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RESEARCH ARTICLE

Reducing the incidence of root-rot disease of some sugar beet varieties by sowing dates and irrigation regimes

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Abstract

Two field trials were conducted at the experimental farm of Malawi Agricultural Research Station, El-Minia Governorate, Egypt, during 2018/2019 and 2019/2020 seasons to study the effect of three sowing dates (the 15th of September, October and November) under three irrigations number [eight, nine and seven irrigations] and their effects on root-rot disease, yield and quality of three sugar beet varieties (Farida, Panther and Gazil). A split -split plot design was used. The results indicated that sowing sugar beet on 15th Sept. significantly reduced root rot disease incidence and increased root traits (length, diameter and fresh weight), sucrose %, root and sugar yields/fed and recorded lower contents of impurities, compared to the others two sowing dates in both seasons. Sowing beet plants on 15th Nov. gave the highest phenolic compounds in both seasons. Decreasing irrigations number up to seven times significantly reduced disease severity% in both seasons. Irrigating sugar beet plants nine times significantly achieved the heavier roots and root yield compared to the other two irrigations in both seasons. Applying eight times of irrigation recorded the maximum phenolic compounds, sugar yield, and sucrose % compared to the less or a greater number of irrigations in both seasons. The combined analysis of variance and AMMI analysis of Farida cv. recorded the lowest response of root-rot severity % when applying seven times of irrigation at the first date of sowing (15th Sept.) and Ghazil cv. recorded the highest response to applying nine times of irrigation in the last date of sowing (15th Nov).

Keywords: Sugar beet; Root-rot disease; Sowing dates; Irrigation

Introduction

In Egypt, sowing sugar beet usually takes place during the period extended from August to November. The suitable date for sowing sugar beet mainly depends on many factors such as the previous crop, weathering conditions, and cultivated variety. There is a general agreement that early planting of sugar beet during Sept.-Oct. results in highest sucrose % as well as root and sugar yields per unit area (Nasr and Abd El- Razek, 2008). On the other hand, Sakr et al., (2013) reported that the highest values of total chlorophyll were shown at sowing date of 15th Oct. while, total phenols were the very high at sowing date 15th Dec. El-Mansoub and Mohamed Hanan, (2014) revealed that sowing date of 15th Oct. significantly reduced root-rot incidence and increased productivity traits top and root yields of sugar beet. (Aly and Khalil Soha, 2017) cleared that, sugar beet planted on October had the higher values of root fresh weigh/plant, root and sugar yields/fed, as well as the sucrose%, and less significant impurities compared with that sown on November. Water is the basis of life and an important constituent in plants. Sugar beet requires a certain amount of water for cellular functions and turgor pressure, which supports the structure of the plant. Irrigation frequency (the number of watering and the time interval between them),

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can affect the yield of sugar beet response to water (Howell et al., 1987). Good Most soil borne pathogens of sugar beets are favored by warm and moist soil conditions (Rush, 1990), therefore, irrigation can have profound influences on the development of certain root diseases. Most sugar beet plants can be affected by some fungi responsible for causing root-rot. These opportunistic, soil-borne plant pathogens infect plant root systems, where they thrive under low oxygen or anaerobic conditions. They take advantage of roots that are injured by excessive soil moisture and the resulting low soil oxygen conditions. Prolonged standing water or compacted, water-soaked soils cause oxygen levels in the soil to drop significantly. These soils with little to no oxygen are referred to being anaerobic, and this condition is favorable for root suffocation and injury, which allows for infection by soil-borne pathogens (Andrew, 2019). Piccinni and Rush (2000) showed that sugar beets irrigated every 4 weeks had the lowest disease severity, and higher yield and sucrose compared with the 2- and 3-week frequencies. Abdelaty et al.,(2020) found that, irrigation sugar beet plants 6 irrigations were superior than 4 and 8 irrigations in root length ,diameter ,and weight root yield and sucrose%.

Sugar beet crop is liable to attack by many soil-borne pathogens at all stages of growth causing pre-and post emergence damping-off, as well as various degrees of root-rots (Abada, 1994). Soil-borne fungal pathogens are often responsible for poor establishment and stand loss in sugar beet (Kiewnick et al., 2001 and Weiland and Sundsbak, 2000).They also reduce yield and sugar content (Harveson, 2007). In Egypt, among the most important diseases affecting sugar beet production are damping-off and root-rot caused by several pathogens, i.e. *Rhizoctonia solani*, *Macrophomina phaseolina*, *Sclerotioum rolfsii and Fusarium spp.* (EL-Kazzaz et al., 2000; El-Kholi, 2000 and Husseien Manal, 2005). The biggest challenge faces sugar industry in Egypt and worldwide are diseases and pests (Mehareb and El-Mansoub 2020). *Sclerotium rolfsii and Rhizoctonia solani* were reported to cause serious root-rot disease affecting yield crop in Egypt. Also, the choice of the sugar beet variety is an important agronomic measure directly affecting disease severity and occurrence of Rhizoctonia crown and root rot (Baker and Martinson, 1970 and Windels and Brantner, 2000).

A number of options are available for managing these diseases, including, using resistant varieties, and cultural practices that attempt to modify the soil environment to the benefit of the plant and the detriment of the pathogen are effective in reducing disease severity. These techniques include planting early, and avoiding excess irrigations, which they proved to be very effective in reducing fungal attack to plants (Khalil, 2007). Agricultural practices, i.e. water irrigation frequency and sowing dates may be useful in controlling root-rot disease.

Contrasts in varietal stability and adaptability to environment can be subjectively surveyed utilizing the biplot graphical representation that scatters the varieties as per their PC esteems (De Vita et al., 2010). Biplot analysis is possibly the most dominant interpretive tool for AMMI models (Kulsum et al., 2013). A biplot analysis is an important breeding tool commonly used by breeders to identify traits that could be used to discriminate crop genotypes. (Abo Elenen et al 2019). A biplot, by definition, is a scatter plot that graphically summarizes two factors in such a way that relationships among the factors and underlying interactions between them can be visualized simultaneously. This technique can provide useful information on grouping similar genotypes and/or environments, and can also provide some useful information about the GEI to identify genotypes, which are well-adapted to a particular environment Anley et al., (2013) or MEs in which to conduct tests (Dlamini and Ramburan, 2016). The objective of this research was to assess some agricultural practices including three sowing dates and three number of irrigations pattern per season on root-rot incidence, yield and its quality of three sugar beet varieties.

MATERIALS AND METHODS

Two field trials were conducted at the experimental farm of Malawi Agricultural Research Station, (latitude of 28O N, longitude of 30O E and altitude of 49 m above sea level) El-Minia Governorate, Egypt, during 2018/2019 and 2019/2020 seasons to evaluate the performance of three sugar beet varieties namely (Farida, Panther and Gazil), to three irrigation numbers [irrigating with nine irrigations (recommended practice adopted by local farmers in the studied area, at 20 days intervals), eight (at 23 days intervals) and seven (at 26 days intervals) irrigations] under three planting dates (the 15th of both September, October and November in both seasons respectively) on management of root-rot disease, some biochemical traits, yield and quality attributes of sugar beet crop (Beta vulgaris var. saccharifera, L.) in soil was naturally heavily infested with root-rot causal pathogens. The experiments were conducted in a split-split plot design, where the main plots were assigned to sowing dates, while number of irrigations was allocated in the sub plots and the three sugar beet varieties were sown randomly in the sub-sub plots. The experimental unit was 21 m2 including 5 ridges of 7 m in length and 60 cm in width, with 20 cm between hills. Phosphorus fertilizer was given in the form of calcium super phosphate (15% P_2O_5) at the rate of 30 kg P_2O_5/fed at seed bed preparation. Nitrogen fertilizer was applied as urea (46. % N) at the rate of 80 kg N/fed, in two equal doses; after thinning and three weeks later. Potassium was added with the second nitrogen dose at the rate of 50 kg K_2O/fed as potassium sulfate (48% K_2O).Physical and chemical properties of the experimental soil site are presented in Table 1 that carried out according to (Page, 1982). The averages of monthly temperature (Co) and relative humidity from every season of the experimental sites are illustrated in Table 2.

Table 1: Particle size and some chemical properties of a representative soil sample of the experimental site for 2018-2019 and 2019-2020 growing seasons

Properties	2018/2019		2019/2020	
Texture analysis				
Clay %	45.20		46.40	
Silt %	32.20		28.60	
Sand %	23.60		24.00	
Texture class	Clay		Clay	
pH at (1:2.5) soil : water suspension	7.50		7.50	
Ec m.mohs /cm	1.32		1.15	
Organic matter %	1.18		1.24	
Soluble Cations(meq/100g soil)				
$Ca^{++} + Mg^{++}$	0.71		0.78	
Na^+	0.37		0.40	
K^+	0.09		0.11	
Soluble Anions:				
CO_3+ HCO_3 meq/100g soil	0.33		0.36	
Cl^- meq/100g soil	0.84		0.93	
Available N mg / kg soil	21.10		19.35	
Available P (ppm)	8.50		7.85	
Available K mg kg soil	175		180	
Moisture content (%)				
Soil Depth (cm)	F. C.%	A.W %	F. C.%	A.W %

0-30	35.12	16.75	34.33	15.64
30-60	33.68	15.23	33.14	15.17

F.C. = Field capacity %, A.W.= Available water%

Table 2. Averages of temperature degrees and relative humidity percentages during the two growing seasons at Mallwi.

Season	2018/2019					2019/2020				
Month	Temp.(C^o)			Rh%	R.F (mm)	Temp.(C^o)			Rh%	R.F (mm)
	Max	Min	Avr.			Max	Min	Avr.		
September	34.7	19.8	27.3	37.3	…	37.3	21.6	29.5	35.3	….
October	30.3	15.9	23.1	40.0	…	32.7	18.8	25.8	37.1	….
November	26.1	13.5	19.8	48.9	5.4	28.1	14.2	21.2	48.0	5.0
December	24.1	6.0	15.1	56.8	9.3	23.7	6.7	15.2	55.5	8.3
January	19.4	5.1	12.3	61.4	32.2	19.8	5.5	12.7	59.2	29.7
February	22.3	6.0	14.2	59.4	14.6	24.1	5.9	15.0	58.0	13.9
March	23.61	9.8	16.7	53.7	2.3	25.9	10.8	18.4	51.4	…
April	29.78	12.6	21.2	48.9	…	30.8	14.6	22.7	48.1	…
May	34.98	18.0	26.5	46.8	…	35.3	18.7	27.0	43.6	…..

Source: Agro-meteorological station, Agric. Res. Center, Giza, Egypt. Temp. = Temperature (Co). Rh% = Relative humidity %. Max. = Maximum,. Min. = Minimum. Avr.= Average , R.F =Total rainfall (mm)

The recorded data:

Determination of total chlorophyll and phenolic compounds:

After 120 days from sowing a random sample of ten plants was taken from each sub-plot to determine: leaves total chlorophyll content, was measured as Optical density (OD) using Chlorophyll Meter Model (SPAD-502). Total and free phenol compounds were determined using UV/Vis. Spectrophotometer, Jenway England at wave length 750 nm as described by Singleton *et al*., (1999).

At harvest time (210 day after sowing), the following traits were determined:

1- ***Yield components****:*

1.1 Root length and diameter (cm).

1.2 Root fresh weight (Kg/plant).

2- ***Quality traits:***

2.1. Sucrose percentage was determined using "Saccharometer" according to the procedure outlined by Le Docte (1927). Sodium and Potassium percentages were determined using the Flame photometer according to A.O.A.C. (2005). Alpha-amino-N was determined using Hydrogenation method according to Carruthers *et al*., (1962).

2.2. Sugar lost to molasses (SLM%) was calculated according to the equation of Deviller (1988). as the following formula**:** SLM% = 0.14 (Na% + K%) + 0.25 (α–amino N%) + 0.5.

2.3. Extracted sugar (Ex.S%) was calculated according to the following formula:

Ex.S% = sucrose % - SLM% - 0.6**.** According to Dexter *et al.* (1967).

3- ***Root and sugar yields:***

Weight per plot was obtained and used to calculate:

3.1. Root yield (ton fed^{-1}).

3.2. Sugar yield (ton/fed) was calculated by multiplying root yield by extracted sugar percentage.

Assessment root--rot severity:

The severity of infection by root-rot was assessed using the devised 0-7 scale by Engelkes and Windels (1996) as follows:

0= No visible lesions,

1= Arrested lesions at point of inoculation,

2= Less than 5% shallow, dry rot canker,

3= 5 to 24% deep, dry rot canker,

4= 25 to 49% extensive rot,

5= 50 to 89% rot extensive into interior root.

6= 90 to less than 100%, most dead foliage and

7= 100% dead plants

Statistical analysis

The collected data were statistically analyzed according to Snedecor and Cochran (1980). Treatment means were compared using L.S.D at 5% level of probability.

AMMI Biplot analysis:

For analysis of the interaction of genotype × environment, the AMMI model equation according to Gauch and Zobel (1996) was employed. To determine genotypes stability, the first and second main components were used, to relate the different genotypes to the different environments the biplot diagrams were utilized as described by Gabriel (1971).

Stability analysis of the three sugar beet varieties (Tables 1) was carried out for characters under study and nine field experiments representing the different environments (Table 3). Three different approaches were adopted for estimating stability using the AMMI biplot method of stability analysis with the GeneStat-17.1.13780 software program.

Table 3: Designation and name of nine environments used in this study

Environments	Sowing date	Irrigations number
EN1	15th September	7 times
EN2	15th September	8 times
EN3	15th September	9 times
EN4	15th October	7 times
EN5	15th October	8 times
EN6	15th October	9 times
EN7	15th November	7 times
EN8	15th November	8 times
EN9	15th November	9 times

RESULTS AND DISSCUION

Total chlorophyll and phenol compounds (free, conjugated and total phenols):

The results in Table 4 manifest that all mentioned traits were significantly affected by studied treatments. Sowing sugar beet on 15th Oct., increased leaves total chlorophyll compared to that sown on 15th Sep. or Nov. Sowing beet plants on 15th Nov. attained the highest values of free, conjugated and total phenols contents followed by that sown on 15th Oct., while the planting date on15th Sept. occupied the final rank in both seasons. These results are similar with those reported by Sakr *et al.,* (2013) The relative increase in the values of total chlorophyll due to the enhanced influence of the sowing sugar beet on the 15th Oct. and/or 15th Sept., which exhibited a good canopy for solar energy trapping, in turn high assimilation rate and finally reflected on total chlorophyll, in addition, these effects are attributed in general to the potential ability of the phenolic compounds to reduce, counteract or repair damage resulting from oxidative stress and associated with these diseases

Concerning the effect of irrigations number, data in the same Table cleared that, free, conjugated and total phenols contents significantly increased in leaves of plants irrigated with 8 times followed by plants which received 9 times of irrigation in both seasons. Decreasing irrigations number up to 7 irrigations significantly reduced leaves total chlorophyll whereas, the maximum values were observed with 9 times of irrigation in the two growing seasons. The same trend was found by Piccinni and Rush (2000).These results could be attributed to water shortage leads to closure of stomatal, reduced transpiration, decrease in water potential of plant tissues, decrease in photosynthesis and chlorophyll contents, also the first step of the defense mechanism in plants involves a rapid accumulation of phenols at the infection site, which act as mobilized defense system can be translocated by plants and enzymatically converted into defensive substance at the site attack by root-rot disease under moist soil conditions (Rush 1990 and Lawson *et al.*, 2003)

Data in Table 4 showed that all tested sugar beet varieties significantly differed in total chlorophyll in both seasons ,conjugated, and total phenols in the 2nd season. Farida variety showed a significant superiority over the other tested two varieties in the previously mentioned traits, and recoded the maximum contents of conjugated (75.27) and total phenols (100.87 mg/100 g f.w) in 2nd seasons. This observation may be basically due to the genetic structures of sugar beet varieties These results are in harmony with those achieved by Sakr *et al.*, (2013) and Aly and Khalil Soha, (2017). According to Matern and Kneusal (1988),

Table 4. Total chlorophyll (SPAD value) and phenolic compounds (mg/100 g f.w), of three sugar beet varieties as affected by sowing dates and number of irrigations and their interaction during 2018/2019 and 2019/2020 growing seasons.

Treatments	T. chl.		Phenolic compounds					
			Free		Conj.		Total	
Seasons	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Sowing dates (S)								
15th Sept.	43.23	45.93	24.29	22.27	70.77	62.46	95.06	84.72
15th Oct.	50.41	51.83	28.37	24.86	83.12	72.17	111.49	97.03
15th Nov.	36.91	39.00	31.83	28.87	84.03	81.39	115.87	110.26
LSD at 0.05	2.31	1.07	0.92	0.86	0.11	3.06	1.16	4.22
No. of irrigations (I)								
7	35.18	37.56	27.86	23.60	73.69	69.07	101.54	92.67
8	44.62	46.63	29.52	27.05	84.20	75.21	113.72	102.26
9	50.75	52.54	27.11	25.35	80.03	71.73	107.14	97.08
LSD at 0.05	2.07	3.09	0.84	1.01	2.11	1.25	3.14	1.66
Varieties (V)								
Farida	49.71	51.92	31.50	27.64	84.12	75.27	115.62	102.91
Panther	42.54	44.36	28.44	25.40	79.50	71.05	107.94	96.45
Ghazil	38.30	40.49	24.55	22.95	74.30	69.70	98.86	92.66
LSD at 0.05	3.01	2.54	1.22	0.97	2.06	0.75	3.03	1.98
Interaction								
S x I	*	*	NS	NS	*	NS	*	NS
S x V	NS	NS	NS	NS	NS	NS	NS	NS
I x V	NS	NS	NS	NS	NS	NS	NS	NS
S x I x V	NS	NS	NS	NS	NS	NS	NS	NS

T. Chl. =Total chlorophyll Conj.=Conjugated, 1st: First season, 2nd :Second season

Root- rot severity%, root length, diameter and fresh weight, root and sugar yields:

The collected data in Table (5) recorded that delaying sowing date significantly affected disease severity (D.S %), all growth traits and yields of sugar beet in both seasons. Sowing sugar beet on 15th Sept. produced higher root length ,diameter and fresh weight as will as root and sugar yields/fed with insignificant differences were observed between sowing on mid-Sept. and mid- Oct. for Root rot severity%, and root diameter in the 2nd season, root yield/fed in the 1st season and root fresh weight in both seasons . Earlier planting date on 15th Sept. reduced the averages of disease severity from 11.13 to 10.16% and from 10.22 to 9.21 in the 1st and 2nd seasons as compared to late sowing date on 15th Nov. These findings are in agreement with those reported by Nasr and Abd El- Razek, (2008); El-Mansoub and Mohamed Hanan, (2014) and Aly and Khalil Soha, (2017). These results may be due, the enhanced influence of temperature degrees to the rapid growth, which in turn reflected on plant growth and yields. Also sowing sugar beet at 15th Sep.t achieved the highest yield by minimizing root rot disease%.

In the same Table date indicate that decreasing irrigations number up to 7 times significantly reduced disease severity% From 11.11 to 10.18% and 10.22 to 9.16%, respectively in the 1st and 2nd season. On the other hand, beet plants which irrigated 9 times had a significantly higher root fresh weight and root yields/fed in both seasons and root length in the 2nd season compared with those given by the other two number of irrigation and significantly increased root yield by 1.73., 0.86% and 1.22, 0.50%, respectively over 7 and 8 times of irrigation in the 1st and 2nd season. The maximum values of sugar yield, being 4.46 and 5.08 ton fed $^{-1}$ were obtained when applying 8 times of irrigation in the 1st and 2nd season. The obtained results are agreement with the results of other studies in which limited irrigation was used to control disease caused by soil borne pathogens (Cappaert *et al.*, 1994, Piccinni and Rush 2000, Abdelaty *et al.*, 2020).This may be due to the plants had earlier and greater disease symptoms with excessive irrigation. soil-borne plant pathogens infect plant root systems, where they thrive under low oxygen or anaerobic conditions. They take advantage of roots that are injured by excessive soil moisture and the resulting low soil oxygen conditions (Andrew, 2019).

Data in Table (5) showed that all tested sugar beet cvs. were significantly differed in Root rot disease severity%, root length, diameter, fresh weight and root and sugar yields/fed in both seasons. Farida variety. recorded the lowest disease severity%. On the other hand, surpassed Panther and Ghazil in, root diameter and fresh weight and out-yielded Panther and Ghazil varieties in root yield by 0.9, 1.64 and 0.71,1.49 ton fed^{-1}. and in sugar yield by 0.33,0.61 and 0.36 ,0.82 ton fed^{-1} ,respectively in the 1st and 2nd season However, Panther variety. achieved higher root length in both seasons . These fluctuations in the results may be due to the genetic structures of sugar beet cvs. These results are in harmony with those achieved by El-Mansoub and Mohamed Hanan, (2014) and Aly and Khalil Soha, (2017).

Table 5. Root-rot severity%, root length, diameter and fresh weight and root and sugar yields of three sugar beet varieties as affected by sowing dates and number of irrigations and their interaction during 2018/2019 and 2019/2020 growing seasons.

Treatments	Root rot severity%,		Root traits						Yield (ton fed^{-1})			
			Length(cm)		Diameter(cm)		Fresh weight (Kg/plant)		Root		Sugar	
Seasons	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Sowing dates (S)												
15th Sept.	10.16	9.21	35.42	39.73	10.06	10.21	0.687	0.818	29.23	32.25	4.42	4.95
15th Oct.	10.66	9.65	33.28	36.38	9.41	9.86	0.675	0.814	29.20	32.11	4.40	4.90
15th Nov.	11.13	10.22	31.32	35.05	9.04	9.46	0.673	0.808	29.12	32.12	4.37	4.85
LSD at 0.05	0.11	0.84	0.53	1.27	0.23	0.43	0.05	0.043	0.04	0.03	0.02	0.05
No. of irrigations (I)												
7	10.18	9.16	32.38	35.73	10.42	10.06	0.660	0.803	28.93	31.95	4.30	4.73
8	10.66	9.66	33.54	36.60	9.36	9.81	0.687	0.811	29.18	32.18	4.46	5.08
9	11.11	10.22	31.51	38.84	8.73	9.65	0.696	0.830	29.43	32.34	4.44	4.89
LSD at 0.05	0.55	0.42	0.88	1.23	1.09	0.19	0.011	0.014	0.19	0.11	0.11	0.16

Varieties (V)												
Farida	9.17	8.20	32.65	36.35	10.85	10.65	0.751	0.864	30.03	32.89	4.71	5.29
Panther	10.63	9.63	35.23	39.46	9.07	9.78	0.665	0.818	29.13	32.18	4.38	4.93
Ghazil	12.14	11.26	32.56	35.35	8.60	9.09	0.619	0.759	28.39	31.40	4.10	4.47
LSD at 0.05	1.08	1.56	1.64	3.01	1.07	0.18	0.062	0.072	0.11	0.96	0.29	0.14
Interaction												
S x I	*	*	*	*	NS	NS	NS	NS	*	*	*	*
S x V	*	*	*	*	*	*	NS	NS	*	*	*	*
I x V	*	*	*	*	NS	NS	*	*	*	*	*	*
S x I x V	*	*	*	NS	NS	NS	NS	NS	*	*	*	*

1st: First season, 2nd :Second season .

***Sucrose, impurities (sodium, potassium and alpha-amino-N), extracted sugar and sugar lost to molasses percentages*:**

All of aforementioned characters significantly affected by the three sowing dates with exception of, K% and sugar lost to molasses% in both seasons and α- amino N in the 2nd season (Table 6). Sucrose% and extracted sugar % significantly decreased with delaying sowing date from mid- Sept. to mid- Oct. and Nov. in both seasons. Sowing sugar beet plants on mid- Sept. was significantly associated with the highest sucrose being 17.01 and 17.17%, respectively in the 1st and 2nd season, On the other hand, the lowest Na% in the two seasons. Similar results were obtained by Nasr and Abd El- Razek, (2008); Tawfic *et. al*., (2014) and El-Mansoub and Mohamed Hanan, (2014). This enhancement can be related to favorable climatic conditions, especially light which was represented in sunny days and cool nights are the best sugar production and reserving in sugar beet roots and reduction in root rot severity%. El-Hag *et al*., (2015) observed highly positive correlation between climatic factors and yield quality of sugar beet.

Results in the same Table cleared that, applying 8 times of irrigation significantly increased sucrose% and extracted sugar (Ex. S %) and observed lower

Na% as compared to less or more number of irrigations per season. Sugar beet varieties. had a significant effect on all juice quality parameters, except sugar loss to molasses % (SLM %) in the two seasons. Farida cvs. recorded the highest values of all quality parameters and the lowest impurities %, *i.e.* sodium, potassium and α-amino N % in both seasons. The obtained results are harmony with those obtained by (Bassiony *et al*., 2020). However, the difference between Panther and Ghazil cvs. was insignificant in the 1st season and between Farida and Panther cvs. in the 2nd season for sucrose%

Table 6. Sucrose%, impurities, and some technological parameters of some sugar beet varieties as affected by sowing dates and number of irrigations and their interaction during 2018/2019 and 2019/2020 growing seasons

Treatments	Sucrose%		Impurities percentage						Technological parameters%			
			Na		K		α- amino N		Ex.S		SLM	
Seasons	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Sowing dates (S)												
15th Sept.	17.01	17.17	0.99	0.95	2.16	2.06	1.38	1.33	15.12	15.32	1.29	1.25
15th Oct.	16.94	17.12	1.00	0.95	2.17	2.12	1.38	1. 34	15.05	15.26	1.29	1.27
15th Nov.	16.88	16.95	1.02	0.96	2.17	2.12	1.39	1.34	14.98	15.08	1.29	1.27
LSD at 0.05	0.04	0.07	0.21	0.08	NS	NS	0.03	NS	0.26	0.11	NS	NS
No. of irrigations(I)												
7	16.74	16.65	1.04	0.98	2.20	2.11	1.40	1.35	14.84	14.78	1.30	1.27
8	17.14	17.61	0.97	0.93	2.14	2.08	1.37	1.33	15.26	15.76	1.28	1.25
9	16.95	16.99	1.00	0.95	2.17	2.10	1.38	1.34	15.06	15.12	1.29	1.26
LSD at 0.05	0.23	0.41	0.02	0.02	NS	NS	NS	NS	0.27	0.51	NS	NS
Varieties (V)												
Farida	17.53	17.93	0.89	0.89	2.09	2.07	1.34	1.30	15.68	16.09	1.25	1.24

Panther	16.93	17.19	0.98	0.94	2.18	2.11	1.39	1.34	15.04	15.33	1.29	1.26
Ghazil	16.37	16.12	1.14	1.03	2.24	2.11	1.42	1.37	14.44	14.24	1.33	1.28
LSD at 0.05	0.95	1.02	0.10	0.09	0.06	0.02	0.03	0.02	0.05	1.04	NS	NS
Interaction												
S x I	*	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S x V	*	*	NS	NS	NS	NS	NS	NS	*	*	*	*
I x V	*	*	NS	NS	NS	NS	NS	NS	*	*	*	*
S x I x V	*	*	NS	*	NS	NS	NS	NS	NS	NS	NS	NS

Na : Sodium; K: potassium; α- amino N: alpha amino nitrogen ; Ex.S: Extracted sugar%; SLM%: Sugar lost to molasses%.

***Interaction effects*:**

Data listed in Table (7) express significant effect for the first order interaction between sowing dates and number of irrigations for root-rot severity (%),total chlorophyll, root length , root and sugar yields/fed, and sucrose%, in both seasons, conjugated and total phenols in the 1^{st} seasons. Sugar beet plants which sown on mid-Sept. and irrigated 7 times achieved minimum disease severity% in both seasons. Meantime, under irrigating sugar beet 8 times and sown on the same sowing date, the highest mean values of sugar yield/fed and sucrose% were obtained in the two seasons. On the other hand, applying 8 times of irrigation on (15^{th} Nov.) attained the highest mean values of conjugated and total phenols contents in the 1^{st} seasons.

From Table (8) it could be seen that, the first order interaction between sowing dates and varieties was statistically significant for disease severity, root length and diameter and root and sugar yields/fed, sucrose, (Ex.S%) and sugar loss to molasses (SLM%) in both seasons. Farida cv. which planted on mid-Sept. surpassed the other two tested sugar beet varieties and recorded the highest values of root length, diameter and root and sugar yields/fed, as well as sucrose and extractable sugar % in the two seasons. On the other hand, the same cv. under the same sowing date demonstrated the lowest values of root-rot severity and sugar loss to molasses % in both seasons.

Data shown in Table (9) indicate that, the interaction between number of irrigations and sugar beet varieties had a significant effect on root-rot severity %, root length, and fresh weight and root and sugar yields/fed as well as sucrose%, sugar extracted (Ex.S%) and SLM% in both seasons. In this respect, irrigated Farida cv. 7 times produced the lowest disease severity%. However, when applying 8 times of irrigation to the same sugar beet cv. recorded the highest values for sugar yield/fed, sucrose %,(Ex.S%), in addition to achieve the lowest (SLM%) in both seasons. While the highest root length and fresh weight and root yield/fed were obtained by irrigated Farida variety 9 times in the two seasons.

It is cleared from the data presented in Table (10) that the second order interaction was significant for root-rot severity %, root and sugar yield/fed and sucrose% in both seasons and root length in the 1^{st} season, sodium % in the 2^{nd} season. Sowing Farida cv. Earlier on mid Sept. and irrigated 7 times revealed the minimum disease severity%, being 8.27 and 7.23%, respectively in the 1^{st} and 2^{nd} season,. Meantime, the highest sugar yield, being 4.84 and 5.62 ton fed $^{-1}$ and sucrose %, being 17.89 and 18.82% were achieved by applying 8 times of irrigation to the same cv when sown earlier on 15^{th} Sept. However, when Farida variety irrigated 9 times on the same sowing date, the greatest root yield/fed, being 30.41 and 33.21 ton fed $^{-1}$, respectively were recorded in the1^{st} and 2^{nd} season.

Table 7. Significant interaction between sowing dates and number of irrigations affected sugar beet root-rot severity (%), total chlorophyll (SPAD value), conjugated and total phenols, root length, root and sugar yields, and sucrose % during 2018/2019 and 2019/2020 seasons. .

Sowing dates	No. of irriga-tions	D.S		T.chl.		Conj. Ph.	T. Ph.	RL (cm)		Yields (ton fed^{-1})				Suc. %	
										Root		Sugar			
Sea.		1st	2nd	1st	2nd	1st	1st	1st	2nd	1st	2nd	1st	2nd	1st	2nd
15th Sept.	7	9.67	8.72	35.93	38.80	66.40	88.83	34.78	38.22	29.01	32.01	4.33	4.76	16.80	16.69
	8	10.14	9.16	43.93	46.57	75.30	101.23	35.89	37.29	29.25	32.24	4.49	5.11	17.20	17.66
	9	10.65	9.75	49.83	52.43	70.60	95.10	36.86	43.68	29.42	32.51	4.46	4.97	17.02	17.15
15th Oct.	7	10.21	9.13	40.87	43.57	74.27	103.23	32.15	35.30	28.93	31.94	4.22	4.72	16.73	16.65
	8	10.68	9.67	51.83	53.13	88.60	117.83	33.46	36.39	29.17	32.18	4.46	5.07	17.14	17.60
	9	11.08	10.16	58.53	58.50	86.40	113.40	34.22	37.45	29.48	32.20	4.44	4.91	16.95	17.11
15th Nov.	7	10.66	9.64	28.73	30.13	80.40	112.57	30.22	34.60	28.85	31.90	4.27	4.70	16.69	16.59
	8	11.14	10.15	38.10	40.17	88.70	122.10	31.27	35.18	29.12	32.11	4.43	5.05	17.06	17.56
	9	11.60	10.89	43.90	46.70	83.10	112.93	32.46	35.38	29.39	32.31	4.41	4.80	16.88	16.69
L.S.D at 5% level		1.06	0.67	3.14	2.04	094	3.06	3.04	2.41	0.16	0.24	0.09	0.08	0.22	0.35

D.S: Disease severity; T.chl.= Total chlorophyll Conj.Ph= Conjugated phenols, T.ph.=Total phenols, RL: Root length ; Suc.%= Sucrose% , 1st =First season,2nd =Second season

Table 8: Significant interaction between sowing dates and sugar beet varieties affected sugar beet root-rot severity (%), root length, diameter , root and sugar yields/fed, sucrose % and some technological parameters % during 2018/2019 and 2019/2020 seasons.

Sowing dates	Varieties	D.S%	RL(cm)	RD (cm)	Yields (ton fed^{-1})		Suc. %	Technological parameters %	
					Root	Sugar		Ex.S	SLM
2018/2019									
15th Sept.	Farida	8.67	38.17	11.81	30.07	4.73	17.62	15.77	1.25
	Panther	10.15	34.20	9.70	29.21	4.41	16.98	15.10	1.29
	Ghazil	11.65	35.16	8.68	28.45	4.13	16.42	14.50	1.33
15th Oct.	Farida	9.20	35.24	10.82	30.02	4.71	17.52	15.67	1.25
	Panther	10.65	32.37	8.80	29.13	4.38	16.93	15.04	1.29
	Ghazil	12.12	32.20	8.61	28.39	4.10	16.37	14.44	1.33
15th Nov.	Farida	9.63	32.26	9.92	29.99	4.68	17.45	15.59	1.26
	Panther	11.09	31.38	8.69	29.25	4.35	16.86	14.97	1.29
	Ghazil	12.68	30.31	8.50	28.33	4.08	16.32	14.93	1.33
LSD at 0.05		1.65	3.18	1.09	1.16	0.21	0.91	1.01	0.01
2019/2020									
15th Sept.	Farida	7.68	43.74	11.08	33.03	5.34	17.98	16.15	1.23
	Panther	9.15	37.19	10.19	32.24	4.96	17.24	15.39	1.26
	Ghazil	10.79	37.25	9.36	31.50	4.54	16.28	14.41	1.27
15th Oct.	Farida	8.14	37.39	10.71	32.74	5.27	17.93	16.09	1.25
	Panther	9.64	36.39	9.70	32.17	4.93	17.19	15.33	1.26
	Ghazil	11.18	35.37	9.16	31.41	4.51	16.24	14.35	1.29
15th Nov.	Farida	8.77	36.26	10.15	32.91	5.27	17.86	16.02	1.24
	Panther	10.10	35.48	9.46	32.12	4.91	17.14	15.27	1.27
	Ghazil	11.80	33.42	8.76	31.30	4.37	15.84	13.95	1.29
LSD at 0.05		2.14	4.61	1.35	1.09	0.216	1.15	1.18	0.02

D.S: Disease severity; RL: Root length, RD: Root diameter; Suc.%= sucrose %, Ex.S: Extracted sugar%, SLM%: Sugar lost to molasses%,

Table 9. Significant interaction between number of irrigations and sugar beet varieties affected sugar beet root-rot severity (%), root length and fresh weigh, root and sugar yields, sucrose% and some technological parameters % during 2018/2019 and 2019/2020 growing seasons.

No. of irrigations	Varieties	D.S%	RL (cm)	RFW (kg/p)	Yields (ton fed^{-1})		Suc. %	Technological parameters %	
					Root	Sugar		Ex.S	SLM
2018/2019									
7	Farida	8.72	34.18	0.717	29.77	4.58	17.23	15.37	1.27
	Panther	10.13	31.47	0.651	28.83	4.28	16.75	14.85	1.30
	Ghazil	11.68	31.51	0.612	28.20	4.03	16.23	14.29	1.34
8	Farida	9.15	35.22	0.753	30.06	4.80	17.80	15.96	1.24
	Panther	10.69	32.83	0.666	29.12	4.43	17.08	15.20	1.28
	Ghazil	12.13	32.57	0.616	28.36	4.14	16.53	14.61	1.32
9	Farida	9.62	36.28	0.781	30.24	4.75	17.55	15.70	1.25
	Panther	11.07	33.66	0.679	29.44	4.43	16.94	15.06	1.29
	Ghazil	12.64	33.60	0.629	28.62	4.13	16.36	14.43	1.33
LSD at 0.05		2.65	2.83	0.046	1.07	0.261	0.82	0.96	0.05
2019/2020									
7	Farida	7.71	36.85	0.850	32.74	5.11	17.47	15.61	1.25
	Panther	9.10	36.04	0.805	32.01	4.87	17.08	15.21	1.27
	Ghazil	10.67	34.29	0.754	31.12	4.20	15.39	13.50	1.28
8	Farida	8.16	38.02	0.861	32.93	5.59	18.77	16.94	1.23
	Panther	9.65	36.39	0.816	32.16	4.97	17.31	15.46	1.25

	Ghazil	11.17	35.38	0.756	31.36	4.66	16.74	14.87	1.28
9	Farida	8.71	43.52	0.882	33.01	5.17	17.54	15.71	1.24
	Panther	10.15	36.62	0.832	32.36	4.96	17.18	15.32	1.26
	Ghazil	11.93	36.37	0.775	31.72	4.55	16.24	14.35	1.29
LSD at 0.05		2.11	4.86	0.073	1.22	0.628	0.91	1.05	1.02

D.S: Disease severity; RL: Root length, RD: Root diameter; RFW: Root fresh weight, Suc.= sucrose %, ; Ex.S: Extracted sugar%, SLM%: Sugar lost to molasses%,

Table 10. Effect of three-way significant interactions among sowing dates, No. of irrigations and varieties affected some traits of sugar beet during 2018/2019 and 2019/2020 growing seasons.

			2018/2019					2019/2020				
Sowing dates	No. of irriga-tions	Varieties	D.S	RL (cm)	Yield(ton fed^{-1})		Suc. %	D.S	Yield (ton fed^{-1})		Suc. %	Na%
					Root	Sugar			Root	Sugar		
15th Sept.	7	Farida	8.27	37.13	29.91	4.62	17.30	7.23	32.81	5.14	17.51	0.90
		Panther	9.59	33.09	28.90	4.31	16.81	8.65	32.05	4.90	17.14	0.95
		Ghazil	11.16	34.13	28.23	4.05	16.28	10.28	31.18	4.23	15.43	1.06
	8	Farida	8.58	38.10	30.11	4.84	17.89	7.58	33.07	5.62	18.82	0.86
		Panther	10.29	34.36	29.21	4.46	17.13	9.15	32.16	4.99	17.37	0.92
		Ghazil	11.56	35.22	28.42	4.17	16.59	10.75	31.50	4.70	16.80	0.98
	9	Farida	9.15	39.24	30.41	4.75	17.66	8.24	33.21	5.24	17.62	0.86
		Panther	10.58	35.15	30.04	4.46	17.01	9.67	32.50	4.99	17.22	0.92
		Ghazil	12.22	36.14	28.71	4.16	16.40	11.33	31.81	4.69	16.62	0.98
15th Oct.	7	Farida	8.74	34.18	29.73	4.57	17.22	7.62	32.72	5.10	17.46	0.91
		Panther	10.22	31.12	28.86	4.28	16.74	9.10	32.01	4.87	17.08	0.96
		Ghazil	11.66	31.15	28.21	4.03	16.22	10.67	31.10	4.20	15.41	1.07
	8	Farida	9.27	35.28	30.06	4.80	17.81	8.16	33.02	5.59	18.76	0.86
		Panther	10.65	32.86	29.11	4.43	17.09	9.63	32.13	4.97	17.31	0.93
		Ghazil	12.12	32.23	28.35	4.14	16.52	11.22	31.38	4.66	16.74	0.99
	9	Farida	9.58	36.27	29.51	4.77	17.53	8.63	32.49	5.12	17.58	0.88
		Panther	11.08	33.16	29.43	4.44	16.96	10.18	32.38	4.69	17.18	0.94
		Ghazil	12.59	33.23	28.62	4.13	16.36	11.66	31.74	4.66	16.57	1.04
15th Nov.	7	Farida	9.15	31.22	29.68	4.54	17.18	8.29	32.68	5.09	17.43	0.92
		Panther	10.59	30.19	28.72	4.25	16.71	9.55	31.96	4.84	17.03	0.96
		Ghazil	12.23	29.24	28.16	4.01	16.19	11.07	31.07	4.17	15.32	1.07
	8	Farida	9.61	32.29	30.02	4.76	17.70	8.75	32.95	5.57	18.72	0.87
		Panther	11.12	31.28	29.05	4.40	17.02	10.16	32.18	4.96	17.26	0.93
		Ghazil	12.70	30.25	28.30	4.12	16.47	11.53	31.21	4.62	16.69	1.00
	9	Farida	10.14	33.29	30.27	4.72	17.46	9.26	33.10	5.16	17.43	0.89
		Panther	11.56	32.66	29.37	4.40	16.86	10.60	32.21	4.92	17.13	0.95
		Ghazil	13.10	31.43	28.54	4.10	16.31	12.80	31.61	4.31	15.52	1.05
LSD at 0.05			2.43	3.73	1.16	0.46	0.46	3.19	0.92	0.38	1.01	0.06

D.S: Disease severity; RL: Root length, , Suc.%=Sucrose% Na% : Sodium%

AMMI analysis

The combined analysis of variance and AMMI analysis is presented in Fig.(1). The commercial Farida sugar beet cv. recorded the lowest infection by root-rot, when seven times of irrigation were applied in first date of sowing (15th Sept.) and Ghazil cv. recorded the highest infection to applying 9 times of irrigation in last date of sowing (15th Nov.). These results are in harmony with those obtained by Bassiony *et al*. (2020), who observed that there were highly significant differences for the environment, genotype and their interactions on the infection of chili pepper by Phytophthora root-rot..

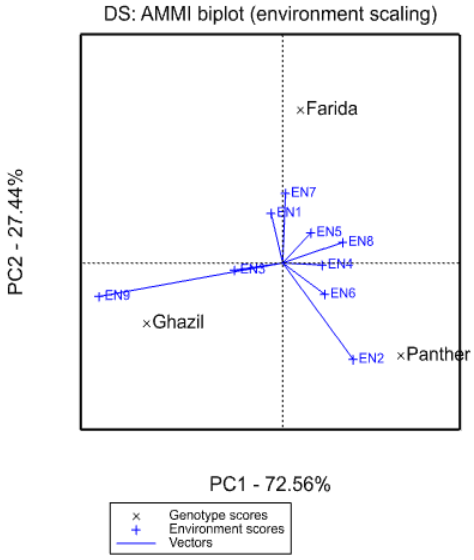

Fig.1. The AMMI biplot showing relationship among varieties under different sowing dates and irrigation times.

Conclusion

Our findings indicate that, sowing Farida variety on 15th Sept. and irrigated seven times of irrigations to reduce root-rot disease severity%. or nine time to obtain the highest root yield (30.41 and 33.21 tons/fed), or eight times to achieve the higher sugar yield (4.84 and 5.62 tons fed) and quality under the experimental condition.

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