ^{ns}
Variety (D)	3	0.197**	358628523**	24114691.5**	7315048**	1541255.8**	0.064**
A × D	3	0.024**	19086466.6**	4889380.9**	670423.2**	337649.7**	0.005**
B× D	6	0.021**	39701079.7**	4194332.3**	498687.6**	161322.06**	0.006**
A × B × D	6	0.021**	39701079**	4194332.3**	498686.9**	161322.58**	0.006**
C × D	9	0.006 ^{ns}	935987.7 ^{ns}	41967.04 ^{ns}	50074.6 ^{ns}	5284.77 ^{ns}	0.001*
A × C × D	9	0.005 ^{ns}	1013742.3 ^{ns}	42334.91 ^{ns}	50175.8 ^{ns}	6600.5 ^{ns}	0.000493 ^{ns}
B × C × D	18	0.055 ^{ns}	671398.1 ^{ns}	51873.61 ^{ns}	49185.5 ^{ns}	9828.79 ^{ns}	0.000352 ^{ns}
A × B × C × D	18	0.005 ^{ns}	671398.1 ^{ns}	51873.61 ^{ns}	49185.4 ^{ns}	9828.8 ^{ns}	0.000361 ^{ns}
Error 2	180	0.005	832890.256	45752.136	31575.7	6729.915	0.00375
C.V%		3.27	4.43	5.86	4.47	6.43	1.03

S.O.V	df	Mean of Square					
		Percentage starch of tuber	Percentage fiber of tuber	Tuber dry matter	percentage of soluble sugars	Tuber yield	Water use efficiency (WUE)
Year (A)	1	2.042 ^{ns}	0.025 ^{ns}	4.009 ^{ns}	0.001 ^{ns}	1.021 ^{ns}	0.587 ^{ns}
Error 1	4	0.277	0.036	0.746	0.00024	72.527	1.639
Planting Date (B)	2	0.624 ^{ns}	0.028 ^{ns}	17.943 ^{ns}	0.000282 ^{ns}	2179.495**	26.983*
A × B	2	0.623 ^{ns}	0.027 ^{ns}	1.079 ^{ns}	0.000382 ^{ns}	1.123 ^{ns}	0.316 ^{ns}
Error 2	8	0.357	0.025	0.692	0.000187 ^{ns}	114.575	3.884
Planting Depth (C)	3	0.279 ^{ns}	0.023**	2.524 ^{ns}	0.002**	337.039**	2.707 ^{ns}
A × C	3	0.129 ^{ns}	0.008 ^{ns}	4.929*	0.000085 ^{ns}	3.041 ^{ns}	0.67 ^{ns}
B × C	6	0.07 ^{ns}	0.004 ^{ns}	5.009**	0.000487**	176.274**	2.506 ^{ns}
A × B × C	6	0.07 ^{ns}	0.004 ^{ns}	3.29 ^{ns}	0.000293 ^{ns}	2.701 ^{ns}	0.385 ^{ns}
Variety (D)	3	21.996**	0.034**	273.653**	0.000257 ^{ns}	10.233 ^{ns}	10.013**
A × D	3	1.612**	0.006 ^{ns}	0.394 ^{ns}	0.00008 ^{ns}	0.443 ^{ns}	4.365 ^{ns}
B× D	6	2.869**	0.01 ^{ns}	14.889**	0.000481*	114.1277**	8.52**
A × B × D	6	2.869**	0.01 ^{ns}	1.918 ^{ns}	0.000329 ^{ns}	0.224 ^{ns}	3.955 ^{ns}
C × D	9	1.188**	0.007 ^{ns}	2.861 ^{ns}	0.000134 ^{ns}	52.699**	3.220 ^{ns}
A × C × D	9	0.329*	0.008 ^{ns}	1.681 ^{ns}	0.000159 ^{ns}	1.53 ^{ns}	0.88 ^{ns}
B × C × D	18	0.322**	0.006 ^{ns}	5.604**	0.000335*	30.583**	2.037 ^{ns}
A × B × C × D	18	0.321**	0.006 ^{ns}	2.742 ^{ns}	0.000338*	1.334 ^{ns}	0.845 ^{ns}
Error 2	180	0.155	0.005	1.662	0.000167	14.272	2.065
C.V%		2.79	3.37	6.43	9.17	16.76	21.10

*,**, ns:Significant at 5 and 1% level of probability & Non significant, respectively

Table 6. Comparing the simple effect mean of planting depth and cultivar on the evaluated traits of potato tuber

Simple effects	Traits	
Planting Depth	Nitrogen og tuber (%)	Fiber of tuber (%)
10 cm	2.095 ^{b}	2.103 ^{a}
15 cm	2.128 ^{a}	2.107 ^{a}
20 cm	2.117 ^{ab}	2.102 ^{a}
25 cm	2.112 ^{ab}	2.069 ^{b}
Cultivars	Fiber of tuber (%)	
Esprit	2.083 ^{ab}	
Marfona	2.114 ^{a}	
Savalan	2.07 ^{b}	
Agria	2.113 ^{a}	

The amount of potassium, phosphorus and zinc of the tubers

The results of variance analysis of potassium, phosphorus and zinc values of the tuber showed that (**Table 5**) the effect of cultivar, effect of cultivar × year, planting date × cultivar, effects of year × planting depth × cultivar and effect of year × planting date × cultivar at 1% probability level. The highest potassium percentage of the tuber in planting date of November, December and April in the first year was related to Marfona cultivar and compared with others was at the highest statistical level, and in the second year, Marfona cultivar had the highest potassium content in November and December cultivation. In the second year of planting date, the Esprite cultivar had the highest potassium percentage of the tuber (**Table 7**). The relationship between potassium content of the gland with the percentage of phosphorus, iron, zinc and fat percentage of the tuber was positive and significant, with the nitrogen percentage of the tuber, the starch percentage of the tuber and dry matter percentage of the tuber was negative and significant (**Table 10**). The results of the mean comparison of the

Table 7. Comparing the average of the triple interaction of (Year × Planting date × cultivar) on the evaluated traits of potato tuber

(Year×Data×Cultivare)			Traits											
			Nitrogen of tuber (%)		Potassium (mg/kgDM)		Phpsphorus (mg/kgDM)		Zinc (mg/kgDM)		Iron (mg/kgDM)		Fat of tuber (%)	
Year 1	10 Aban (Nov)	Esprit	2.082	cde	19153.62	de	2740.75	e	1187.85	e	3549.68	ef	0.146	d
		Marfona	2.019	e	24354.37	b	4711.37	a	1388.87	bc	4046.68	cd	0.21	abc
		Savalan	2.109	bcd	20154.37	cd	3412.12	d	1490.94	a	4413.5	a	0.226	a
		Agria	2.183	ab	18684	e	3635.12	cd	1033.37	f	3946.87	d	0.196	c
	10 Azar (Dec)	Esprit	2.082	cde	19153.62	de	2740.75	e	1187.87	e	3549.68	ef	0.145	d
		Marfona	2.019	e	24354.37	b	4711.37	a	1388.87	bc	4046.68	cd	0.211	abc
		Savalan	2.109	bcd	20154.37	cd	3412.12	d	1490.94	a	4413.5	a	0.228	a
		Agria	2.183	ab	18684	e	3635.12	cd	1033.37	f	3946.87	d	0.195	c
	10 Ordibehesht (April)	Esprit	2.082	cde	19153.62	de	2740.75	e	1187.87	e	3549.68	ef	0.145	d
		Marfona	2.019	e	24354.37	b	4711.37	a	1388.87	bc	4046.68	cd	0.211	abc
		Savalan	2.109	bcd	20154.37	cd	3412.12	d	1490.94	a	4413.5	a	0.228	a
		Agria	2.183	ab	18684	e	3635.12	cd	1033.37	f	3946.87	d	0.195	c
Year 2	10 Aban (Nov)	Esprit	2.067	de	18895.29	e	2778.25	e	1255.25	de	3450.52	f	0.137	d
		Marfona	2.063	de	25576.45	a	4718.04	a	1334.67	cd	4059.18	cd	0.217	abc
		Savalan	2.109	bcd	20570.21	c	3512.12	d	1450.79	ab	4394.42	a	0.21	abc
		Agria	2.203	a	18562.33	e	3609.54	cd	1036.67	f	3680.21	e	0.197	c
	10 Azar (Dec)	Esprit	2.202	a	18321.49	e	2786.55	e	1180.14	e	3439.13	f	0.135	d
		Marfona	2.112	bcd	23983.51	b	4484.95	a	1341.25	cd	4163.31	bc	0.205	abc
		Savalan	2.156	abc	20528.54	c	3777.66	bc	1413.73	abc	4348.05	ab	0.221	ab
		Agria	2.234	a	18079.89	e	3909.05	b	1204.28	e	3964.74	cd	0.198	bc
	10 Ordibehesht (April)	Esprit	2.019	e	24354.37	b	4711.37	a	1388.87	bc	4046.68	cd	0.21	abc
		Marfona	2.109	bcd	20154.75	cd	3412.12	d	1490.94	a	4413.5	a	0.226	a
		Savalan	2.183	ab	18684	e	3635.12	cd	1033.37	f	3946.87	d	0.196	c
		Agria	2.082	cde	19153.62	de	2740.75	e	1187.87	e	3549.68	ef	0.146	d

phosphorus of the tuber showed (**Table 7**). The highest amount of phosphorus of the tuber in the first and second years in the planting date of November and December was related to Marfona cultivar. In the planting date of May in the first year it was related to Marfona cultivar and in the second year it was related to Esprite cultivar. The correlation of phosphorus content of the tuber with percentage of potassium, iron content, zinc content, fat percentage, and tuber fiber content was positive and significant and with nitrogen percentage of the tuber, the starch percentage of the tuber, and dry matter percentage of the tuber was negative and significant (**Table 7**). Louie et al. (2003) said that potato starch has a significant phosphorus content (456-757 ppm) compared to other plant sources, which is consistent with the results of this research. Also, in the importance of phosphorus. Morrison et al. (2000), reported that increasing the amount of starch phosphorus increases the viscosity in water. Comparison of mean zinc content of the gland showed (**Table 7**). The Savalan cultivar with the average of 1490.938 had the highest zinc percentage of the tuber in the first year in November, December and April cultivation and in the second year, the same cultivar in November and December cultivation was the highest and the sowing date of May, Marfona had the highest zinc content of the tuber. The relation between the zinc content of the tuber with phosphorus percentage of the tuber, potassium percentage of the tuber, iron percentage of the tuber zinc content of the tuber, fat percentage of the tuber was positive and significant with the nitrogen percentage of the tuber, the starch percentage of the tuber and dry matter percentage of the tuber was negative and significant (**Table 10**).

Iron content of the tuber

The results of variance analysis of the iron content of the tuber showed that (**Table 5**) the simple effect of year,

planting date and cultivar at the 5 and 1% probability level, the bilateral effect of year × planting date, year × cultivar and planting date × cultivar and triple effect of Year × planting date × cultivar was significant at 1% probability level. Comparison of mean iron content of the tuber showed that in the first year, in the planting date of November, December and April, Savalan cultivar had the highest percentage of iron in the tuber. In the second year, the Savalan cultivar had the highest content in planting date of November and December and in the April cultivation the Marfona cultivar had the highest amount (**Table 7**). Also, the results showed that there was a positive and significant correlation between iron percentage of the tuber with phosphorous percentage of the tuber, percentage potassium of the tuber, zinc content of the tuber, fat percentage of the tuber, and has negative and significant correlation with percentage of starch (**Table 10**).

Fat percentage of the tuber

The results of variance analysis of fat percentage of the tuber showed that (**Table 5**) the simple effect of sowing depth and simple effect of cultivar, effect of cultivar × year, planting date × cultivar, planting depth × cultivar and triangular effect of planting date × cultivar× level significant at the 5% and 1% probability level. Comparison of the average of interaction of planting date × year × cultivar fat percentage of the tuber showed that Savalan cultivar was placed on the highest date (on average 0.228 mg/kg) in planting date of December, November and April of the first year and December of the second year. In the second year, Marfona cultivar

Table 8. Comparing the average of the Triple interaction of (Planting depth × Planting date × cultivar) on the evaluated traits of potato tuber

(Data× Depth×Cultivar)			Traits					
			Tuber Dry Matter		Water use efficiency (WUE)		Tuber yield (ton/ha)	
10 Aban (Nov)	10 cm	Esprit	20.78	b-f	5.677	ab	25.29	d-h
		Marfona	15.16	i	4.113	c-j	18.33	h-o
		Savalan	22.065	a-d	5.43	abc	24.19	d-h
		Agria	21.112	b-f	5.49	abc	24.5	d-h
	15 cm	Esprit	20.04	c-f	6.147	a	27.38	c-f
		Marfona	16.05	i	4.737	a-g	21.11	e-l
		Savalan	22.07	a-d	5.657	ab	25.22	d-h
		Agria	20.34	c-f	4.24	b-i	18.91	g-n
	20 cm	Esprit	21.88	a-d	4.173	b-j	18.59	h-o
		Marfona	15.54	i	2.963	g-n	13.21	l-o
		Savalan	20.86	b-f	3.32	i-p	14.78	n-o
		Agria	20.15	c-f	4.813	a-g	21.44	e-l
	25 cm	Esprit	21.76	a-d	5.103	a-d	22.74	e-j
		Marfona	16.78	hi	4.693	a-g	20.91	e-m
		Savalan	21.92	a-d	4.79	a-g	21.35	e-l
		Agria	20.18	c-f	4.943	a-e	22.02	e-k
10 Azar (Dec)	10 cm	Esprit	19.82	def	2.733	j-p	12.18	o
		Marfona	16.32	i	3.392	f-n	15.11	l-o
		Savalan	20.30	c-f	3.728	d-l	16.61	j-o
		Agria	20.25	c-f	5.018	a-d	22.36	e-j
	15 cm	Esprit	21.02	b-f	5.462	abc	24.33	d-h
		Marfona	16.75	hi	5.105	a-d	22.75	e-j
		Savalan	22.23	abc	4.635	b-h	20.66	f-m
		Agria	21.34	a-e	4.757	a-g	21.20	e-l
	20 cm	Esprit	18.78	fgh	3.888	d-k	17.33	i-o
		Marfona	17.02	ghi	3.763	d-l	16.78	j-o
		Savalan	21.76	a-d	4.557	b-h	20.3	g-m
		Agria	20.48	c-f	4.448	b-h	19.82	g-n
	25 cm	Esprit	22.26	abc	4.837	a-f	21.54	e-l
		Marfona	16.29	i	3.652	d-l	16.27	j-o
		Savalan	21.38	a-d	3.178	h-o	14.17	mno
		Agria	20.35	c-f	3.453	e-m	15.39	k-o
10 Ordibehesht (April)	10 cm	Esprit	21.06	b-f	2.115	m-p	29.58	a-d
		Marfona	18.83	fgh	2.56	k-p	35.86	a
		Savalan	23.46	a	2.417	l-p	33.86	ab
		Agria	21.28	a-e	2.155	m-p	30.16	a-d
	15 cm	Esprit	21	b-f	19.48	nop	27.28	c-f
		Marfona	19	efg	2.313	l-p	32.39	abc
		Savalan	20.01	c-f	2.165	m-p	30.29	a-d
		Agria	21.12	b-f	1.84	op	25.76	d-g
	20 cm	Esprit	21.02	b-f	1.758	op	24.61	d-h
		Marfona	19.10	efg	1.958	nop	27.45	c-f
		Savalan	20.08	c-f	1.977	nop	27.69	b-e
		Agria	21.2	b-f	1.753	op	24.57	d-h
	25 cm	Esprit	20	c-f	1.72	op	24.05	d-i
		Marfona	19	efg	1.79	op	25.03	d-h
		Savalan	23	ab	1.738	op	24.32	d-h
		Agria	20	c-f	1.578	p	22.09	e-k

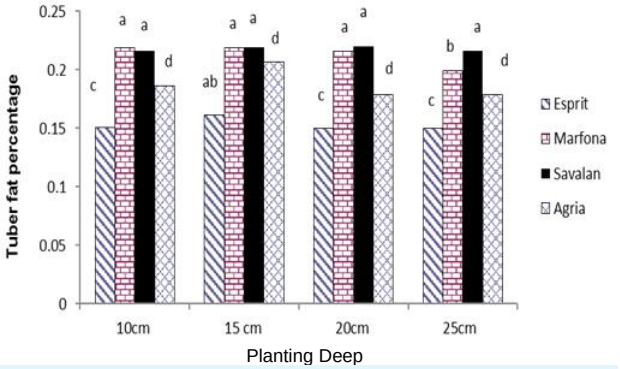

Fig. 1. Comparing the mean of bilateral effect (sowing depth × cultivar) on fat percentage of the potato tuber

had the highest fat percentage in October and April cultivation (**Table 7**). Also, interaction of depth × cultivar of fat percentage of the tuber showed that (**Fig. 1**) Marfona and Savalan cultivars had the highest values in all four sowing depths. The results showed that Savalan and Marfona cultivars had the highest amount of tuber fat for each of the four sowing depths in each of the three seasons. This trait had a positive and significant correlation with potassium, phosphorus, iron, zinc and fiber of the tuber and had a negative and significant correlation with starch percentage and dry matter of the tuber (**Table 10**).

Percentage Starch of Tuber

The results of variance analysis of starch percentage of the tuber showed that (**Table 5**), simple effect of cultivar at 1% probability level, effect of year × cultivar, planting date × cultivar, planting depth × cultivar and triple effects of year × planting date × cultivar, year × sowing depth × sowing date and sowing year × depth × cultivar, at a probability level of 5% and 1%, and

Table 9. Comparing the average of the interaction of (Yaer×Planting depth×Planting date×cultivar) on the evaluated traits of potato tuber

(Year×Data× Depth×Genotype)			Traits			
			Starch of Tuber		soluble sugars	
			Yaer 1	Year 2	Yaer 1	Year 2
10 Aban (Nov)	10 cm	Esprit	14.450a-f	14.07e-m	14.927a-e	0.207a-e
		Marfona	13.200k-o	12.867no	13.253j-o	0.193b-e
		Savalan	14.400a-f	14.773a-e	14.327a-h	0.210a-e
		Agria	14.650a-e	14.483a-f	14.527 a-f	0.203a-e
	15 cm	Esprit	14.400a-f	14.067e-m	15.153a-d	0.210a-e
		Marfona	13.300h-n	13.300h-n	13.135l-o	0.223ab
		Savalan	14.300a-h	14.167c-l	14.153c-l	0.223a-d
		Agria	14.600a-e	14.267a-j	14.153c-l	0.223 ab
	20 cm	Esprit	14.927a-e	15.260ab	14.017e-m	0.193b-e
		Marfona	13.250j-o	12.250op	12.667no	0.213a-d
		Savalan	14.327a-h	14.100c-m	14.733a-e	0.207a-e
		Agria	14.527a-f	14.527a-f	14.483a-f	0.193b-e
	25 cm	Esprit	15.150a-d	15.167 bc	14.067e-m	0.207a-e
		Marfona	13.150l-o	13.267 i-n	13.300h-n	0.183d-e
		Savalan	14.150c-l	14.083d-m	14.167 c-l	0.213a-d
		Agria	14.150c-l	13.483f- n	14.267 a-j	0.177e
10 Azar (Dec)	10 cm	Esprit	14.453a-f	14.320a-h	15.260ab	0.187cde
		Marfona	13.200k-o	11.807p	12.250op	0.220abc
		Savalan	14.400 a-f	14.280a-i	14.100c-m	0.197 a-e
		Agria	14.653a-e	14.203b-k	14.527a-f	0.213a-d
	15 cm	Esprit	14.400a-f	14.343a-g	15.167bc	0.223ab
		Marfona	13.300h-n	12.977no	13.267i-n	0.217a-d
		Savalan	14.300a-h	14.543a-f	14.083d-m	0.223ab
		Agria	14.600a-e	14.003e-m	13.483f- n	0.197a-e
	20 cm	Esprit	14.927a-e	15.290 a	14.320a-h	0.213a-d
		Marfona	13.253 j-o	3.087mno	11.807p	0.213a-d
		Savalan	14.327a-h	13.227k-o	14.028a-i	0.187cde
		Agria	14.527 a-f	14.390 a-f	14.203b-k	0.210a-e
	25 cm	Esprit	15.153a-d	14.477a-f	14.343a-g	0.183d-e
		Marfona	13.153l-o	13.187k-o	12.977no	0.210abc
		Savalan	14.153c-l	14.363a-f	14.543a-f	0.177e
		Agria	14.153c-l	13.320g-n	14.003e-m	0.207a-e
10 Ordibehesht (April)	10 cm	Esprit	14.453a-f	13.150l-o	15.290 a	0.227ab
		Marfona	13.200k-o	14.150c-l	3.087mno	0.217a-d
		Savalan	14.400 a-f	14.150c-l	13.227k-o	0.210a-e
		Agria	14.653a-e	14.450a-f	14.390a-f	0.210a-e
	15 cm	Esprit	14.400 a-f	13.200k-o	14.447 a-f	0.200a-e
		Marfona	13.300 h-n	14.400 a-f	13.187k-o	0.207a-e
		Savalan	14.300 a-h	14.650a-e	14.363a-f	0.197a-e
		Agria	14.600 a-e	14.400a-f	13.320g-n	0.210a-e
	20 cm	Esprit	14.927a-e	13.300h-n	0.230 a	0.210a-e
		Marfona	13.253j-o	14.300a-h	0.213a-d	0.203a-e
		Savalan	14.327a-h	14.600a-e	0.213a-d	0.217a-d
		Agria	14.527a-f	14.927a-e	0.197a-e	0.220abc
	25 cm	Esprit	15.153a-d	13.250j-o	0.207a-e	0.217a-d
		Marfona	13.153l-o	14.327a-h	0.200a-e	0.213a-d
		Savalan	14.153c-l	14.527a-f	0.207a-e	0.217a-d
		Agria	14.153c-l	15.150a-d	0.197a-e	0.207a-e

quadruple effect on year × sowing date × sowing depth × the cultivar, were significant at 1% probability level (**Table 5**). The results of the comparison table showed that the Esprite cultivar had the highest starch percentage of the tuber by 15.290% at depth of 20cm percentage in the second year in December cultivation (**Table 9**). Also, there was a positive and significant correlation between starch percentage of the tuber with nitrogen, potassium, phosphorus, iron, zinc, fat, starch, fiber, dry matter, and soluble sugar of the tuber (**Table 10**). To assess the quality of potatoes, different indices have been used that starch concentration and reducing sugars of the potato are one of the most important indices and are used in potato processing evaluations in the food industry; also, considering the per capita consumption of potatoes in Iran (more than 45 kilograms per year), which has the largest share in the food basket of the people of the country after wheat and rice (Eskandari et al., 2011). Since 80-60% of dry matter is formed from starch, there is a certain correlation between the starch content and dry matter of the tuber and, as seen, The cultivars with the highest dry matter content were the same as those with higher starch content It was reported that dry matter percentage of large gland is usually smaller than the small tubers, because the brain tissue is relatively rich in water, but the relation between tuber size and dry matter percentage is not linear (Napendir, 2003).

Fiber percentage of the tuber

The results of variance analysis of tuber fiber showed that (**Table 5**) was significant only in terms of simple effect of cultivar and planting depth at 1% probability

Table 10. Correlation between of evaluated traits in cultivars

Correlation coefficient	1	2	3	4	5	6	7	8	9	10	11
Nitrogen of tuber (1)	1										
Potassium of tuber (2)	-0.462**	1									
Phosphorus of tuber (3)	-0.188**	0.74**	1								
Iron of tuber (4)	-0.025	0.308**	0.418**	1							
Zinc of tuber (5)	-0.134**	0.502**	0.236**	0.54**	1						
Percentage Fat of Tuber (6)	0.007	0.348**	0.585**	0.674**	0.383**	1					
Starch of Tuber (7)	0.127*	-0.703**	-0.679**	-0.299**	-0.328**	-0.381**	1				
fiber of Tuber (8)	0.213**	0.076	0.222**	0.088	-0.088	0.116*	-0.381**	1			
Tuber dry matter (9)	0.233**	-0.586**	-0.478**	-0.09	-0.15*	-0.135*	0.116*	-0.188**	1		
soluble sugars (10)	-0.072	0.108	0.083	0.073	-0.023	0.099	-0.135*	0.192**	-0.064	1	
total tuber yield (11)	-0.086	-0.079	-0.084	-0.017	-0.039	-0.018	0.163**	-0.142*	0.225**	0.071	1
WUE (12)	0.06	-0.088	-0.065	-0.092	-0.063	-0.089	0.073	-0.037	0.016	-0.05	0.096

level. The fiber percentage affected by different planting depths showed that the sowing depths of 10, 15 and 20 cm had the highest value by mean of 2.11% and were in the same group and the lowest percentage of fiber was at depth of 25 cm by 2.069% (**Table 6**). The fiber percentage of Agria, Marfona and Sprit cultivars with the highest percentage of fiber content were in a statistical group, among which the Savalan cultivar was at the lowest level. As a result, Agria, Marfona and Esprit cultivars had the highest values at the depth of 10, 15 and 20 cm, by mean of 10.2% fiber percentage (**Table 6**). The relations between tuber fiber and nitrogen content of tubers, phosphorous percentage of tuber, fat percentage of tuber and soluble sugars of the tubers were positive and significant and with tuber yield, starch percentage of the tubers and dry matter of tubers were negative and significant (**Table 10**).

Percentage of dry matter

The amount of dry matter of potato is an important indicator of quality. So, in the conversion industries, production efficiency in terms of fresh weight increases the tubers with more solid contents. The results of variance analysis for dry matter of tubers showed that (**Table 5**), simple effect of cultivar at 1% probability level, bilateral effect of sowing date × sowing depth and planting date × cultivar and triple effects of year × sowing date × sowing depth × cultivar at 1% probability level were significant (**Table 5**). The average of dry matter percentage of tubers in cultivars and sowing dates and swing depths were between 15.62 and 23.5, among which the Savalan cultivar at sowing depths of (10, 15 and 25 cm) and Sprite cultivar at sowing depth of 20cm in swing date of November1 were placed in a statistical group and had the highest value and the Marfona cultivar was at the lowest level in all four cultivars. Savalan cultivar on sowing date of December 1, at swing depths of (15, 10, 20cm) and The Savalan and Sprite cultivars had the highest value at swing depths of 25cm and Marfona cultivar was at the lowest statistical level. The Savalan cultivar had the highest value at the depth of 10 and 25 cm in the May cultivation. The results showed that Savalan cultivar had the highest values at all three sowing dates and in all four swing depths (**Table 8**). The relation between dry matter percentage of tubers with tuber yield, percentage of nitrogen and starch of the gland were positive and significant and with percentage of potassium, phosphorus, zinc, fat, fiber and soluble sugar of the tubers were significant and negative (**Table 10**). According to the reports of McCrone and Jeffries (1993), water stress causes premature aging of the leaves, decreasing the growth period, decreasing the intake of solar radiation and consequently, reducing the dry matter yield of the gland. The research results of Mohammadi et al. (2001) showed that, the dry matter percentage of potato tubers increases by increasing water use efficiency. Hersokolpal (1976) showed that water stress reduces the starch percentage of tuber, while Jeffrey McCrone (1993) said that water stress reduced total dry matter and yield, but increases the percentage of dry matter (dry matter ratio to available water).

Soluble sugars

The results of variance analysis of soluble sugars of the tubers showed that (**Table 5**), simple effect of sowing depth at 1% probability level, bilateral effect of sowing date × sowing depth and planting date × cultivar and triple effects of year × sowing date × sowing depth × cultivar and quadripartite effect of year × sowing date × sowing depth × cultivar was significant at 1% probability level (**Table 5**). The average of soluble sugars percentage in Esprite cultivar at depth of 20 cm in swing date of May had the higher value by 0.23 mg in the first year, which Compared to control cultivar increased by 16.75%. (**Table 9**). The soluble sugars percentage with the percentage of starch and fiber had a positive and significant correlation (**Table 10**). Suukins et al. (2000) concluded that glucose content and the end of the potato tuber than at the beginning increases significantly in the post-Glandularisation steps in potato by decreasing irrigation water and creating stress. The activity of the enzymes involved in the synthesis of starch and sucrose (SPS -UGPas) was also significantly reduced. Mezaurric et al. (2002) reported that the dry matter and starch content of different cultivars in different irrigation regimes were almost constant in non-stress conditions, the mean of diversity coefficient of the best tibia for the percentage of dry matter of the gland and the percentage of gastric starch was 8.4 and 8.8. In these

experiments, fewer different cultivars showed amount of reducing sugars in different irrigation regimes. Changes in reducing sugars were varied from 34.2% to 50%. Also, factors such as mechanical damage, germination, temperature and humidity stress, and inappropriate irrigation management are effective on the amount of glucose changes in the gland. If the amount of glucose gets too high, it will increase the color of the product, especially chips, and reduce their quality. Smith et al. (2006) reported that reducing sugars of potato tubers mainly consist of glucose monosaccharaides and fructose, and a small amount of Disaccharide and sucrose. The amount of reducing sugars is one of the effective factors in the quality of color of potato products. Therefore, conditions that reduce the amount of reducing sugars can be recommended for producing potatoes suitable for industrial use.

Water use efficiency

Combined variance analysis table of Water use efficiency showed that the effect of planting date, depth, cultivar and their interaction was significant at 1% probability level (**Table 5**). Sprat, in sowing date of November, Esprit, Agria and Savalan cultivars at depth of 10cm, Esprit, Savalan, Marfona cultivars at depth of 15 cm, Agria cultivar at depth of 20 cm and each four cultivars at depth of 25 cm, in the sowing date of December, Agria cultivar was at a depth of 10 cm, Esprite and Marfona cultivars at a depth of 15 cm and sprite cultivar at a depth of 25 cm were placed in one group. All cultivars were in the lowest group in the planting date of the April in all four depths. Because water consumption is high because of increasing irrigation frequency in the planting date of May 12 times of irrigation took place for potato However, it was determined that in planting date of November sprit cultivar was 10, 15 and 25 cm and Agria cultivar was at depth of 20 cm with water use efficiency of 6 and in planting date of December the Esprit cultivar was at depth of 15 and 25, and Agria cultivar was at depth of 10 cm and Savalan cultivar was at depth of 20 cm with water use efficiency of 5.5, which indicates that they are suitable for water shortage areas and lack of irrigation frequency (**Table 8**). Water shortage during the tubers bulking period greatly reduces the weight of the potato tubers. It seems that with proper planting depth, the plant has a proper root system and, with the optimal absorption of water and food, has a good vegetative growth and plant photosynthesis levels have increased and more photosynthetic materials have been produced, resulting in increased yields (Rezaei et al., 2004).

Tuber yield

The results of variance analysis of tuber yield showed that (**Table 5**) the simple effect of sowing date and sowing depth at 1% probability level, bilateral effect of sowing date × sowing depth, sowing date × cultivar and sowing depth × cultivar and triangular effects of the year × Planting date × Planting depth × cultivar were significant at 1% probability level (**Table 5**). In the study of the interaction of treatment compounds of cultivars and planting depths in April cultivation Savalan, Marfona, Esprit and Agria cultivars at planting depth of 10 cm, Marfona and Savalan cultivars at sowing depth of 15 and 20 cm were in the highest statistical group with the highest yield. In the sowing date of November at planting depths of 15 and 20 cm, Esprite and Agria cultivars had the highest yield. In sowing date of December, Agria cultivar at planting depth of 10 cm and Esprit at depth of 15 cm and Savalan and Agria cultivars at a depth of 20 cm and Esprit cultivar at a depth of 25 cm had greater tuber yield. The final result indicated that in April cultivation Marfona cultivar had the highest desirable yield in all four sowing depths with average of 36 ton per hectare (**Table 8**). The correlation of tuber yield with starch percentage of the tuber and fiber percentage of the tuber was negative and significant and with dry matter percentage of the tuber was significant and positive (**Table 10**).

CONCLUSION

Results showed that autumn planting of potato is very suitable, especially in areas with water shortage, the yield is reduced with low irrigation frequency from 12 steps to 4 steps. Water use efficiency was measured as an important indicator in identifying plant performance versus consuming water. The results of two years indicated that water use efficiency was higher in November and December at depths of 10, 15 and 25 by considering less water consumption with Sprite cultivar. In December cultivation, Esprite cultivar at depth of 15 and 25, Agria cultivar at depth of 10 cm, and Savalan cultivar at depth of 20 cm with water use efficiency of 5.5 (kg/m3) are appropriate as treatments combination for areas where there is a shortage of water and lack of irrigation frequencies. The highest yield was on sowing date of (April) and was significantly superior to two planting dates of November and December. The highest positive correlation coefficient was observed between potassium content of the tuber and phosphorus with coefficient of (r = 0.74 **) and the highest negative coefficient was obtained between the starch percentage of tuber and potassium content of the gland with coefficient of (r = -0.703 **). The correlation of tuber yield with starch percentage of tuber and fiber percentage of tuber was negative and significant and with dry matter percentage was positive and significant.

REFERENCES

Abbasifar, A., A. Kashi, & H. Ghaffari. 1994. Estimate the effects of planting depth in potato varieties. Report of Investigation Project, Agricultural and Natural Resource Research Center of Markazi Province. 74 p. (In Persian)

Abeledo L.G., R. Savin & A. Slafer. 2008. Wheat productivity in the Mediterranean Ebro Valley: Analyzing the gap between attainable and potential yield with a simulation model. European Journal of Agronomy. 28: 541-550.

Ali-mohammadi, R., A. Imani & A. Rezaei. 2004. Study the effect of density and planting depth on growth and yield of potato. Journal of Seed and Plant. 19: 75-58. (In Persian)

Arzehgar, Z., Azizkhani, V., Sajjadifar, S., Fekri, M. (2019). Synthesis of 2-Amino-4H-chromene Derivatives under Solvent-Free Condition Using MOF-5. Chemical Methodologies, 3(2), 251-260.

Attiyah, Kh., S. Mobzar, K. Moslemkhani & H. Hassan-Abadi. 2011. National guidelines for determining the value of cro cultivars. Seed and Plant Registration and Certification Institute. 35 p. (In Persian)

Casa, A., G. Ovando, L. Bressanini & J. Martínez. 2013. Aqua crop model calibration in potato and its use to estimate yield variability under field conditions. Atmospheric and Climate Sciences. 3: 397-407.

Darabe, A. & F. Khidrzadeh. 2015. Khavaran cultivar and clone 8-397009 suitable for autumn fallow potato in Khuzestan province. Scientific-extension publication of research findings in arable and garden plants. 4(1): 116-101. (In Persian)

Eskandari, A., H.R. Khazaie, A. Nezami & M. Kafi. 2011. Study the effects of irrigation regimes on yield and some qualitative characteristics of three cultivars of potato (Solanum tuberosum L.). Journal of Water and Soil. 25(2): 240-247. (In Persian)

Ezaazimi, J.M., M. Svdar, M. Zsaefzadh & S.H. Haghjo. 2009. Different tillage and planting methods on yield of potato in the Irbil region. Proceedings of the Fifth National Congress of Agricultural Engineering and Mechanization machine. The site, http://www. civilica.com.

Gayler, S., E. Wang, E. Priesack, T. Schaaf & F. Maidl. 2002. P Modeling biomass growth, Nuptake and phenological development of potato cro. Geoderma. 105: 367-383.

HassanPanah, D. 2016. The most suitable cultivars and planting depths for autumn fallow cultivation potato in different regions of Ardebil province. Ardabil Agricultural Jihad Organization, Coordination of Promotion Affairs. Promotion magazine. No. 115. Register number 45825 at Agricultural Science Information Center. (In Persian)

Hassan-Panah, D., Kh. Nikisad & M. Hassani. 2008. Seed Potatoes. Ardabil Agricultural Jihad Organization. 193 p. (In Persian)

Khayatnezhad, M. & R. Gholamin. 2011. Effects of planting depth and soiling time of the plant foot on the potato yield. African Journal of Agricultural Research. 16:3804-3809. (In Persian)

Khorshidi-benam, M.H., F. Rahimzadeh, M. Mirhadi and G. Noor-mohammadi. 2003. Study the effect of drought stress on the growth of potato varieties. Journal of Iranian Crop Sciences. 4:58-48. (In Persian)

King, B., J. Stark & S. Love. 2003. Potato production with limited water supplies. Proc. Univ. of Idaho Winter Commodity Schools. 35:45-54.

Laei, G., M. Noryan & H. Afshari. 2012. Determination of the planting depth of potato seed tuber yield and yield components of two varieties agria and draga response curves seed. Annals of Biological Research. 12:5521-5528.

Lal, S.S. & K.C. Sud. 2001. Potato. In: P.S. Rathore (ed.), Techniques and management of field crop production. Agrobios.

Lalehgani-dezaki, B., A.R. Kocheki & M. Nasirimahallati. 2007. Effect of manure and planting depth on phenological stages and tuber yield of potato. Journal of Iranian Crop Researches. 2: 1-10. (In Persian)

Miri, Z., J. Asghari & G. Panahi. 2009. Effect of irrigation regimes and fertilizer combinations on yield of two potato cultivars in Feridan. Journal of Science and Technology of Agriculture and Natural Resources. 46: 34-42. (In Persian)

Mortazavibak, A. & R. Aminpor. 2003. Effect of season and planting depth on commercial yield varieties of potatoes. Journal of Seed and Plant. 4: 33-42. (In Persian)

Onder, S., M. Caliskan, D. Onder & S. Caliskan. 2005. Different irrigation methods and water stress effects on potato yield and yield components. Agricultural Water Management. 73: 73–86.

Pavek, M.J. & R.E. Thornton. 2009. Planting depth influences potato plant morphology and economic value. American Journal of Potato Research. 86: 56-67.

Rafi, M.R. and A. Darabi. 2008. Effect of irrigation on yield and yield components of potato varieties. Journal of Agriculture Science. 3: 36-47. (In Persian).

Rezaei, A. & A. Soltani. 2004. Potato farming. Pub. Mashhad University. (In Persian)

Van Ittersum, M.K., P.A. Leffelaar, H. Van Keulen, M.J. Kropff, L. Bastiaans P& J. Goudriaan. 2003. On approaches and applications of the Wageningen crop models. European Journal of Agronomy. 18: 201-234.

Van Wart, J., K.C. Kersebaum, S. Peng, M. Milnera & K.G. Cassman. 2013. Estimating crop yield potential at regional to national scales. Field Crops Research. 143: 34-43.