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European Journal of Experimental Biology, 2014, 4(1):177-185

ISSN: 2248 –9215
CODEN (USA): EJEBAU

A comparison of quantitative and qualitative yield on some resistant cultivars to rhizomania disease of sugar beet (*Beta vulgaris* L.) in to qualification of alloy and unspotted to rhizomania

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ABSTRACT

Rhizomania or root madness is one of the main diseases of sugar beet (Beta vulgaris L.) and it is common all around the world. The disease usually causes more than 50% of product yield loss and even 100% in more acute cases. An experiment on more than 11 Rhizomania resistant cultivars, randomly placed on blocks with three replications (in two locations: Fariman Sugar Mill Research Farms (contaminated and free of contamination, Khorasan Razavi) was conducted in 2012 to measure resistance of the specimens. The results showed, for station 1, Merak and 006 cultivars were the most resistant cultivars concerning development of root per hectare. In addition, Merak, 006, Azar, Rozir, Delta, and Native Color cultivars had the maximum yield/ha. Moril cultivar had the lowest root yield and genotypes 004, Iranian Razifort, 005, and Zarghan had the lowest yield. However, in case of the station 2, 005 and 004 cultivars had the maximum and minimum root and sugar yields respectively.

Keywords: Rhizomania, sugar beet, cultivar, resistant, stimulate, station

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INTRODUCTION

Rhizomania or Root madness is one of the most threatening diseases of sugar beet (Beta vulgaris L). The cause of the disease is beet necrotic yellow vein virus (BNYVV), which is communicated by Polymyxa betae Keslein. [18, 19]

The first ever report of the disease with similar symptoms of Rhizomania was reported in North Italy (1952). Kanowa (1966) named the disease Rhizomania or root madness due to abnormal behavior of the root of the infected plant [12]. At the same time other reports of the disease came from Japan [11]. Afterward, in 1985 in France the relatively resistant variety of Rizor was developed and product yield was considerably increased in the farm planted with the new variety [15]. Stone et al. (2006) studied 21 genotypes resistant to Rhizomania in two farms (contaminated and free of contamination) in Siberia and Montenegro. They reported that comparing with the control group (12 MT/ha), Concento cultivar (85.78MT/ha) had the highest product yield in the farm infected with the disease. In addition, in comparison with control cultivar (10.92%), Ivona (15.365%) had the highest rate of sugar; and Remos cultivar (9.205MT) had the highest sugar yield comparing with the control group (0.842MT).

furthermore, no significant qualitative and quantitative difference was observed in the free of contamination farm [17]. Efficient control needs significant increase in disease inoculums in the soil as a way to increase resistance of the plant. Resistant against the disease is mono genic and this makes it vulnerable. Resistance mechanism includes limiting virus multiplication or transfer. Currently, there are several highly resistant to Rhizomania mono gene cultivars available in the market; including Dorethea, Avantage, Laetitia, etc. It is noticeable that the resistance is not 100% and it might fail depending the patho-type of the virus or severity of the disease. There are reports of Rhizomania from different parts of the world which indicate that the disease still is one of the main threats against sugar beet [13]. Sustained loss usually is more than 50% and reaches 100% in some cases. [15, 16]

Iezadpanah et al. (1996) made the first report of Rhizomania in Fars, Iran [1] and afterward, the case was witnessed in other sugar beet farms in the country including in Khorasan, Fars, Isfahan, Kermanshah, Ghazvin, Zanjan, Hamedan, Kohkuloyeh va Boirahmad, Char Mahal Bakhtiari, Semnan, and Lorestan [2-4]. Currently, the extent of economic loss of the disease have forced many sugar beet farms stop farming the plant. In addition, the disease considerably shrinks the mass of the root and sugar content. Consequently, product yield is reduced up to about half of the normal yield. Several measures have been prescribed to fight the disease thus far including farming operation, chemical solutions, and genetic solutions. [15, 16]

Farming methods include early planting, avoiding excessive moisture, shorter irrigation process and closer irrigation turns, avoiding contamination of the healthy farms, and other alternatives. However, in spite of all these measure, damages caused by the disease still can be considerable and make the measure obsolete [9, 14]. For chemical measures, there are several fungicides to fight the disease and among them, except for soil sterilizer (e.g. methyl bromide) other fungicides are ineffective [10, 16]. Currently, extensive surveys are in hands in different fields of diseases, among them studies to develop resistive cultivars is notable. The present research is aimed to assess performance of commercial cultivars of sugar beet (domestic or imported) after being affected by the disease and to recommend the most compatible and resistive case to be used in the contaminated regions.

MATERIALS AND METHODS

The cultivars were prepared from the supplier institutes (11 cultivars, Table 3) and were randomly planted in randomly block design with three replications (5 May 2011) in two stations of the research farms of Fariman Sugar Co. (Tables 1 & 2). The site of experiment was adopted taking into account the climate of the region [6-8]. Each cultivar was planted on six lines (8m) and 50 rows. Irrigation method was sub-irrigation and during growth season, thinning, weeding, and noting were carried out. In 6^{th} of November 2011 at 10.7°C, 4m2 of each block (two mid lines) was harvested and number/weight of roots were measured separately. Qualitative and quantitative traits including yield of root, rate of sugar, rate of molasses, sugar and white sugar, health threatening level of nitrogen, sodium, and potassium, alkalinity, and dry mass of root were determining and the data was analyzed in SPSS 15, SAS, and Excel. (Table 2, 5, 6).

Table 1- Average temperature, precipitation, and physical/chemical analyses on the farm soil [6-8]

Total annual precipitation (ml)	Ave. temperature at growth season (C)	Irrigation method	Soil texture	Rate of Rhizomania contamination of soil (farm 1)	Rate of Rhizomania contamination of soil (farm 2)
296.4	14.7	Sub-irrigation	Loam	Severe	Clean

Station	EC (ds/m)	pH	% T.N.V	% O.C	% Sand	% Clay	% Silt	% Sp
1	1.2	7.9	17.5	0.241	34	25	41	38.4
2	1.9	8.2	16	0.504	46	19	35	37.6

Table 2 - Temperature and precipitation statistics research farm during the growing season

						2011-12									Torbat heidarie			
Monthly evaporation	**Sunny (hrs)**	**Direction**	**Max. wind speed**			**Rain**	**rain**				**Relative moisture**				**Temperature**			**Month**
			Speed (m/s)	**Day**	**Frost**			**Ave.**	**Max ave.**	**Min. Ave.**	**Definite max.**	**Definite Min.**	**Ave.**	**Max. ave.**	**Min. Ave.**	**Definite max.**	**Definite Min.**	
107.8	214.1	350	12	25	1	17	130.7	64	88	39	99	12	10.7	16.2	5.2	23.4	-0.4	**April**
207.5	267.7	200	15	10	0	10	23.6	54	78	31	95	13	17.5	23.4	11.6	30.2	3.4	**May**
326.9	349.5	330	14	2	0	2	0.8	35	50	19	75	06	22.4	28.9	15.8	34.5	8.2	**June**
415.8	378.7	050	09	22	0	0	0	27	36	17	53	07	25.9	32.6	19.1	37.6	13.2	**July**
411.2	366.4	060	11	20	0	0	0	30	41	20	56	08	27.7	34.2	21.2	37.4	16.2	**August**
292.4	329.8	340	12	24	0	2	6.6	32	48	17	86	05	21.8	29.1	14.4	34.8	7/2	**September**
201.6	306.5	010	10	3	0	0	0	32	48	17	77	10	16.5	24.4	8.6	33	0	**October**
98.5	238.3	280	09	10	6	5	9.7	48	70	25	100	10	10.7	18.1	3.3	24	-3.2	**November**
-	129.4	350	10	1	16	10	33.7	75	94	56	100	31	3.6	7.5	-0.3	13	-5.4	**December**
-	186	060	08	20	13	5	14.3	68	91	46	100	16	5	10.8	-0.8	15	-8.4	**January**
-	166.1	350	11	18	20	12	43.8	69	93	45	100	24	3.8	9	-1.5	17.4	-10.4	**February**
-	169.4	060	11	28	0	9	33.2	62	87	36	98	08	11.2	17.5	5	28	0.4	**March**
2061.7	3101.9				56	72	296.4											**Annual total**
								49	69	31			14.7	21	8.5			**Ave.**
		200	15								100	5				37.6	-10.4	**definite**

Table 3- Properties of the sugar beet cultivars

Remark	Cultivar	No.
Resistant to Rhizomania (Iranian mono-gene)	004	1
Resistant to Rhizomania (Iranian mono-gene)	005	2
Resistant to Rhizomania (Iranian mono-gene)	006	3
Resistant to Rhizomania (Iranian mono-gene)	ZARHGAN	4
Resistant to Rhizomania (Iranian mono-gene)	RIZOFORT(IRAN)	5
Resistant to Rhizomania (mono-gene)	AZAR	6
Resistant to Rhizomania (mono-gene)	BOMIRANG	7
Resistant to Rhizomania (mono-gene)	DELTA	8
Resistant to Rhizomania (mono-gene)	MORIL	9
Resistant to Rhizomania (mono-gene)	ROZIER	10
Resistant to Rhizomania (mono-gene)	MERAK	11

Table 4. Technical terms of sugar beet yield and quality (Abdollahi Noghabi et al. 2005)

English	Definition		Title: Symbol	Title: English	No.
t. ha^{-1}	Weight of harvested roots in area unit after rinsing (net weight)	Root yield of sugar beet per area unit (root wet weight)	RY	Root yield	1
% in beet or g sugar.100g beet^{-1}	Polarimetric method	Sugar content in wet root of sugar beet	SC or (Pol)	Sugar content	2
meq.100g beet^{-1} or mmol. 100g beet^{-1}	Potassium and sodium were measured through photometric film Nitrogen was measured using chromometry (blue number)	Amount of health threatening potassium, sodium, amino-nitrogen	K Na α-N	Impurities: - Potassium - Sodium - Amino-nitrogen	3
mg. 100g beet^{-1} or mg. 100g sugar^{-1}	According to Berlin Institute method	Total amount of glucose and fructose with reducing sugars in root of sugar beet	RS (I)	- Reducing sugar (Invert sugar)	4
% in beet or g sugar.100g beet^{-1}	Based on volume of health threatening potassium, sodium, and nitrogen and using a standard experimental formula	Amount of extractable sugar from root of sugar beet (molasses/sugar beet rate)	MS	Molasses sugar	5

* *Terms in the parentheses are wrong commonly used term which are not recommended*

Table 4. Continued, Technical terms of sugar beet yield and quality (Abdollahi Noghabi et al. 2005)

% in beet	WSC = SC - (MS + 0.6*) Sugar waste in the mill (set to 0.6)*	Amount of extractable white sugar content of sugar beet in mill Among of extractable sugar	WSC RWS	- White sugar content or - Recoverable white sugar	6
t. ha^{-1}	SY = SC × RY	Amount of produced sugar in area unit (sucrose content of sugar beet root)	SY	Sugar yield	7
t. ha^{-1}	WSY = WSC × RY	Extractable while sugar content of white beet per area unit	WSY	White sugar yield	8
% in sugar	ECS = (WSC ÷ SC) ×100	Content of extractable white sugar from sucrose content in sugar beet root	ECS (Yield)	Extraction coefficient of sugar (Purity)	9
-	Alc=(K+Na) ÷ (α-N)	Health threatening sodium/potassium to nitrogen ratio in sugar beet	Alc or AC	Alkalinity coefficient	10

* *Terms in the parentheses are wrong commonly used term which are not recommended*

Table 4. Continued, Technical terms of sugar beet yield and quality (Abdollahi Noghabi et al. 2005)

% in beet	Weight of roughage materials in root of sugar beet after four stages of extracting essence with boiling water and drying afterward (105°C)	Amount of non-solved solid materials (roughage) in root of sugar beet	Marc	Marc	11
% in extract	Refrectometry method	Density of roughage in extract of sugar beet root	Brix	Brix	12
% in extract	RJP = (SC × 100) ÷ Brix	Sugar content to total roughage in extract of sugar beet ratio	RJP (Q)	- Raw juice purity (Quotient)	12
mmol K. 1000g sugar^{-1}	KSR = (K × 1000) ÷ SC	Potassium in 1000gr of sugar beet root	KSR (KS)	Potassium to sugar ratio	14
mmol α-N. 1000g sugar^{-1}	NSR = (α-N × 1000) ÷ SC	Amino nitrogen content per 1000gr of sugar in root of sugar beet	α- NSR (NS)	Amino nitrogen to sugar ratio	15
mmol Na. 1000g sugar^{-1}	NaSR = (Na × 1000) ÷ SC	Sodium content per 1000gr of sugar in root of sugar bee	NaSR	Sodium to sugar ratio	16
Kg sugar. m^{-3}	WUE = (SY÷WU) × 1000	Sugar yield to water use ratio	WUE	Water use efficiency	17

Variation of the elements has been found in the root of sugar beet in Iran and Germany climate by researchers. Given that the study was carried out in Razavi Korasan, Iran, the related data were used for comparing the results. [11] (Table 5-7)

Table 5- variation of potassium content (meq) of root of sugar beet in Iran and Germany (Abdollahian Noughabi, 2001)

Location	Number of samples	Min.	Max.	Ave.	Std. deviation	Variation rate (%)
Korasan	2570	0.04	11.58	5.83	1.27	22
Isfahan	3946	3.27	12.78	6.57	1.13	17
Hamedan	115	4.43	10.69	6.27	1.04	17
Fars	345	4.97	11.78	7.70	1.41	18
Kermanshah	111	4.29	9.59	6.02	1.00	17
Chaharmahal bakhtiari	476	4.50	11.15	6.92	0.94	14
Experiments	10943	0.81	18.46	5.83	1.79	31
Germany (1974)	58	4.19	10.23	6.38	1.63	26

Table 6- variation of sodium content (meq) of root of sugar beet in Iran and Germany (Abdollahian Noughabi, 2001)

Location	Number of samples	Min.	Max.	Ave.	Std. deviation	Variation rate (%)
Korasan	2570	0.13	13.22	2.81	1.52	54
Isfahan	3946	0.53	19.99	3.85	2.29	59
Hamedan	115	1.00	11.15	3.39	1.51	45
Fars	345	0.58	11.08	1.93	1.03	53
Kermanshah	111	0.94	7.48	3.54	1.50	42
Chaharmahal bakhtiari	476	0.68	8.55	2.23	1.31	59
Experiments	10943	0.22	15.72	3.66	2.41	66
Germany (1974)	58	0.35	5.48	0.98	0.83	84

Table 7- variation of amino nitrogen content (meq) of root of sugar beet in Iran and Germany (Abdollahian Noughabi, 2001)

Location	Number of samples	Min.	Max.	Ave.	Std. deviation	Variation rate (%)
Korasan	2570	1.01	14.70	4.91	1.71	35
Isfahan	3946	0.59	13.16	4.33	1.83	42
Hamedan	115	1.65	8.59	4.42	1.54	35
Fars	345	1.18	10.84	3.97	1.30	33
Kermanshah	111	1.36	9.99	5.14	1.80	35
Chaharmahal bakhtiari	476	1.85	8.41	3.83	1.08	28
Experiments	10943	0.03	40.12	2.90	2.10	72
Germany (1974)	58	0.93	5.14	2.61	0.82	31

Results from station 1

1. Sugar and white sugar percentage

The results revealed that the rate of sugar (impure sugar) and white sugar (pure sugar) were affected by the genotypes under study at 1% level (Table 8). As indicated in the table, comparison of average figures shows that cultivar 4 yielded highest level of sugar (21.50) and white sugar (18.67); and cultivars 8 and 9 had the lowest yield of sugar (18.88 and 18.70 respectively) and white sugar (15.87 and 15.41 respectively). Table 9)

2. Root yield

Root yield per area unit is mainly important concerning the sugar yield. Variance analyses showed that root yield was influenced by the genotype with variance of 161/166 and the effect was significant at 1%. That is, significant difference was observed regarding root yield among the genotypes udder study. (Table No. 8)

As listed in Table 9, maximum root yield was obtained by cultivars 7 and 8 (Iranian) with 72.71 and 69.08MT/ha respectively. Moreover, minimum root yield was obtained for cultivar 2 (46.83MT/ha) and the difference between the maximum and minimum yields is 25.55MT/ha.

3. Sugar extraction and molasses sugar rate

As indicated in the variance table below, variance of sugar extraction (15.619) and molasses sugar (0.471) of the cultivars are significant at 1% and 5% levels respectively (Table 8). Genotype 3 (88.15) had the maximum rate of sugar extraction and genotypes 2 (82.08), 9 (81.89), and 10(79.95) had the minimum rates of sugar extraction. Regarding molasses sugar extraction, cultivar 10 and 2 had the maximum molasses sugar extract (3.16 and 3.19 respectively) and minimum extractable sugar (82.08 and 79.95 respectively). It is notable that a wide gap exists cultivar 3 (8.20, 6.26, 6.07) and cultivars 2, 9, and 10; which is a crucial factor for sugar mill. That is, the higher the rate of extractable sugar, the higher the rate of white sugar; to put it another way, less rate of molasses sugar means less waste of product. (Table 9)

4. White sugar yield

There was a significant difference in white sugar yield (root yield * white sugar rate) between the cultivars under the effect of the genotypes and control group at 1% and variance level of 5.677 (Table 8). As listed in variance table, maximum white sugar yield was obtained in cultivars 7, 8, 3, 5, 6, and 7 at 12.73, 10.98, 10.77, 10.74, 10.24, and 9.73 MT/ha respectively; while minimum white sugar yield was obtained for the cultivars 1, 9, 10, 11, and 2 equal with 9.50, 8.71, 8.70, 8.56, and 8.07MT/ha respectively. (Table 9)

5. Dry mass rate

Difference between the experiment and control groups regarding dry mass rate was significant at 5% and variance of 2.301. That is, there is a significant difference regarding root performance among the genotypes under study (Table 8). As listed in Table 9, dry mass rate is maximum for cultivars 8 (27.62%) and 4 (27.52%); and minimum dray mass rate is for cultivar 6 (24.90%).

Results from station 2

1. Sugar and white sugar percentage

The results revealed that the rate of sugar (impure sugar) and white sugar (pure sugar) were affected by the genotypes under study at 1% level (Table 10). As indicated in the table, comparison of average figures shows that cultivar 4 yielded highest level of sugar (21.62) and white sugar (18.39); and cultivar 9 had the lowest yield of sugar (17.93) and white sugar (15.46). (Table 11)

2. Root yield

Root yield per area unit is mainly important concerning the sugar yield. Variance analyses showed that root yield was influenced by the genotype with variance of 55/055 and the effect was significant at 1%. That is, significant difference was observed regarding root yield among the genotypes udder study. (Table 10)

As listed in Table 11, maximum root yield was obtained by cultivar 11 (Iranian) with 63.00MT/ha.. However, no significant was observed regarding root yield between the cultivars.

3. Sugar extraction and molasses sugar rate

As indicated in the variance table below, variance of sugar extraction (15.619) is significant at 1%, while regarding molasses sugar (0.471) it is not significant (Table 10). Genotypes 4 and 7 (89.21 and 89.28 respectively) had the maximum rate of sugar extraction and genotype 9 (86.23) had the minimum rate of sugar extraction. Regarding molasses sugar extraction, cultivar 9 and 11 had the maximum molasses sugar extract (1.93 and 1.90 respectively) and minimum extractable sugar (86.23 and 86.65 respectively). It is notable that a wide gap exists cultivar 3 (8.20, 6.26, 6.07) and cultivars 2, 9, and 10; which is a crucial factor for sugar mill. That is, the higher the rate of extractable sugar, the higher the rate of white sugar; to put it another way, less rate of molasses sugar means less waste of product. (Table 11)

4. White sugar yield

There was a significant difference in white sugar yield (root yield * white sugar rate) between the cultivars under the effect of the genotypes and control group at 1% and variance level of 3.046 (Table 8). As listed in variance table, maximum white sugar yield was obtained in cultivars 1, 6, and 11 at 9.69, 10.18, and 11.85MT/ha respectively; while minimum white sugar yield was obtained for the cultivars 9 equal with 6.57MT/ha. (Table 11)

5. Dry mass rate

Difference between the experiment and control groups regarding dry mass rate was significant at 5% and variance (2.301). That is, there is a significant difference regarding root performance among the genotypes under study (Table 10). As listed in Table 11, dry mass rate is maximum for cultivars 1 (30.29%), 4 (30.21%), and 7 (30.12%); and minimum dray mass rate is for cultivars 11 (27.45%) and 5 (27.09%).

Table 8 – Variance analysis of the traits under study (station 1) Mean square of traits

(S.O.V)	(df)	Sugar (%)	White sugar (%)	Root yield	Dry mass (%)	Sugar yield	White sugar yield	Sugar extraction coefficient	Molasses sugar (%)
Replication	2	0.993	1.747	88..830	4.521	1.940	0.999	1.026	0.003
Treatment	10	*2.887	*3.965	*161.616	*2.301	*6.603	*5.677	*15.619	*0.471
Error	20	0.868	1.051	87.304	0.817	3.692	2.623	6.039	0.222
%CV		8.50	11.90	21.47	5.74	2.18	24.11	4.71	26.29

*Ns, *, ** significant and insignificant at 1 and 5% levels respectively*

Table 9- average effect of the treatments on the traits under study based on Duncan's test (station 1)

treatment	cultivar	treatment cultivar	Molasses sugar (%)	White sugar yield	Sugar yield	Dry mass (%)	Root yield	white sugar (%)	Sugar (%)
1	ZARGHAN	83.96 abc	2.55abc	9.50 b	11.31 b	26/31 abc	57.38 abc	16.55 bcde	19.70 bcde
2	MORIL	82.08c	3.16 a	8.07 b	9.80 b	25/16 bc	46.83 c	17.42 abc	2118 ab
3	AZAR	88.15 a	1.82 c	10.77 ab	12.22 ab	26.86 ab	59.75 abc	18.05 ab	20.47 abcd
4	DELTA	86.86 ab	2.23 bc	9.73 ab	11.21 b	27.52 a	52.25 bc	18.67 a	21.50 a
5	ROZIR	83.72 abc	2.76 ab	10.74 ab	12.84 ab	26.82 ab	62.08 abc	17.36 abcd	20.72 abc
6	BOMIRANG	84.44 abc	2.41abc	10.24 ab	12.11ab	24.90 c	62.75 abc	16.34 bcda	19.35 cde
7	MERAK	84.69 abc	2.24bc	12.73 a	15.09 a	26.67 ab	72.71 a	17.51 abc	20.68 abcd
8	006	83.99 abc	2.41abc	10.97 ab	13.05 ab	27.62 a	69.08 ab	15.87 cde	18.88 e
9	004	81.89 c	2.78 ab	8.71 b	10.57 b	26.74 ab	56.42 abc	15.41 de	18.70 e
10	RIZOFORT(IRAN)	79.95 c	3.19 a	8.70 b	10.85 b	26.31 abc	57.38 abc	15.13 e	19.70 bcde
11	005	82.72 bc	2.79 ab	8.56 b	10.67 b	26.39 abc	54.54 abc	15.72 cde	19.60 bcde

Table 10 – Variance analysis of the traits under study (station 2)
Mean square of traits

(S.O.V)	(df)	Sugar (%)	White sugar (%)	Root yield	Dry mass (%)	Sugar yield	White sugar yield	Sugar extraction coefficient	Molasses sugar (%)
Replication	2	5.079	5.094	662.73	9.466	27.909	22.185	5.343	0.051
Treatment	10	*1.565	*1.942	*77.05	**3.456	**3.804	**3.046	**2.863	ns0.034
Error	20	0.710	0.986	95.71	1.329	3.170	3.408	3.014	0.051
%CV		6.47	8.21	13.80	6.47	18.79	19.16	19.30	10.48

*Ns, *, ** significant and insignificant at 1 and 5% levels respectively*

Table 11- average effect of the treatments on the traits under study based on Duncan's test (station 2)

treatment	cultivar	Molasses sugar (%)	White sugar yield	Sugar yield	Dry mass (%)	Root yield	white sugar (%)	Sugar (%)
1	ZARGHAN	1.71 ab	9.69 a	10.95 ab	30/29 a	55.71 ab	17.37 abc	19.65 ab
2	MORIL	1.77 ab	8.84 ab	10.03 ab	28/90abc	50.53 ab	17.46 ab	19.81 ab
3	AZAR	1.80 ab	9.46 ab	10.91 ab	27/78 bc	55.42 ab	17.10 abc	19.73 ab
4	DELTA	1.56 c	8.95 ab	10.02 ab	30/21 a	48.54 ab	18.39 a	21.62 a
5	ROZIR	1.81 ab	90.52 ab	10.84 ab	27/09 c	55.62 ab	17.14 abc	19.55 ab
6	BOMIRANG	1.64 ab	10.18 a	11.36 a	27/86 bc	57.27 ab	17.81 ab	19.82 ab
7	MERAK	1.51 c	9.25 ab	10.66 ab	30/12b	57.37 ab	16.30 bc	18.73 bc
8	006	1.63 ab	8.38 ab	9.50 ab	29/68 ab	49.92 ab	16.82 abc	19.05 abc
9	004	1.90 a	6.57 b	7.62 b	28/31abc	42.25 b	15.46 c	17.93 c
10	RIZOFORT(IRAN)	1.77 ab	9.16 ab	10.49 ab	28/94 abc	55.87ab	16.41 bc	18.78 bc
11	005	1.93 a	10.24 a	11.85 a	27/45c	63 a	16.47 abc	19 abc

DISCUSSION

In the case of station 1 (contamination with Rhizomania), cultivar 4 (DELTA) had the maximum rate sugar (21.50%) and white sugar (18.67%), while the minimum rate of sugar was by cultivar 8 (006) and 9 (004) (18.88% and 18.78% respectively); and cultivar 19 (Rizofort (Iran)) yielded minimum rate of white sugar (15.31%). On the other hand, cultivar 7 had the maximum yield of sugar (15.06 MT/ha) and white sugar (12.73MT/ha) comparing with other treatment. This makes it one of the best options for the regions contaminated with virus (Table 9). In addition, cultivar 7 (MERAK) and 8 (006) had the maximum root yield (72.71 and 69.08MT/ha respectively); while maximum amount of white sugar was obtained from cultivars MERAK (12.73MT/ha), 006 (10.97MT/ha), AZAR (10.77MT/ha), ROZIR (10.74MT/ha), BOMIRNG (10.74MT/ha), and DELTA (9.73MT/ha). In general, cultivar 7

(MERAK) had higher root (71.71MT/ha) and white sugar (12.73MT/ha) yields in comparison with other genotypes under study. (Table 9)

Two qualitative factors of sugar beet are rate of molasses sugar and sugar extraction rate so that the lower the rate of molasses sugar, the higher the sugar extraction rate (Table 9). The results highlighted that cultivars with lower molasses sugar rate had higher sugar extraction rate and better white sugar yield. As indicated cultivar 2 (MORIL) and RIZOFORT (IRAN) had the highest rate of sugar molasses and consequently the minimum sugar extraction rate. It is noticeable that cultivars 9 (004), 11 (005), and 1 (ZARGHAN) had high molasses sugar rate and lower sugar extraction rate. On the other hand, more resistive cultivars 7 (MERAK), 8 (006), 3 (AZAR), 5 (BOMIRANG), 6 (DELTA), and 4 with higher root yield produced less rate of molasses sugar and higher sugar extraction rate. (Table 9)

Statistical analyses on the data obtained from station 2 (no contamination with Rhizomania) showed that cultivar 4 (DELTA) had the highest rate of sugar (21.62%) and white sugar (18.39%) (similar with the station 1). In fact, cultivar 4 (DELTA) produced highest rate of sugar and white sugar both in contaminated and free of contamination stations. Among other cultivars, 9 (004) produced the minimum rate of sugar (17.93%) and white sugar (15.46%). On the other hand, maximum yield of root, sugar and white sugar (MT/ha) was produced by cultivar 11 (005) (43.35, 7.62, and 6.57 respectively), 6 (BOMIRNG) 57.21, 11.63, 10.18 respectively), and 1 (ZARGHAN) (55.71, 10.95, and 9.69 respectively) (Table 11). Moreover, genotype 4 (004) had the minimum yield of root (43.35MT/ha), sugar (7.62MT/ha), and white sugar (6.57MT/ha) in comparison with other cultivars. It is notable that, except for cultivar 9 (004) no considerable difference was found between the genotypes under study. (Table 11)

The results regarding the station 2 also showed that cultivars with less molasses sugar rate had lower rate of sugar extraction and white sugar yield. Cultivar 9 (004) and 11 (005), comparing with other cultivars had the maximum level of molasses sugar and minimum sugar yield. Cultivar 9 (004), 11 (005, and 1 (RAZGHAN) with high rate of molasses sugar and more resistive cultivars 7 (MERAK) and 4 (DELTA) with low rate molasses sugar produced low and high rate of sugar extraction respectively. (Table 11)

CONCLUSION

Taking into account impossibility of diagnosing soil contamination with Rhizomania virus (in contrast with what is done to diagnose nemathod eggs and larva though testing the soil before plantation), attenuation of probable damages to sugar beet farm by Rhizomania virus is achievable by using the genotypes with good performance in the both conditions (contamination and free of contamination) including 006, BOMIRGN, MERAK, and DELTA. (Table 9, 11)

In general, the healthy end product counts for the farmer and the sugar mill. White sugar yield – the end product – is calculated by multiplying the root yield and white sugar rate. As listed in Table (9, 11), different cultivars were significantly different regarding the two parameters of root yield and white sugar rate. Given the current market price of sugar, each MT increase in white sugar production per hectare means Rls.11750000000 increase in the profit; which with 170000 hectare of farm (2011), this figure comes to RLS.1990 billion or in other words 170.000MT sugar. This figures herald the importance of choosing suitable cultivar for cultivation.

Generally, negative effect of Rhizomania on lessening qualitative and quantitative yield of sugar beet is undeniable and adopting cultivars resistive to the disease is the best approach available. Apparently, different cultivars have different reactions to the disease, which is due to genetic and hereditary features. To have better result, conducting similar experiments in different climates is recommended.

Acknowledgement
Conducting the present study was not possible without financial supports for doing the experiments by Messrs Elahi (Eng.), Nazeran (Eng.), Araghi (Eng.) and other dear colleagues who made great contributions during the study.

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