

PRODUCTIVITY AND QUALITY OF SUGAR BEET AS INFLUENCED BY NITROGEN FERTILIZER AND SOME MICRONUTRIENTS

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Abstract

Two field experiments were conducted during 2008/2009 and 2009/2010 seasons at Sakha Research Station, Kafr EL-Shaikh Governorate to study the influence of three nitrogen rates (75, 100 and 125%) of recommended rate (RR=80Kg N/fed), sprayed with Zn, Mn and Fe individually or in mixture, on some chemical composition, juice quality and yield of sugar beet plants.

Decreasing N dressing up to 60 Kg N/fed (75% of RR) significantly decreased photosynthetic pigments (chlorophyll a, b and carotenoids) at the age of 120 days from sowing in the two seasons, also a reduction in sucrose% and some technological parameters such as sugar extractable (SEX), sugar losses to molasses (SLM) and sugar coefficient (Sco), yield component (root length, diameter and fresh weight of tops in the two seasons have been recorded. Yields of roots and sugar, uptake of N, Mn and Zn had the same trend. On the other hand, increasing N dressing up to 100 Kg N /fed (125% of RR) significantly increased photosynthetic pigments i.e. chlorophyll a,b and carotenoids at the age 120 days from sowing in the two seasons, Na, K and α - amino N as impurities, sugar loss to molasses (SLM), yields of roots and sugar but juice purity was significantly decreased.

Foliar spray with Mn, Zn and Fe individually or in mixture significantly increased chlorophyll a, b and carotenoids in both samples in the two seasons. Sucrose% and impurities as K and α - amino N were significantly increased but juice purity was significantly decreased. Root length, diameter, fresh weight of roots and tops, sugar yield were significantly affected. Foliar spray with Zn, Mn and Fe significantly increased their uptake and N uptake. Foliar spray with the mixture of Zn, Mn and Fe exhibited the best treatment, where it gave the highest values of most traits under study.

The interaction between N at the high rate and the mixture of Zn, Mn and Fe was the superior treatment where, it gave the highest values for chl a, b and carotenoids, K, α - amino N, juice purity and N uptake.

Keywords: Nitrogen, Zn, Mn and Fe, sugar beet.

INTRODUCTION

Sugar beet is one of just two crops (the other being sugar cane) which constitute the only important sources of sucrose. In Egypt, sugar production is still insufficient to cover consumption therefore, many devoted attempts to improve beet

quality and quantity. These may be achieved via nutrition which had a great effect on beet productivity. Nitrogen management is one of the important keys to accomplish this goal. A sufficient nitrogen supply of sugar beet is decisive to a considerable extent both for root yield and its quality. Over supply as well as undersupply of nutrients, in particular of nitrogen, means a reduction of quality of the harvested product (Jozefyova et al, 2004). Nitrogen fertilization promotes vigorous early season growth thereby reducing the number of days to canopy closure. Early closure allows the sugar beet to make better use of sunlight and more sugar is produced. In this connection, nitrogen is the sensitive elements that affect the beet production and sugar content (Zhou, 1993). Franzen (2003) found that excess nitrogen reduced root sucrose content and higher impurity level as well as poor recoverable sugar yield. (Cai, and Ge 2004) stated that the nitrogen content of sugar beet plant was significantly and positive correlated with nitrogen amount used and found that the study of nitrogen amount on beet production and sugar content will be important and significant

Micronutrients as foliar application are particularly useful under Egyptian soil conditions where, it suffers greatly from alkalinity, therefore, most micronutrients fixed and become unavailable to plant uptake (Shalaby, 1998).

Micronutrients deficiency is one of many factors that affect sugar beet production. This deficiency is particularly referred to many factors such as the intensive cropping system in Egyptian agriculture and the reduction in the amount of Nile alluvium after the construction of Aswan High Dam as well (Shalaby, 1998). Application of foliar Fe combined with Zn and Mn was very effective in increasing root and sugar yields as well as juice purity and sugar content, which in turn improve sugar extractability (Moustafa et al., 2006). Great attention to the response of sugar beet to micronutrients has been recorded by many workers (Moustafa et al., 2006 and Soudi and El-Guibali, 2008).

The aim of this work is to evaluate the effect of nitrogen rates and some micronutrients on growth, quality and quantity of sugar beet.

MATERIALS AND METHODS

Two field trials were set up in Sakha Research Station (ARC) at Kafr EL-Shaikh Governorate to study the effect of three rates of nitrogen (60, 80 and 100 kg N/fed) along with foliar spray with five treatments control (without micronutrients), Zn, Mn, Fe and mixture of Zn+Mn+Fe and their interactions on growth, root quality and yield

of sugar beet plants. Average mechanical and chemical properties of the experimental soil are illustrated in Table (1).

Table 1. Soil mechanical and chemical properties of the experimental site in the two seasons.

Seasons	Soil properties									Available nutrients (ppm)					
	Coarse sand %	Fine sand %	Silt %	Clay %	Textural class	Ca CO ₃ %	E.C.(1:5 dSm ⁻¹)	pH	Organic matter %	N	P ₂ O ₅	K	Fe	Zn	Mn
2008/09	5.05	16.5	30.1	47.0	Silty clay	3.45	2.74	7.95	1.85	30.2	9.01	419	9.51	8.61	13.4
2009/10	4.73	15.1	28.0	49.3		2.60	3.35	8.13	1.89	31.1	9.63	398	12.6	7.81	14.5

A multigerm sugar beet variety kawemira was planted on 25th and 27th of October 2008 and 2009 seasons respectively. The experimental design was split plot with three replications where, the three nitrogen rates 75, 100 and 125% of the recommended rate (80 kg N/fed) were allocated in the main plots which was assigned into five sub plots including control (without micronutrients), 2.5g Zn /L as zinc sulfate (40% Zn), 2.5 g Mn/L as manganese sulfate (36% Mn) and 1.5 Fe/L as Fe-EDTA (13.2 % Fe) and the mixture of Zn, Mn and Fe in 400 L water / fed. Nitrogen fertilizer was added as urea form (46%N) in two equal doses the first after thinning and the second after 30 days later. Foliar spraying with micronutrients was applied after 70 and 90 days from sowing. The sub plot size was 21 m² (1/200 fed). All cultural practices for growing sugar beet were done as recommended.

Random samples of leaves were taken from each plot after 85 and 105 days from sowing to determine photosynthetic pigments i.e. chlorophyll a, b and carotenoids (mg/g fresh weight) according to the method of Wettstein (1957).

On the other hand, samples were taken at harvest (after 210 days from sowing) to determine:

Root quality in the second season

- Sucrose (pol %), purity% and impurities (k, Na and α- amino N (meq/100g beet).

All traits were determined using automatic French system (Hycl)

-Some technological parameters: [sugar lost to molasses (SLM), sugar extractable (SEx) and alkalinity coefficient (AC) were calculated using an automatic French system (Hycl).

-Root and sugar yields (ton/fed).

Root elemental uptake in two seasons

- N as macro elements.

- Zn, Mn, and Fe as microelements

All elements were determined according to A.O.A.C. (1990)

Yield components in two seasons

- Average root length and root diameter/plant (cm).
- Average fresh weight of roots and tops/ plant (Kg).

Analysis of variance was computed for each trait in each season according to Steel & Torrie (1980). Least significant differences (LSD) at 5% level of probability were used to compare treatment means.

RESULTS AND DISCUSSION**Photosynthetic pigments****Effect of N fertilizer rates**

Results of photosynthetic pigments i.e. chlorophyll a, b and carotenoids in 2008/09 (I) and 2009/10 (II) seasons are listed in Table (2). Data showed that decreasing N rate to 75% of RR significantly decreased chlorophyll a, b and carotenoids in the samples at 90 and 120 days from sowing in both seasons except chlorophyll a and carotenoids in the first season in sample at 90 days from sowing. On the other hand, increasing the rate of N to 125% of RR increased chlorophyll a, b and carotenoids in the two samples in both seasons. The increases were significant in the second sample at the age of 120 days in both seasons. This increase may be due to the positive effect of N fertilization on the vegetative growth of sugar beet plants and consequently increasing the photosynthetic area capable for solar energy conversion. Similar results were obtained by Moustafa and Omran (2006).

Effect of micronutrients

Foliar spray with Zn, Mn and Fe individually or in mixture significantly increased chlorophyll a, b and carotenoids in both samples in the two seasons as compared with control (without micronutrients). The mixture of micronutrients together was the best treatment where, it gave the highest value of chlorophyll a, b and carotenoids in both seasons in two samples ages. The positive effect of micronutrients may be due to its role as activator or coenzymes in all vital biosynthetic processes in plant such as chlorophyll synthesis. The same trend was obtained by Soudi and El-Guibali (2008) who found that Fe with Zn tended to show significantly an increase in photosynthetic pigments.

Effect of the interactions

Data in Table (2) showed that there was a significant difference among all interactions order on chlorophyll a, b and carotenoids in both samples except chlorophyll a in the first sample in both seasons and chlorophyll b in the second sample in the first season. In general, the interaction between N fertilizer at the high rate and the mixture of Zn, Mn and Fe was the superior treatment, where, it exhibited the highest chlorophyll a, b and carotenoids values.

Table 2. Effect of different rates of nitrogen fertilizer with some micronutrients on photosynthetic pigments.

Treatments N Kg/fed		First sample at 85 days from sowing						Second sample at 105 days from sowing					
		Chl A		Chl B		Carotienoids		Chl A		Chl B		Carotienoids	
		2008/09	2009/10	2008/09	2009/10	2008/09	2009/10	2008/09	2009/10	2008/09	2009/10	2008/09	2009/10
N1 (60 kg/fed)	control	1.10	1.15	0.580	0.591	0.399	0.401	1.43	1.47	0.601	0.596	0.365	0.360
	Zn	1.16	1.18	0.605	0.611	0.412	0.410	1.55	1.60	0.719	0.710	0.510	0.512
	Mn	1.21	1.19	0.624	0.630	0.421	0.419	1.49	1.68	0.688	0.653	0.489	0.510
	Fe	1.33	1.32	0.629	0.635	0.442	0.441	1.61	1.71	0.720	0.712	0.546	0.553
	Zn+Mn+Fe	1.36	1.39	0.641	0.639	0.448	0.445	1.68	1.77	0.801	0.810	0.608	0.600
	Means	1.23	1.25	0.616	0.621	0.424	0.423	1.55	1.65	0.706	0.696	0.504	0.507
N2 (80 kg/fed)	control	1.15	1.18	0.600	0.628	0.407	0.411	1.51	1.35	0.611	0.606	0.381	0.381
	Zn	1.23	1.23	0.621	0.619	0.418	0.420	1.59	1.62	0.725	0.719	0.499	0.508
	Mn	1.25	1.31	0.634	0.628	0.424	0.425	1.73	1.75	0.700	0.710	0.483	0.495
	Fe	1.40	1.45	0.651	0.655	0.438	0.440	1.82	1.88	0.741	0.749	0.566	0.555
	Zn+Mn+Fe	1.42	1.50	0.680	0.681	0.451	0.455	1.90	2.00	0.813	0.815	0.617	0.621
	Means	1.30	1.33	0.637	0.642	0.428	0.430	1.71	1.76	0.718	0.720	0.509	0.512
N3 (100 kg/fed)	control	1.20	1.19	0.611	0.615	0.415	0.415	1.69	1.65	0.656	0.660	0.389	0.390
	Zn	1.33	1.31	0.628	0.630	0.422	0.429	1.85	1.90	0.778	0.775	0.523	0.532
	Mn	1.38	1.34	0.635	0.638	0.433	0.430	1.73	1.81	0.723	0.730	0.510	0.511
	Fe	1.55	1.48	0.660	0.664	0.443	0.438	1.96	1.98	0.752	0.761	0.581	0.576
	Zn+Mn+Fe	1.60	1.52	0.677	0.673	0.462	0.458	2.08	2.10	0.815	0.818	0.620	0.618
	Means	1.41	1.37	0.642	0.644	0.435	0.434	1.86	1.89	0.745	0.749	0.525	0.525
Mean of micro- nutrients	control	1.15	1.17	0.597	0.611	0.407	0.409	1.54	1.55	0.623	0.621	0.378	0.377
	Zn	1.24	1.24	0.618	0.620	0.417	0.420	1.66	1.71	0.741	0.735	0.511	0.517
	Mn	1.28	1.28	0.631	0.632	0.426	0.425	1.65	1.75	0.704	0.698	0.494	0.505
	Fe	1.43	1.42	0.647	0.651	0.441	0.440	1.80	1.86	0.738	0.741	0.564	0.561
	Zn+Mn+Fe	1.47	1.47	0.666	0.664	0.454	0.453	1.89	1.96	0.810	0.814	0.615	0.617
L.S.D of 5%	(N)	0.14	0.06	0.006	0.009	0.007	0.004	0.07	0.04	0.006	0.005	0.003	0.005
	(M)	0.07	0.10	0.004	0.008	0.003	0.004	0.05	0.04	0.015	0.007	0.006	0.006
	N x M	N.S	N.S	0.007	0.014	0.007	0.007	0.08	0.07	N.S	0.012	0.010	0.011

Root quality and some technological parameters

Effect of N fertilizer rates

Root quality comprises several parameters i.e. sugar content, impurities or non sugar (such as potassium, sodium and α -amino N) and juice purity. Results in the second seasons are presented in Table (3) and indicated that, N dressing at the rate 60 kg N/fed (75% of RR) decreased all the root quality traits i.e. sucrose %, impurities (Na, K and α - amino N) and juice purity % as compared with RR. It is worth to mention that the reduction was significant for sucrose % only. Data also cleared that excess nitrogen (125 % of RR) increased root sucrose% but statistically was not significant. While, all impurities traits were significantly increased. On the other hand, juice purity was significantly decreased. From above mentioned results, it is important to note that underrate or overrate significantly decreased most root qualities. In this connection, Milford and Watson (1971) showed that excess nitrogen fertilizer increased the fraction of the assimilate entering the root that was used in growth at the expense of that stored as sugar. Thus, plants with more nitrogen had a smaller proportion of their root dry weight as sugar because more was used in growth. The reduction in purity % was defected from exceed N dose over rate may be due to the increase in non sugar contents such as α -amino N which affected sugar accumulation in roots and hence sugar extraction. The above results are partially in agreement with those recorded by Jozefyova et al, (2004) who found adjust N doses resulted in better quality due to decreasing amino-N concentration of sugar beet by about 30% and less residual nitrate after harvest. Oversupply as well as undersupply of soil nutrients, in particular of nitrogen, means a reduction of quality of the harvested product.

Dealing with the effect of the two N fertilizer levels (60 and 100 Kg N/fed) on some technological parameters i.e sugar loss to molasses (SLM), sugar extractable (SEX) and sugar coefficient (SCo) at harvest time as compared with RR (80 kg N /fed). Data in Table (3) showed a significant decrease in SLM, SEx and SCo as N application at 75 % of RR. While, overrate of N (125 % of RR) led to significant increase SLM only. Such effect may be due to that excess N significantly increased all impurities as mentioned especially α -amino N, which necessarily had to be taken into account in almost all calculations aimed at assessing the contribution of the non-sugar to potential loss of sugars into molasses (Van Geijn et al, 1983).

Table 3. Effect of different rates of nitrogen fertilizer with some micronutrients on root quality and some technological parameters.

Treatments N Kg/fed		Sucrose (Pol %)	Impurities (meq/100 g beet)			purity	Some technological parameters			Root yield (t/fed)	Sugar Yield (t/fed)
Nitrogen (N)	Micronutrients(M)		Na	K	α-amino-N		SLM	SEX	SCo		
N1 (60 kg/fed)	control	15.50	1.49	3.08	1.22	94.02	1.42	13.46	86.80	28.8	4.46
	Zn	16.50	1.44	3.33	1.29	94.12	1.49	14.41	87.33	29.6	4.89
	Mn	16.10	1.46	3.40	1.29	93.90	1.50	14.00	86.91	28.7	4.62
	Fe	16.80	1.43	3.44	1.38	94.05	1.53	14.67	87.33	28.9	4.85
	Zn+Mn+Fe	17.25	1.41	3.52	1.57	93.98	1.58	15.07	87.35	30.5	5.26
Means		16.43	1.45	3.35	1.35	94.02	1.51	14.32	87.14	29.3	4.82
N2 (80 kg/fed)	control	16.38	1.56	3.19	1.28	94.10	1.49	14.30	87.26	29.8	4.89
	Zn	17.56	1.49	3.34	1.34	94.34	1.51	15.45	87.97	29.9	5.25
	Mn	17.50	1.52	3.48	1.31	94.21	1.53	15.37	87.84	30.2	5.28
	Fe	17.82	1.45	3.67	1.42	94.12	1.57	15.65	87.81	31.9	5.69
	Zn+Mn+Fe	17.90	1.45	3.74	1.60	93.95	1.63	15.67	87.56	32.7	5.86
Means		17.43	1.49	3.48	1.39	94.15	1.54	15.29	87.68	30.9	5.39
N3 (100 kg/fed)	control	16.52	1.61	3.07	1.33	94.17	1.49	14.43	87.36	31.0	5.12
	Zn	17.74	1.53	4.09	1.40	94.52	1.50	15.64	88.17	31.6	5.60
	Mn	17.70	1.58	4.09	1.49	93.59	1.67	15.43	87.19	32.7	5.58
	Fe	17.90	1.53	4.25	1.59	93.48	1.71	15.59	87.11	32.3	5.79
	Zn+Mn+Fe	18.65	1.48	4.31	1.80	93.55	1.76	16.30	87.34	35.4	6.60
Means		17.70	1.55	3.76	1.52	93.86	1.62	15.48	87.44	32.4	5.74
Mean of micro- nutrients	control	16.13	1.55	3.11	1.28	94.10	1.47	14.06	87.14	29.9	4.82
	Zn	17.27	1.49	3.25	1.34	94.33	1.50	15.17	87.82	30.4	5.25
	Mn	17.10	1.52	3.66	1.36	93.90	1.57	14.93	87.31	30.1	5.16
	Fe	17.51	1.47	3.79	1.46	93.89	1.60	15.31	87.42	31.0	5.45
	Zn+Mn+Fe	17.93	1.45	3.86	1.66	93.83	1.66	15.78	87.42	32.9	5.91
L.S.D of 5%	(N)	0.44	0.06	0.14	0.07	0.14	0.02	0.44	0.35	1.12	0.21
	(M)	0.47	0.04	0.10	0.04	0.19	0.02	0.47	0.39	1.40	0.26
	N x M	N.S	N.S	0.17	0.07	0.33	N.S	N.S	N.S	N.S	N.S

Effect of micronutrients

Data in Table (3) illustrated that in general, foliar spray with Zn, Mn and Fe individually or in mixture significantly increased sucrose %, impurities as K and α -amino N but significantly decreased Na as compared with control (without micronutrients). These results led to significant decrease in juice purity under Mn, Fe and the mixture of Zn+Mn+Fe. It is worth to mention that beet sprayed with the mixture of Zn, Fe and Mn gave the highest percent of sucrose and the lowest percent of purity. Such effect may be due to that the increase in impurities was much higher than the increase in sucrose%.

As for the effect of micronutrients on some technological parameters, the available data in Table (3) showed significant increase in SLM and SEx as compared with control (without micronutrients). From results, it is mentioned that in spite of micro-nutrients particularly, the mixture of Zn, Mn and Fe increased sugar loss to molasses, the extractable sugar increase may be due to the highest increase of sucrose%. These results coincide with those reported by Moustafa et al, (2006), Moustafa and Omran (2006) who stated that treating sugar beet plants with trace elements have a considerable influence on the metabolic activities and in turn exert an increase in its sugar content.

Effect of the interactions

The interactions between N rates and some micronutrients Mn, Fe individually or the mixture of Zn+Mn+Fe significantly affected K, α amino N and purity. Meantime the highest purity was obtained when beet treated with N at 125% of RR and foliar spray with Zn. Data also cleared that all interactions significantly affected both SLM, SEx or SCo.

Root and sugar yield

Effect of N fertilizer rates

Data in Table (3) revealed that decreasing the rate of N to 75% of RR significantly decreased roots and sugar yield. On the contrary, increasing N rate to 125% of RR significantly increased roots and sugar yield.

Effect of micronutrients

Treatment with Zn, Mn or Fe individually caused increase in root yield but this increase was not significant (Table, 3). Whereas, the mixture of them led to significant increase in roots yield. As for, sugar yield, it was significantly increased due to foliar sprays with Zn, Mn and Fe individually or in mixture. The present results are in harmony with those of Moustafa et al, (2006) who found that Fe, Zn and Mn significantly increased roots and sugar yields.

Effect of the interactions

The interactions between N fertilizer rate and micronutrients did not show any significant increase for roots or sugar yield.

Yield component**Effect of N fertilizer rates**

Root length and root diameter as well as root and top fresh weights as affected by three rates of nitrogen are presented in Table (4).

Results cleared that growth traits mentioned above significantly decreased by decreasing the rate of N fertilizer from 100 to 75% of RR at harvest in both seasons except for fresh weight of root. On the other hand, the high N fertilizer (125% of RR) increased all growth traits in both seasons as compared with RR at 80 Kg N/fed. The stimulatory effect of N may be due to its effect on plant carbohydrates metabolism which, led to better growth and dry matter accumulation. Also these results may be attributed to the excess of N stimulate absorption of water which increased fresh weight of plants (Milford and Watson, 1971). In this connection, Selim et al (2009) found that foliar application with urea significantly increased root length, root diameter, root fresh weight and sugar yield.

Effect of micronutrients

Foliar spray with Zn, Mn and Fe individually or in mixture significantly affected root length and diameter as well as fresh weight of root and tops. Meantime, the increases were significant by using the mixture of Zn + Mn + Fe followed by Fe alone in both seasons as compared with control (without micronutrients). The pronounced effect of micronutrients is mainly due to their effect on growth hormone production which has a direct effect on plant growth. These results are in agreement with those obtained by Soudi et al, (2008) who found that the mixture of Mn+Zn+Fe has significantly increased all root and top growth parameters of sugar beet plants.

Effect of interactions

The interactions between N fertilizer rates and micronutrients affected positively but insignificantly all growth traits (Table 4).

Root nutrients uptake:**Effect of N fertilizer rates:**

Application of N at the rate 60 kg N/fed (75% of RR) significantly decreased N uptake (macronutrient) as well as Mn and Zn (micronutrients) but insignificantly decreased Fe (Table, 5). Contrary results, were obtained when sugar beet plants treated with N at 125% of RR, Where it gave significant increase in N, Zn and Fe in both seasons. Such effect may be duo to that N enhanced the uptake of other minerals, which finally was reflected as better growth. In this connection (Cai, and Ge, 2004) found that the nitrogen content of sugar beet plant was significantly and positively correlated with nitrogen amount used.

Table 5. Effect of different rates of nitrogen fertilizer with some micronutrients on root nutrients uptake.

Treatments N Kg/fed		Macronutrient		Micronutrients					
Nitrogen (N)	Micronutrients (M)	N(g/plant)		Mn(mg/plant)		Zn(mg/plant)		Fe(mg/plant)	
		2008/09	2009/10	2008/09	2009/10	2008/09	2009/10	2008/09	2009/10
N1 (60 kg/fed)	control	1.66	2.04	4.98	6.01	3.14	3.62	7.26	8.13
	Zn	2.21	2.46	5.77	6.14	3.95	4.85	7.80	8.42
	Mn	2.46	2.62	8.85	7.93	3.32	4.04	8.03	8.33
	Fe	2.73	2.95	6.33	6.91	3.49	4.34	10.65	12.29
	Zn+Mn+Fe	3.07	3.28	9.04	7.50	4.83	5.20	9.68	9.87
Means		2.43	2.67	7.00	6.90	3.75	4.41	8.68	9.41
N2 (80 kg/fed)	control	2.66	2.83	6.25	6.55	3.79	3.77	8.02	8.50
	Zn	3.12	3.05	6.49	7.09	4.80	5.50	8.32	8.72
	Mn	3.03	3.18	9.16	9.27	4.16	4.63	8.49	8.77
	Fe	3.39	3.75	8.42	7.63	4.67	5.00	11.43	12.81
	Zn+Mn+Fe	3.73	4.63	10.19	8.50	5.80	6.65	9.21	11.50
Means		3.19	3.49	8.10	7.81	4.64	5.11	9.09	10.06
N3 (100 kg/fed)	control	3.13	3.19	6.61	7.95	4.77	5.19	9.07	9.17
	Zn	3.53	3.48	6.84	8.29	5.68	5.90	9.23	9.33
	Mn	3.37	3.35	10.48	10.62	5.16	5.25	9.26	9.52
	Fe	4.08	4.26	9.01	8.42	4.99	5.52	12.49	14.18
	Zn+Mn+Fe	5.02	5.84	12.45	9.50	6.49	7.98	10.11	12.80
Means		3.82	4.02	9.08	8.95	5.42	5.97	10.03	11.00
Mean of micro-nutrients	control	2.48	2.69	5.95	6.83	3.90	4.20	8.12	8.60
	Zn	2.95	3.00	6.37	7.17	4.81	5.42	8.45	8.82
	Mn	2.96	3.05	9.50	9.27	4.21	4.64	8.60	8.87
	Fe	3.40	3.66	7.92	7.66	4.39	4.95	11.52	13.09
	Zn+Mn+Fe	3.94	4.58	10.56	8.50	5.71	6.61	9.67	11.39
L.S.D of 5%	(N)	0.07	0.23	0.97	0.64	0.24	0.46	0.55	0.94
	(M)	0.18	0.22	1.03	0.78	0.36	0.47	0.27	0.64
	N x M	0.31	0.39	N.S	N.S	N.S	N.S	N.S	N.S

Effect of micronutrients

Foliar application of micronutrients i.e. Mn, Zn and Fe significantly increased their uptake and also N uptake. Data also found that spray with the mixture of Mn, Zn and Fe was the best treatment where, it gave the highest values for N, Mn, Zn and Fe uptake.

Effect of interactions

The interactions between N rates and studied micronutrients gave significant increase for N uptake only. Treatment with N at the rate 125% of RR along with foliar spray with the mixture of Zn, Mn and Fe gave the best values of N uptake than other interactions under study.

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تأثير التسميد النيتروجيني وبعض العناصر الصغرى على إنتاجية وجودة بنجر السكر

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أقيمت تجربتان حقليتان في موسمي ٢٠٠٨/٢٠٠٩ و ٢٠٠٩/٢٠١٠ بمحطة بحوث سخا (محافظة كفر الشيخ) لدراسة تأثير ثلاث معدلات من النيتروجين ٧٥ و ١٠٠ و ١٢٥% من المعدل الموصى به وهو ٨٠ كجم نيتروجين للفدان على بعض المركبات الكيميائية وجودة العصير والمحصول في نبات بنجر السكر الذي تم رشه بالعناصر الصغرى مثل المنجنيز والزنك والحديد اما مفردة او خليط بينهم.

- قد وجد أن نقص معدل النيتروجين إلى (٧٥% من المعدل الموصى به) أدى إلى إنخفاض معنوي في كل من الصبغات النباتية مثل كلورفيل ا ، ب والكاروتينات عند عمر ١٢٠ يوم من الزراعة في كلا الموسمين. وأيضا أدى إلى إنخفاض معنوي لجوده العصير مثل السكروز وبعض القياسات التكنولوجية (السكر المستخلص والسكر المفقود في المولاس ومعامل السكر) وبعض صفات المحصول كطول وعرض الجذر والوزن الطازج للاوراق في كلا الموسمين، أيضا إنخفض محصول الجذر والسكر. كما أدى إنخفاض النيتروجين عن الموصى به إلى نقص النيتروجين ، الزنك والمنجنيز الممتص .

- من ناحية أخرى أدى ارتفاع التسميد النيتروجيني إلى ١٠٠ كجم نيتروجين للفدان (١٢٥% من المعدل الموصى به) إلى زيادة معنوية للصبغات النباتية مثل كلورفيل ا ، ب والكاروتينات عند عمر ١٢٠ يوم من الزراعة في كلا الموسمين كما أدى إلى زيادة الصوديوم وألفا امينو نيتروجين كشوائب وبالرغم من انه أدى إلى زيادة معنوية للسكر المفقود في المولاس وانخفاض معنوي للنقاوة الا انه أدى إلى زيادة معنوية في محصول الجذر والسكر.

- أدى الرش الورقي بالعناصر الصغرى (المنجنيز، الزنك والحديد) مفردة أو مجتمعة إلى زيادة معنوية لكل من كلورفيل ا ، ب والكاروتينات في كلا العينتين عند عمر ٩٠ و ١٢٠ يوم من الزراعة في كلا الموسمين وأيضا إلى زيادة السكروز والبوتاسيوم وألفا امينو نيتروجين ولكنه خفض معنويا الصوديوم. وقد تأثرت معنويا صفات المحصول مثل طول وعرض الجذر والوزن الطازج لكل من الجذر والمجموع الخضري ، كما أدى الرش الورقي بالعناصر الصغرى إلى زيادة معنوية لمحصول السكر (طن/فدان) وزيادة الممتص من النيتروجين ، الزنك ، المنجنيز والحديد

كانت افضل معاملة هي الرش الورقي للخليط بين العناصر الصغرى (المنجنيز، الزنك والحديد) حيث أعطت أعلى قيم لمعظم الصفات المدروسة بالنسبة للكنترول(الغير معاملة بالعناصر الصغرى).

- التفاعل بين النيتروجين عند المعدل الاعلى (١٠٠ كجم / فدان) والخليط بين العناصر الصغرى أعطى أعلى قيم بالنسبة لكلورفيل ا ، ب والكاروتينات والبوتاسيوم وألفا امينو نيتروجين كشوائب وأعلى نقاوة للعصير والنيتروجين الممتص.

RESPONSE OF THREE SWEET SORGHUM VARIETIES TO POTASSIUM MINERAL - AND BIO - FERTILIZATION

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Abstract

Two field trials were conducted during the summer seasons of 2009 and 2010 on sweet sorghum at Giza Agricultural Research Station, Agricultural Research Center, Giza Governorate, to study the effect of three treatments of potassium fertilization, viz., 24 and 30 kg K₂O/fed as potassium sulfate 48% K₂O as a mineral fertilizer, both of them with 2 bags bio-fertilizer (potassium Mag/fed as a recommended dose) and 36 kg K₂O/fed without bio-fertilizer on yield/fed and chemical composition of three sweet sorghum varieties, namely, Honey, Brandes and Sorgo. Sweet sorghum varieties differed significantly for stripped stalk, juice and surup yields/fed, TSS, purity and extracted juice% as well as chemical composition, i.e. sucrose% and reducing sugars% in juice and syrup. Sorgo variety was the best as compared to Brandes and Honey. The highest values of the most aforementioned traits were obtained at 30 kg K₂O/fed with 2 bags of biofertilizer. The interaction between all studied traits were insignificantly affected in both seasons. Therefore, these results give evidence to the use of sweet sorghum for syrup production instead of sugar cane, to reduce the vast gab between sugar production and consumption.

Key words: Sweet sorghum, potassium, biofertilization, syrup and TSS%.

INTRODUCTION

Sweet sorghum is cultivated mainly for its syrup, which is called Black honey. It is predicted to be one of the major sources for syrup production in the near future if the sorghum syrup quality improved. Good sorghum syrup is light colored and mild and has a characteristic of flavor. (Osman *et. al.* 2005 and Mohamed *et. al.* 2006). Therefore this leads to save cane yield for sugar production and reduce the vast gab between sugar production and consumption which reached about 1.10 million ton. It is still imported annually (CCSC 2010). Sweet sorghum productivity and quality are affected greatly by many factors. Variety selection is one of the most important decisions in the production of sweet sorghum syrup. There is a great variation among sorghum varieties in stalk height, diameter, number of internodes, syrup production and yield and its components (Miller and Creelman 1982 and Chawdhury and Rahman 1990 and Mohamed *et. al.* 2006). In this respect, Nour El Hoda *et. al.* (1994) and Mohamed *et. al.* (2006) illustrated that stripped stalk yield, was the effective

parameter on juice and syrup yield, in addition to the chemical characteristics which in turn affect syrup quality of sweet sorghum varieties. Ismail *et. al.* (2007) and Aly *et. al.* (2008) reported that sweet sorghum varieties show significant differences in leaf area, leaf area index, plant height and diameter, TSS%, sucrose%, purity%, juice and syrup extraction%, stripped stalk, juice and syrup yields.

Potassium is known for its role in sucrose translocation and accumulation in storage tissues of plants. In this respect, potassium fertilizer increases the sucrose % without significant reduction in purity%. potassium fertilizer for sweet sorghum supply 40 pounds for each unit of K₂O/acre is essential to get high yields. A five to seven tons/acre sorghum crop will remove about 180 lb K₂O/acre (Undersander *et. al.* 1990). El-Zeny (2004) found that juice extraction%, juice yield, syrup extraction%, syrup yield, total soluble solids, sucrose% were significantly increased by applying potassium fertilizer at 30 kg K₂O/fed. Mohamed *et. al.* (2006) found that maximum stripped stalk and syrup yield of sweet sorghum were obtained using potassium fertilization at the rate of 24 kg K₂O/fed for both varieties. Meantime, such treatment enhanced greatly juice and syrup quality. This work was carried out to obtain the highest yield and quality of some sweet sorghum varieties by applying different doses of potassium mineral fertilizer and biofertilizer.

MATERIALS AND METHODS

Two field trials were conducted during the summer seasons of 2009 and 2010 on sweet sorghum (*Sorghum bicolor* L. Moench) at Giza Agricultural Research Station. Agricultural Research Center, (Giza Governorate), to study the effect of three levels of potassium fertilizer (24 and 30 kg K₂O/fed potassium sulfate as a mineral fertilizer both of them with 2 bags of biofertilizer potassium Mag/fed as a recommended dose) and 36 kg K₂O/fed without biofertilizer on yields/fed and chemical compositions of three sweet sorghum varieties, viz., Honey, Brandes and Sorgo. A split plot design with four replications was used, potassium and biofertilizer levels i.e., the three levels of potassium fertilizer were allocated to the main plots and the three sorghum varieties to the sub plots. Plot size was 14 m² (1/300 fed) and consisted of four rows, 7 m long and 50 cm apart. Sowing date was 1st of May and harvest was done after four months from sowing in both seasons. Seeds were inoculated before sowing with potassium Mag (recommended dose 2 bags/fed) in a shadow place pre planting and immediately sown and irrigated. The biofertilizer was provided by the Biofertilization Unit, Soil, Water and Environment Research Institute, Agricultural Research Center. Nitrogen fertilizer (as urea 46.5% N), was added at the recommended rate of 60 kg

N/fed in two equals doses, the 1st one was after one month from sowing and the 2nd one 15 days later. Phosphorus fertilizer (as calcium superphosphate 15.5% P₂O₅), was added at the recommended rate of 15 kg/fed during seed bed preparation. Potassium fertilizer (as potassium sulphate 48% K₂O), was added at the 24, 30 with biofertilizer and 36 kg K₂O/fed without biofertilizer in two equal doses with nitrogen fertilizer. All Agricultural practices were done as recommended by Sugar Crops Research Institute. Some physical and chemical properties of the experimental soils were analyzed according to Jakson (1967) and shown in Table (1).

Table 1. Some physical and chemical analyses of the experimental soils*.

Particle size %				Soil texture	**E.C. ds/m	Soil pH***	Organic matter %	CaCO ₃ %		
Sand	Silt	Clay	Fine sand							
11.20	25.70	60.10	3.00	Clay	3.20	8.00	1.89	1.60		
Soluble Cations (meq/L)				Soluble anions(meq/L)				Total available contents (ppm)		
Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	CO ₃ ⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻	N	P	K
5.10	2.60	16.30	0.35	0.10	2.90	9.40	13.30	36.0	6.91	280.51

* Each value represents the average of 4 samples at both seasons.

** EC = Electrical conductivity was measured in a soil – water extract (1:5).

*** pH was measured in a soil – water suspension (1: 2.5).

Recorded data

At the dough stage (content of seeds are firm and easily crushed between thumb and index fingers), the plants were harvested after 120 days from sowing. A sample of twenty stalks from each subplot was taken at random to determine the following parameters:

- Yield and extracted juice

- Yield and juice extracted were determined from plants taken from the two middle rows of each sub plot to avoid the border effect. Sample size of 10 plants/plot was used to determine stripped stalk, juice and syrup (tons/fed) according to AOAC (2005).

- Extraction juice %

- Brix% was determined by Brix hydrometer standardized at 20°C.

- Purity% was determined by the following equation:

$$\text{Purity\%} = \text{Sucrose \%} \times 100/\text{TSS\%}.$$

- Juice and syrup extraction (JSE)% was estimated from the following formula:

$$\text{JSE\%} = \text{juice or syrup yield ton/fed} \times 100/\text{stripped stalk yield ton/fed}.$$

- Chemical composition

- Extraction juice and syrup% were chemically analyzed for sucrose%, reducing sugars% which were determined according to methods described by AOAC (2005). Als, pH value was measured by a Beckman pH meter according to Collins *et. al.* (1987).

Data were statistically analysed at 5% level of probability according to Snedecor and Cochran (1981).

RESULTS AND DISCUSSION**I. Varietal effects****-Yields and extracted juice**

The results obtained in Table (2) revealed that varieties significantly differed in stripped stalks, juice and syrup yields/fed in both seasons. The highest values of studied traits were recorded by variety Sorgo as compared with the other varieties, i.e. Brandes and Honey. The differences in these traits among genotypes might be due to the differences in their genetic the make-up. (Nour El Hoda *et. al.* 1994 and Mohamed *et. al.* 2006).

Table 2. Effect of varieties on yield/fed and extracted juice %.

2009 season						
Sweet sorghum	Yields (ton/fed)			Extracted juice		
Varieties	Stripped stalk	Juice	Syrup	Total soluble solids%	Purity%	Juice extraction%
Honey	28.25	12.89	1.45	20.41	53.41	45.63
Brandes	29.31	13.94	2.59	19.94	58.98	47.56
Sorgo	30.33	14.92	2.89	18.17	67.86	49.19
LSD 5%	1.45	0.54	0.19	1.10	4.78	1.29
2010 season						
Honey	29.12	13.74	1.59	21.65	51.04	47.18
Brandes	30.22	14.44	2.12	20.11	63.80	47.78
Sorgo	31.39	15.59	2.86	19.38	69.35	49.67
LSD 5%	0.84	0.17	0.15	0.75	4.25	0.93

- Extracted juice

The results in Table (2) indicated that TSS, purity% and extraction juice% traits significantly differed between the three varieties in both seasons. Variety Honey

produced the highest values of TSS% of juice. While, variety Sorgo had the highest purity and extraction juice% compared to the other varieties. This result might be mainly due to the fact that the non sugar substances % of juice and fiber content were lower for Honey variety than Brandes and Sorgo. Similar findings were obtained by Nour El Hoda *et. al.* (1994) and Mohamed *et. al.* (2006).

- Chemical composition

Results in Table (3) showed that sweet sorghum varieties differed significantly in chemical composition in both seasons. The obtained results in Table (3) indicate that sucrose% and reducing sugars% in extracted juice and syrup as well as extracted syrup% were significantly affected by sweet sorghum varieties, while, pH values did not differ significantly in both seasons. It is important to mention that Sorgo was the best variety where, it gave the highest value of sucrose% and the lowest value of reducing sugars%. This variation among genotypes may be due to the differences in their genetic make-up. Such data are in the same trend with Nour El Hoda *et. al.* (1994), Osman *et. al.* (2005) and Mohamed *et. al.* (2006).

Table 3. Effect of varieties on chemical composition .

2009 season						
Sweet sorghum	Chemical composition					
	Extracted juice			Extracted syrup		
	Varieties	Sucrose%	Reducing sugars%	pH value	Sucrose%	Reducing sugars%
Honey	10.90	2.35	3.83	28.27	30.78	5.13
Brandes	11.76	2.17	3.73	29.80	29.84	8.83
Sorgo	12.33	2.00	3.78	30.04	28.81	8.54
LSD 5%	0.48	0.05	NS	0.65	0.75	2.02
2010 season						
Honey	11.05	2.54	3.83	27.20	31.81	5.46
Brandes	12.83	2.39	3.73	28.83	30.84	7.02
Sorgo	13.44	2.17	3.78	29.02	29.83	9.11
LSD 5%	0.32	0.10	NS	0.85	0.55	1.95

II: Potassium mineral fertilizer and biofertilization

- Yields and extracted juice

The results in Table (4) showed a significant increase in yields of stripped stalks, juice and syrup/fed with potassium mineral fertilizer and biofertilization application at the rate of 30 kg K₂O/fed + 2 bags Mag/fed followed by 36 kg K₂O/fed without biofertilizer and 24 kg K₂O/fed + 2 bags Mag/fed in both seasons. This could

be attributed to the positive effect of potassium on stalk weight, which showed low fiber content and high water content with the application of potassium. These results revealed the importance of mineral fertilizer and biofertilizers for increasing yield and juice extracted of plants.

Table 4. Effect of potassium mineral fertilizer and biofertilization on yield/fed and juice extracted % .

2009 season						
Potassium	Yields (ton/fed)			Juice extracted		
(mineral and biofertilizer Mag kg/fed.)	Stripped	Juice	Syrup	Total soluble solids %	Purity %	Juice extraction %
24 K ₂ O + 2 bags Mag/fed	27.67	14.53	1.26	21.59	50.95	52.51
30 K ₂ O + 2 bags Mag/fed	29.81	16.20	2.93	18.15	71.74	54.34
36 K ₂ O	28.50	15.03	2.48	20.78	62.37	52.74
LSD 5%	0.68	0.50	0.11	0.57	0.89	0.18
2010 season						
24 K ₂ O + 2 bags Mag/fed	28.67	13.10	1.35	21.76	56.02	45.69
30 K ₂ O + 2 bags Mag/fed	30.94	15.99	3.16	18.25	78.08	51.68
36 K ₂ O	29.47	14.69	2.07	20.13	65.57	49.85
LSD 5%	0.41	0.25	0.08	0.37	0.74	2.12

- Extracted juice

Results in Table 4 show that treatment with 30 kg K₂O/fed + 2 bags of Mag/fed or 36 kg K₂O/fed without biofertilizer had a significant increase in purity and juice extraction as compared with 24 kg K₂O/fed + 2 bags Mag/fed in both seasons. The increase in purity% might be due to the increase in sucrose% and decrease in non sugar substances% of sorghum juice with potassium fertilization and syrup extraction % (SEP) of sorghum syrup as compared with the control treatment. These results revealed the importance of potassium (mineral fertilizer twice) and biofertilization for physical properties of extracted juice. These results may be due to role of potassium (mineral fertilizer) in increasing photosynthesis activity and subsequently carbohydrate synthesis and its accumulation which is reflected on the TSS%. Role of potassium biofertilizer may be due to increasing available nutrients for growth and subsequently juice quality. These results are in agreement with those reported by El-Zeny (2004), Mohamed *et. al.* (2006) and Moustafa *et. al.* (2006).

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استجابة ثلاثة اصناف من الذرة الرفيعة السكرية للتسميد البوتاسي المعنى والحيوى

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اقامت تجربتين حقليتين بمركز البحوث الزراعية (محطة بعوث الجزيرة) في صيف ٢٠٠٩ و ٢٠١٠ بتسميد القطع المنشقة مرة واحدة لدراسة تأثير ثلاثة مستويات من التسميد البوتاسي المعنى والحيوى وهي ٢٤ و ٣٠ كجم بوتاسيوم/فدان بالاضافة الى بوتاسيوم حيوى (بوتاسيوم ماج ٢ كيس/فدان) الموصى به و ٣٦ كجم بوتاسيوم معنى بدون تسميد حيوى على محصول العيدان والعصير والسل والصفات الكيماوية للعصير والسل المنتج من اصناف الذرة السكرية وهي هانى وبراندز وسورجو .

كلمات النتائج كالاتي:

١. اختلفت الاصناف معنويا في الصفات المحصولية وهي محصول العيدان النظيفية والشراب والعصير (طن/فدان) والمواد الصلبة الذاتية الكلية للعصير ونسبة التقاوة ومستخلص العصير وايضا المركبات الكيميائية مثل النسبة المئوية للسكريز والسكريات المختزلة في العصير والشراب وقد تفوق الصنف سورجو ثم الصنف براندز ثم الصنف هانى في كلا الموسمين.
 ٢. استخدام السماد البوتاسي بمعدل ٣٠ كجم بو ٢ /فدان + ٢ كيس (بوتاسيوم ماج) حيوى بوتاسيوم الى زيادة معنوية في معظم الصفات المساللة الذكر.
 ٣. لم يكن للتداخل بين الاصناف والتسميد البوتاسي المعنى والحيوى تاثير معنوى على اى من الصفات السابقة في كلا الموسمين.
- يوصى هذا البحث بأنه لزيادة المحصول وتحسين معظم خواص العصير والشراب الناتج عن طريق زيادة محتواهما من السكريز و إنتاج المسل ذو الموصفات الحسنة وتوفير قصب السكر لإنتاج السكر بدلا من المسل الاسود يصبح بإضافة ٣٠ كجم بو ٢ / فدان + ٢ كيس (بوتاسيوم ماج) حيوى بوتاسيوم واستخدام صنف الذرة الرفيعة السكرية سورجو ثم براندز ثم الصنف هانى على التالى.

CHARACTERIZATION OF MID-OLEIC SUNFLOWER OIL PRODUCED BY BLENDING TWO DIFFERENT TYPES OF SUNFLOWER OIL

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Abstract

This research aims to produce mid-oleic sunflower oil (MOSO) and improve oil oxidative stability by blending technology. High oleic sunflower oil (HOSO) was blended with traditional sunflower oil (TSO) at different ratios: B1 [HOSO 30: TSO 70], B2 [HOSO 50: TSO 50] and B3 [HOSO 70: TSO 30]. The increase of oleic acid content in the oil blends lead to improve their oxidative stability. The stability of TSO was 7.88 h and increased by increasing HOSO percent in the blends to reach, 11.32 h (B1), 12.60 h (B2) and 13.89 h (B3). Oil blends B2 and B3 were nearly the same as mid-oleic sunflower produced by breeding technology. HOSO was characterized by the highest content of nature antioxidant, i.e., total tocopherol, total polyphenols and unsaponifiable matter whilst the lowest content of these substances were presented in (TSO).

Keywords: High-oleic sunflower oil, traditional sunflower oil (mid-oleic sunflower oil, oil blends, oxidative stability, fatty acid composition, tocopherols.

INTRODUCTION

Technology is now available to alter the fatty acid composition of oil seeds by genetic modification or traditional breeding. Lowering the linolenic acid content in canola and soybean oils has been the objective of plant breeders to improve the flavor quality and oxidative stability of these oils. Safflower and sunflower oils have also been modified to improve their oxidative stability by increasing oleic acid levels to 70-90% (Warner *et. al.* 1997).

Blending technology was used by many authors to improve oxidative stability (Frankel and Huang, 1994; Kleingartner and Warner 2001). Consequently the sunflower oil quality is assessed by determining the saturated and unsaturated fatty acid ratio (Joita *et. al.* 2005).

The fatty acid composition of traditional sunflower oil, Nusun [mid-oleic sunflower] and high-oleic sunflower oil according to the codex Alimentarius (2001) are as follows : oleic acid ranging from 14.0 to 39.4%, 43.1 to 71.8% and 75.0 to 90.7%, linoleic acid from 48.3 to 74.0%, 18.7 to 45.3% and 2.1 to 17.0%, palmitic acid from 2.0 to 7.6%, 4.0 to 5.5% and 2.6 to 5.0 % and stearic acid from 1.0 to 6.5%, 2.1 to 5.0% and 2.9 to 6.2%, respectively.

Expeller mid-oleic sunflower oil provides a better flavor intensity and quality in fried food products compared to high-oleic sunflower oil, due to its higher linoleic acid (C18: 2) content. Mid-oleic sunflower oil has been shown to give higher flavor intensity and quality to fried foods (Warner *et. al.*, 1997).

Mid-oleic sunflower oil is distinguished by containing high level of healthy monounsaturated fats and free from trans fatty acid due to non-hydrogenated technique. Non genetically modified sunflower oil naturally contains high level of antioxidants and tocopherols (vitamin E) (Kiatsrichart *et. al.*, 2003). This oil genotype significantly reduce the amount of [Low-density Lipoprotein Cholesterol] LDLC compared to traditional sunflower oils, therefore helping to reduce the risk of coronary heart disease (Gupta, 2007).

Oils and fats intended for commercial frying applications must be stabilized to prevent deterioration caused by oxidation, polymerization, and hydrolysis at high-temperature. Modifying the fatty acid composition of the oil, the most common method to stabilize frying oils can be conducted by several methods. For example, blending polyunsaturated oils with more saturated or monounsaturated oils is an option to adjust fatty acid to optimal levels, such as combining high-oleic sunflower oil with corn oil or completely hydrogenated soybean oil with soybean oil (Warner and Knowlton, 1997).

The objective of this research was to prepare mid-oleic sunflower oil by blending technology and to investigate the effect of oleic and linoleic acid composition of traditional sunflower oil, high oleic sunflower oil and their blends on oxidative stability phenomenon.

MATERIALS AND METHODS

Materials

Traditional sunflower oil: [TSO]

Sunflower oil was obtained from Misr Gulf oil processing Company (MIGOPC) Atakah, Suez Governorate.

High-oleic sunflower oil : [HOSO]

High-oleic sunflower oil was obtained from Egyptian General Organization for Export and Import Control.

Oil blends:

Traditional sunflower oil (TSO) and high oleic sunflower oil were blended at different percentages:

Blend 1 = 70% TSO+ 30% HOSO

Blend 2 = 50% TSO + 50% HOSO

Blend 3 = 30% TSO + 70% HOSO

Solvents: All solvents in this study were of analytical grade (Merck).

Analytical Methods :**Physical and chemical characteristics:**

- Refractive index : of the oils was determined at 25°C according to A.O.A.C. (2000) by using refractometer [NYRL -3 Poland].
- Acid, peroxide, iodine and saponification values and unsaponifiable matter (%) were determined according to the methods described in A.O.A.C (2000).
- **Absorbancy in ultraviolet**

The ultraviolet (UV) absorption of 1% solution of the oil in cyclohexane was measured according to FAO/ WHO (1970) at 232 and 270 nm- using Shemadzu sepectrophotometer uv.vis (20-02).

- Fatty acid composition

The fatty acids of the oil samples were determined by GC instrument equipped with DB-23 capillary column (60m x 0.32mm x 0.25um film thickned according to the method mentioned by IOOC, (2001).

- Total tocopherols and polyphenols:

The total tocopherols and polyphenols of oils were determined according to the methods of Wong *et. al.*, (1988) and Gutfinger, (1981), respectively.

- Stability

The oxidative stability of oils was estimated by Rancimat apparatus (Metrohn Herisou, Co., Switzerland) at 100°C with an air flow rate of 20L/hr. according to the method described by Mendez *et. al.* (1997).

Color:

A lovibond tintometer was used to measure the color using 5.25 inch cell according to the method of the A.O.A.C, (2000).

RESULTS AND DISCUSSION**Physical and chemical properties of oils :**

Physical and chemical properties of traditional sunflower oil (TSO), high-oleic sunflower oil (HOSO), B1, B2 and B3 oil blends were carried out and the results are given in Table (1). From these results it is clear that there were a little changes in refractive index, color, absorbances at 232 and 270nm, acid value, peroxide value and saponification value. The highest iodine value was observed in TSO (137.5), followed by B1 (125.90), B2 (117.04) B3 (110.62) and HOSO (90.13). This finding was due to the high amount of polyunsaturated fatty acid in TSO than in HOSO. Thus the more concentration of TSO, the higher iodine value in the blend. These results are in agreement with those reported by Warner *et. al.* (1997), Gupta (1998) and Kiatsrichart *et. al.* (2003).

Table 1. Physical and chemical characteristics of traditional sunflower oil (TSO), high - oleic sunflower oil (HOSO) and their oil blends.

Property	TSO (a)	HOSO (b)	Oil blends		
			B1 70a+30b	B2 50a+50b	B3 30a+70b
Refractive index at 25°C	1.4690	1.4674	1.4685	1.4682	1.4679
Color Yellow	10	7.2	9.1	8.5	8.3
Red	0.8	0.5	0.7	0.6	0.6
Acid value (mg KOH/g oil)	0.104	0.086	0.090	0.088	0.083
Peroxide value (meq/kg oil)	3.60	2.25	3.34	3.57	2.85
Iodine value (g I ₂ / 100g oil)	137.5	90.13	125.90	117.04	110.62
UV-absorbance at 232 nm	0.446	0.351	0.414	0.382	0.365
UV-absorbance at 270 nm	0.190	0.152	0.185	0.163	0.155
Saponification value [mg KOH/ g oil]	189.2	192.0	189.5	190.2	191.4

(a) Traditional sunflower oil.

(b) High oleic-sunflower oil.

Fatty acid composition of oils :

The fatty acid compositions of TSO, HOSO, B₁, B₂ and B₃ are presented in Table (2) and Fig (2) The results indicate that HOSO was rich in oleic acid 75.42% followed by oil blends B₃, B₂, B₁ and TSO (58.66, 49.63, 38.64 and 23.72% respectively). On the other hand, the major polyunsaturated fatty acid, linoleic acid (18: 2) was observed at the highest concentration in TSO (64.34%) followed by oil blends B₁ (50.45), B₂ (40.03), B₃ (32.46) and HOSO (14.96%). These results are in agreement with those reported by Codex Standard (2001) and Frank (2005).

From these results it was clear that oleic acid and linoleic acid contents were changed by blending. Oleic acid levels ranged from 38.64 to 58.66 and linoleic acid from 32.46 to 50.45% in the studied oils and their blends. The fatty acid pattern gave the way to study the effect of these changes on the oxidative stability and at the same time distinguish the oil blend which is more suitable to be mid-oleic sunflower oil (MOSO).

According to the fatty acid composition ranges of TSO, mid-oleic sunflower oil and HOSO from Codex Standard (2001) for vegetable oils, the oleic acid and linoleic acid contents of mid-oleic acid sunflower oil were from 43.1 to 71.8% and 18.7 to 45.3%, respectively. From the data in Table (2) and Fig (1) it is clear that the levels of monounsaturated and polyunsaturated fatty acid of oil blends B₂ and B₃ were 50.47, 59.01 % and 40.15, 32.57%, respectively. These obtained values fall in the above range of codex standard. It means that B₂ and B₃ oil blends were the best blends to be mid-oleic sunflower oil without breeding or genetical modification.

One can use the fatty acid composition obtained by GLC analysis to elucidate the rate of oil oxidation. The equation reported by Fatemi and Hammond (1980) with minor modification was applied in the present study, to calculate oxidisability rates of oils under study.

Table 2. Fatty acid composition (%) of traditional sunflower oil (TSO), high oleic sunflower oil (HOSO) and their oil blends.

Fatty acid %	TSO (a)	HOSO (b)	Oil blends		
			B1 70a+30b	B2 50a+50b	B3 30a+70b
C _{14:0}	0.15	0.05	0.12	0.09	0.08
C _{16:0}	6.55	4.55	5.77	5.29	4.25
C _{16:1}	0.2	0.06	0.17	0.11	0.10
C _{18:0}	4.15	3.8	3.89	3.78	3.45
C _{18:1}	23.72	75.42	38.64	49.63	58.66
C _{18:2}	64.34	14.96	50.45	40.03	32.46
C _{18:3}	0.14	0.12	0.13	0.12	0.11
C _{20:0}	0.28	0.25	0.26	0.27	0.21
C _{20:1}	0.17	0.29	0.20	0.23	0.25
C _{22:0}	0.3	0.5	0.37	0.45	0.43
TS	11.43	9.15	10.41	9.88	8.42
TU	88.57	90.85	89.59	91.12	91.58
18:1/18:2	0.36	5.04	0.77	1.24	1.8
COX	6.89	2.32	5.71	4.64	3.95
AI	0.076	0.051	0.065	0.060	0.047

TS and TU refer to total amount of saturated and unsaturated fatty acids respectively.

COX refer to calculated oxidisability value as reported by Fatemi and Hammond (1980)

$$\text{COX} = 1 [16:1\% + 18:1\% + 20:1 + 22:1\%] + 10.3 (18:2\%) + 21.6 (18:3\%)/100$$

AI : indicates the atherogenic index and calculated as outlined by De Lorenzo *et. al.* (2001).

$$\text{AI} : (12:0 + 14:0 + 16:0) / (\omega\text{-3 PuFA} + \omega\text{-6 PuFA} + \text{MUFA})$$

The calculated oxidisability index (COX) for TSO, HOSO, B1, B2 and B3 were 6.89, 2.23, 5.71, 4.64 and 3.95, respectively. These values indicated that mixing TSO with HOSO at difference level lead to increase its stability towards rancidity, and the stability increased as the HOSO increase in the blend.

One has to look at another parameter resulted from the fatty acid analysis by GLC, i.e., atherogenic index (AI). This factor is important from the human health point of view, the lower value is in the favour of good health Radwan *et al.* (2010). According to GLC data, the oils under study can be arranged according to the benefit of human health as follow: B3 (0.047) > HOSO (0.051) > B2 (0.060) > B1 (0.065) > TSO (0.076). Hence, oil blend (3) is the best one towards decreasing the problems related with coronary heart disease. As shown in Table (2), blending of HOSO with TSO led to lower the values of atherogenic index. It seems that the types of fatty acid consumed with diet affect the diseases of cardiovascular system.

CHARACTERIZATION OF MID-OLEIC SUNFLOWER OIL PRODUCED BY BLENDING TWO DIFFERENT TYPES OF SUNFLOWER OIL

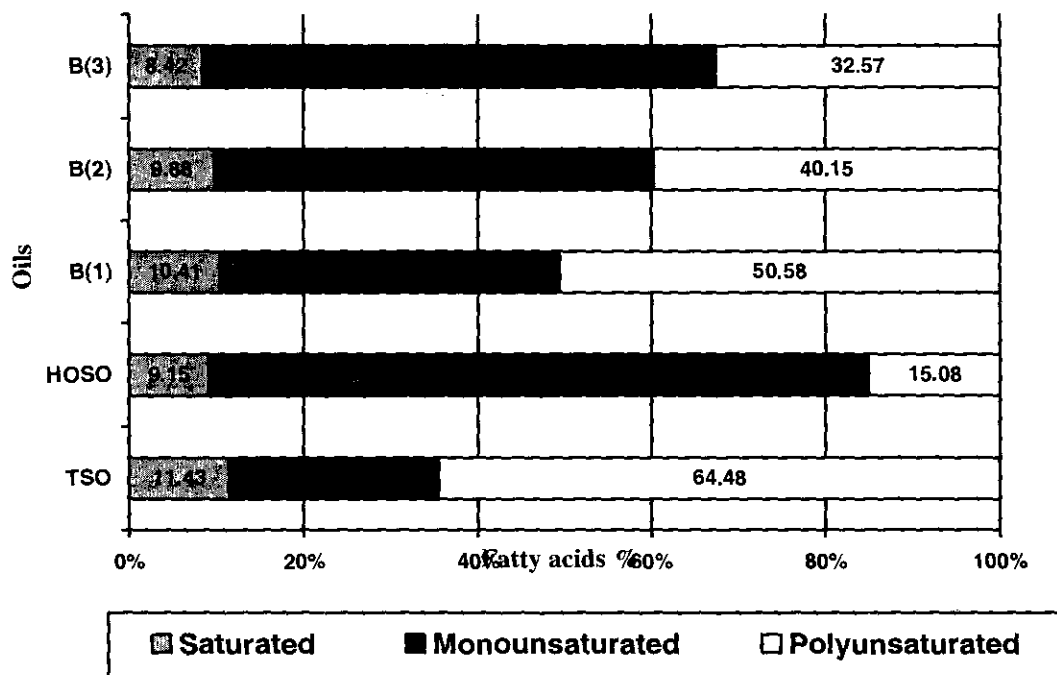


Fig. 1. Saturated, monounsaturated and polyunsaturated fatty, acid contents of traditional sunflower oil (TSO), high-oleic sunflower oil (HOSO) and their blends.

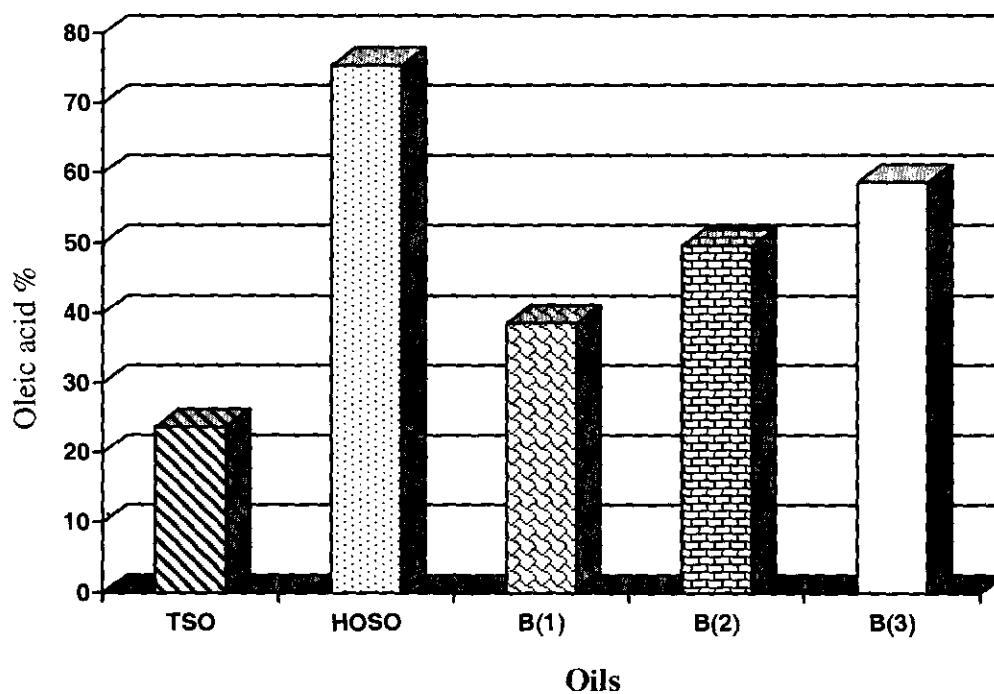


Fig. 2. Oleic acid content of traditional sunflower oil (TSO), high -oleic sunflower oil (HOSO) and their blends.

Oxidative stability of traditional sunflower oil (TSO) high-oleic sunflower oil (HOSO) and their blends:

The effect of fatty acid compositions of TSO, HOSO and their oil blends on oxidative stability phenomenon was studied using Rancimt 976. From the data in Table (3) and Fig. (3) it was observed that the oxidative stability of oils increased as oleic acid content increased. The highest oxidative stability was noted for HOSO (14.76 h at 100°C) and the lowest value was recorded for TSO (7.88 h). Meanwhile, the oxidative stability of oil blends B1, B2 and B3 were fallen in between being 11.32, 12.00 and 13.89 h, respectively). These data are in agreement with that reported by Demurin *et. al.* (1996). Data in Table (3) also demonstrates that the natural antioxidants, tocopherols (mg/kg), phenols (ppm) and unsaponifiable matter (%) possessed the same trend of the oxidative stability. The highest content of these compounds was found in HOSO, while TSO contained the lowest quantity. The levels of these antioxidant materials in oil blends B1, B2 and B3 were fallen in between. These data are in agreement with that described by Gupta, (1998).

From these result one can conclude that the increase of both monounsaturated fatty acid and natural antioxidant content and the decrease of polyunsaturated fatty acid level lead to improve the oxidative stability of the oil. Concerning oil blends B2 and B3 which represent the mid oleic-sunflower their oxidative stability increased to 1.6 and 1.76 times as great as that of TSO. In addition one has to realise their advantages as frying media as recorded by Frankle and Huang, (1994); Kleingartner and Warner, (2001).

Table 3. Natural antioxidant and oxidative stability of traditional sunflower oil (TSO), high oleic sunflower oil (HOSO) and their oil blends.

Parameter	TSO (a)	HOSO (b)	Oil blends		
			B1 70a+30b	B2 50a+50b	B3 30a+70b
Stability (hr.) at 100°C	7.88	14.76	11.32	12.60	13.89
Total tocopherols [mg/kg]	563.20	624.07	570.36	579.50	594.64
Total polyphenols (ppm)	25.70	29.56	26.60	27.43	27.95
Unsaponifiable matter (%)	1.16	1.25	1.19	1.20	1.22

a) Traditional sunflower oil.

(b) High oleic-sunflower oil.

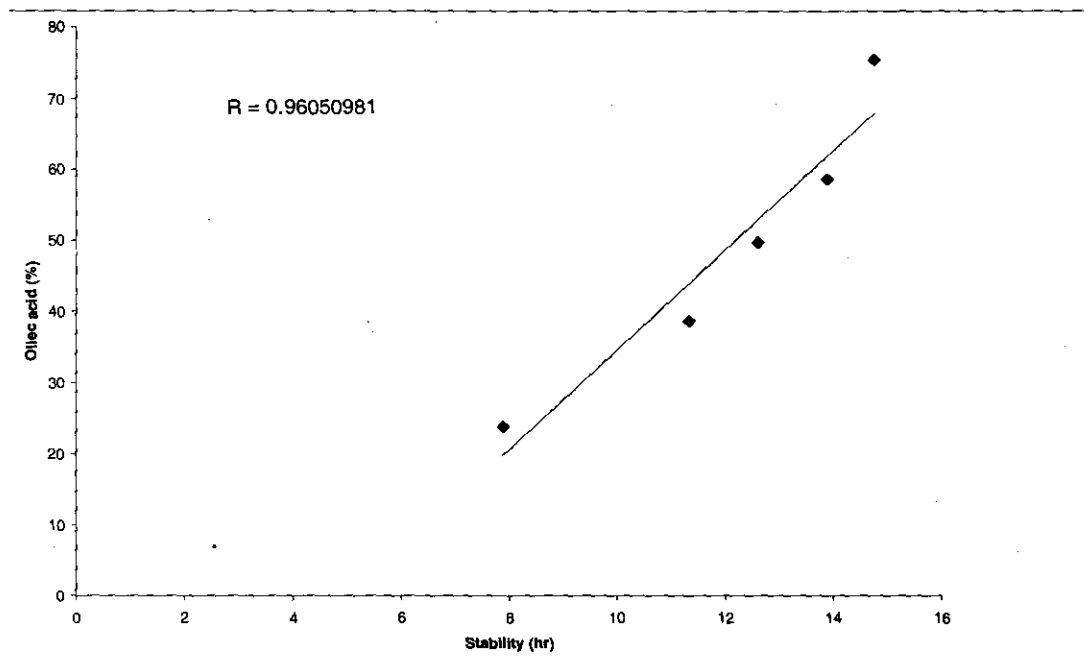


Fig. 3. Relationship between oleic acid content and oxidative stability.

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خواص زيت عباد الشمس متوسط المحتوى من حمض الأوليك الناتج من خلط زيوت صنفين من عباد الشمس

مجدى أحمد العجيمى ، عزة عبد الله أحمد

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يهدف هذا البحث إلى إنتاج زيت عباد الشمس متوسط المحتوى من حمض الأوليك وتحسين الثبات الأكسيدى لزيت عباد الشمس التقليدى بواسطة الخلط. تم خلط زيت عباد الشمس العالى المحتوى فى حمض الأوليك مع زيت عباد الشمس التقليدى بنسب مختلفة. المخلوط الأول (زيت عباد الشمس العالى المحتوى فى حمض الأوليك ٣٠% إلى زيت عباد الشمس التقليدى ٧٠%)، المخلوط الثانى (زيت عباد الشمس العالى المحتوى فى حمض الأوليك ٥٠% إلى زيت عباد الشمس التقليدى ٥٠%) المخلوط الثالث (زيت عباد الشمس العالى المحتوى فى حمض الأوليك ٧٠% على زيت عباد الشمس التقليدى ٣٠%). وجد أن زيادة حمض الأوليك قد أدت إلى تحسين الثبات الأكسيدى لزيت عباد الشمس التقليدى حيث كان ثباته ٧,٨٨ ساعة وزادت عند زيادة زيت عباد الشمس العالى المحتوى فى حمض الأوليك فى الخليط حيث وصلت إلى ١١,٣٢ ساعة فى المخلوط الأول، ١٢,٦ ساعة فى المخلوط الثانى و ١٣,٨٩ ساعة فى المخلوط الثالث.

وقد وجد أن المخلوط الثانى والثالث الذى أنتج تكنولوجيا بالخلط لهما صفات تقريبا هى نفس صفات زيت عباد الشمس المتوسط المحتوى من حمض الأوليك. كما وجد ارتفاع مضادات الأكسدة الطبيعية فى زيت عباد الشمس العالى المحتوى فى حمض الأوليك مثل توكوفيلولات والفينولات والمواد الغير قابلة للتصين بينما كانت هذه المواد منخفضة فى زيت عباد الشمس التقليدى.