

EFFECT OF RIDGE WIDTH, HILL DISTANCE AND NITROGEN FERTILIZER RATES ON GROWTH, YIELD AND QUALITY OF STEVIA PLANT

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ABSTRACT

Two field experiments were laid out at El-Bakatoush Village, Kafr El-Sheikh Governorate, Egypt in 2005/2006 and 2006/2007 seasons to study the effect of two ridge width (40 and 50 cm), three hill distances (15, 20 and 25 cm) and three nitrogen fertilizer rates (0, 30 and 45 kg N/fed/cut) as well as their interactions on growth, yield and quality of stevia plant (*Stevia rebaudiana* Bertoni) c. v. Spanti. The experiments were laid out in split-split plot design with three replications.

The obtained results showed that plants sown on narrow ridge (40 cm) gave the highest values of leaf area index per plant, leaves dry weight cut/feddan, stevioside percentage at all cuts, total leaves dry weight per feddan and stevioside yield per feddan in both seasons. On the other hand, ridge width at 50 cm gave the highest number of leaves per plant at all cuts in both seasons.

The closer hill spacing (15 cm apart) exceeded the middle and widest hill spacing at (20 and 25 cm which) in all previously mentioned traits, except number of leaves per plant was higher at the wider hill spacing (25 cm apart) at all cuts in both seasons.

Increasing nitrogen fertilizer rates up to 45 kg N/fed/cut increased values of all studied characters at all cuts in both seasons.

Planting stevia plants on ridging width 40 cm and hill distance 15 cm gave the highest values of all studied characters at all cuts in both seasons, except number of leaves per plant.

Planting stevia plants on narrow ridge (40 cm) and fertilized with 45 kg N/fed/cut gave the highest averages of all studied characters at all cuts in both seasons, except number of leaves per plant was highest with 50 cm ridge width and 45 kg N/fed/cut.

Plants having the close hill (15 cm) and fertilized by 45 kg N/fed/cut gave the highest values of all studied parameters except, number of leaves in both seasons.

The highest total leaves dry weight per feddan and stevioside yield per feddan was recorded by sowing plants on narrow ridge (40 cm) and closer hill (15 cm) as well as fertilized by 45 kg N/fed/cut in both seasons.

INTRODUCTION

Nowadays, Egypt face a great problem concerned with the lack of sugar production to provide the demands of increasing population. So, increasing sugar production or reduction of the extremely high sugar consumption is necessary to meet demands of population. One of the approaches to reduce sugar consumption is to exploitation and substitution with natural sweeteners are quite important problems, especially artificial substances used at present days food industry such as saccharine, sorbitol and aspartame. Therefore, they have not always meet the producers and consumers requests.

Stevia plants (*Stevia rebaudiana* Bertoni) is the most natural sweeteners and medicinal aid. The established uses for stevia products cover all those of artificial low-calorie (non-sucrose) sweeteners and most other purposes for which sugar can be used. The stevia herb in its natural form is approximately 10 to 15 times sweeter than common table sugar. Extract of stevia in the form of stevioside can range anywhere from 100 to 300 times sweeter than sucrose and has similar taste feel properties. The sweetener from stevia leaves has a good taste and suitable for use in food products. The necessary steps to expand stevia cultivation in Egypt are the development of seeds, care of seedlings and appropriate agricultural practices including information on optimized crop inputs.

Therefore, studying the effect of variations in inter and intra row spacing (row width and hill spacing) on stevia productivity for the first times under Egyptian conditions proved to be of vital importance. In this connection Katayama *et al.* (1976), Lee *et al.* (1978), Bian (1981) and Shu and Wang (1988) found that narrow ridging increased leaf area index per plant, stevioside yield percentage in dry leaves and total stevioside per hectare. Goenddi (1981), Jia (1984), Buona (1988) and Pude (2005) found that the wide ridging increased number of leaves per plant. Dinizfmonza (2003) stated that the wider hill distance had the increase in number of leaves per plant. Infoomfra (2003) showed that narrow hill distance returned to the increase in leaf area index per plant, dry weight leaves per hectare and total stevioside per hectare

Pude (2005) and Niir Board (2008) found that the narrowest hill spacing most gave the most increase in total dry weight leaves per hectare

Maximum stevia productivity in terms of leaves yield and stevioside depending on the growing temperature and nutrients elements supply. Nitrogen had a vital role on the vegetative growth and physiological processes of any plant. Nitrogen requirement of stevia varies from one region to another around the world. In this respect Das *et al.* (2007) and Niir Board (2008) found that increasing N fertilizer rate increased number of leaves per plant, stevioside percentage, and total dry weight leaves per hectare

Anand (2004) and Colombus (2004) found that the increase in N fertilizer rates increased leaf area index per plant and total leaves dry weight per hectare and total stevioside per hectare.

This investigation was carried out to study the response of stevia crop growth, yield and plant distribution on patterns through ridge width and hill spacing and N fertilization under Kafr El-Sheikh Governorate, Egypt.

MATERIALS AND METHODS

Two field experiments were carried out at El-Bakatoush village, Kafr El-Sheikh Governorate, Egypt in 2005/2006 and 2006/2007 seasons to study the effect of two ridge width (40 and 50 cm), three hill distance (15, 20 and 25 cm) and three nitrogen fertilizer rates (0, 30 and 45 kg N/feddan/cut) on growth, yield and quality of stevia (*Stevia rebaudiana* Bertoni) c.v. Spanti. The experiments were laid out in split-split plot design with three replications. The

two ridge width were collected in the main plots, hill distance were assigned in the sub-plots and nitrogen fertilizer rates were devoted in sub sub-plots. The sub-sub plot area was 10.5 m² (3.0 m width x 3.5 m long). Seeds of stevia planted on 15th March in both seasons in wood boxes (40 cm length 30 cm width) contain a mixture of sand, petemos and silt clay soil (1: 1: 1). On 15th May in both seasons seedlings at two months age were transplanted into permanent experiment site.

Mechanical and chemical analysis of soil at the experimental sites are presented in Table (1).

Variables	2005/2006season	2006/2007 season
Mechanical analysis		
Sand %	15.10	14.36
Silt %	30.41	32.35
Clay %	54.49	53.29
Soil textural class	clay	clay
chemical analysis		
Soil pH	7.45	7.37
EC-ds	2.57	2.81
Organic matter%	1.96	2.06
Available N(ppm)	12.07	13.17
Available p(ppm)	7.35	7.15
Available k(ppm)	283.00	277.35

The soil of the permanent experimental site was prepared as usually, phosphorus fertilizer in the form of superphosphate 15%

P₂O₅ was added at the rate of 100 kg superphosphate during land preparation. Nitrogen fertilizer at the previously studied rates was applied in the form of urea (46% N) in two equal half after each cut. The first half was applied just before the first irrigation, while, the second half was added before the second irrigation. Five cuts were taken each two months intervals during the growing seasons. The studied traits were measured at first cut (15/7 Mid July), second cut (15/9-Mid September) third cut (15/11-Mid November), fourth cut (15/1-Mid January) and fifth cut (15/3-Mid March) in both seasons.

At each cut the following date were recorded:

1. Number of leaves per plant.
2. Leaf area index per plant.
3. Dry weight of leaves (cot/ ton/fed).
4. Stevioside percentage in dry leaves, it determined by HPLS according to Nishiyama et al (1992).
5. Total leaves dry weight yield (t/fed).
6. Total stevioside yield (Kg/fed).

The obtained data were analyzed of analysis of variance (ANOVA) and the least significant difference (LSD) calculated at 5% level as reported by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Average number of leaves per plant, leaf area index per plant, leaves dry weight (ton/fed per cut), stevioside percentage total leaves dry weight per feddan (tons/5 cuts) and stevioside yield (t/fed) as affected by ridge width, hill

distance, nitrogen fertilizer rates and their interactions at five cuts in 2005/2006 and 2006/2007 seasons are shown in Tables (2 to 11).

The obtained results showed that ridge width had a significant effect on all studied traits at all cuts in both seasons, except number of leaves per plant at fourth cut in the first season and at second and third cut in the second seasons, leaf area index at third cut in the first season and at first, fourth and fifth cut in the second seasons, leaves dry weight per feddan at first cut in both seasons and at fourth cut in the first season as well as stevioside percentage at first cut in the first season and at third cut in the second season.

Stevia plants sown on ridge width 50 cm gave the highest number of leaves per plant at all cuts in both seasons. On the other hand, planting stevia plants on ridge width 40 cm gave the highest leaf area index per plant, leaves dry weight per feddan (ton/cut) and stevioside percentage at all cuts in both seasons. In this connection, the highest total leaves dry weight per feddan (2.80 and 3.25 ton/5 cuts) and stevioside yield per feddan (492.62 and 551.40 kg/5 cuts) were recorded with plants sown on narrow ridge (40 cm width) in 2005/2006 and 2006/2007 seasons, respectively. These results are in harmony with those of Lee et al (1978) , Bian (1981) and Buana (1988)

The increase in number of leaves per plant due to the wider ridge may be attributed to the little competition between plants and plant shading which led to increasing net assimilation rate as well as increased number of leaves per plant. On the other hand, the increase in leaf area index per plant, leaves dry weight per feddan, stevioside percentage, yields per feddan of total leaves dry weight and stevioside owing to the narrow ridging might be attributed to the increase in number of plant per area unit resulted in increasing leaf area index which increased photosynthesis rate and dry matter translocated and stored in leaves, therefore, total yield of leaves dry weight per feddan and stevioside yield increased.

Data recorded in Tables (2 to 11) indicated that number of leaves per plant significantly affected by hill distance at all cuts, except at fourth cut in the first season and at second and third in the second season. However, the highest number of leaves per plant was found when plants sown on hill distance at 25 cm compared to other hill distances (15 and 20 cm) at all cuts in both seasons. The effect of hill distance on all studied characters was significant at all cuts in both seasons, with the exception, of leaf area index at first and fourth cut in both seasons, leaves dry weight per feddan at third cut in the first season and stevioside percentage at third and fourth cut in the first season and at first cut in the second seasons. Generally, the narrow hill distance (15 cm) exceeded the medium and wider hill (20 and 25 cm) in leaf area index per plant, leaf dry weight per (ton/cut), stevioside percentage at all cuts, total leaves dry weight per feddan and stevioside yield per feddan in both seasons. These results are in agreement with those of Dira Zfronza (2003) and Board (2008)

The increase in number of leaves per plant owing to the wider hill may be attributed to the lowest competition between plants which led to increasing plant growth such as number of leaves.

Table (5): Effect of ridge width, hill distance, nitrogen fertilizer rate and their interaction on leaves dry weight per feddan (ton/cut) in 2005/2006 season.

Ridge width	Hill distance	Cutting (1)			Mean	Cutting (2)			Mean	Cutting (3)			Mean	Cutting (4)			Mean	Cutting (5)			Mean
		Nitrogen rate (kg/fed/cut)				Nitrogen rate (kg/fed/cut)				Nitrogen rate (kg/fed/cut)				Nitrogen rate (kg/fed/cut)				Nitrogen rate (kg/fed/cut)			
		0	30	45		0	30	45		0	30	45		0	30	45		0	30	45	
40 cm	15 cm	0.51	0.86	0.99	0.82	0.39	0.77	0.85	0.67	0.41	0.60	0.96	0.65	0.39	0.56	0.92	0.62	0.85	1.01	1.02	0.86
	20 cm	0.45	0.55	0.92	0.64	0.26	0.39	0.52	0.39	0.22	0.49	0.65	0.45	0.27	0.37	0.60	0.47	0.52	0.85	0.98	0.78
	25 cm	0.35	0.52	0.69	0.52	0.24	0.32	0.47	0.34	0.20	0.47	0.59	0.42	0.25	0.35	0.57	0.39	0.48	0.82	0.90	0.73
Mean		0.44	0.64	0.86	0.66	0.29	0.49	0.61	0.46	0.28	0.52	0.73	0.51	0.30	0.42	0.69	0.47	0.51	0.89	0.96	0.79
50 cm	15 cm	0.52	0.73	0.96	0.74	0.32	0.48	0.72	0.51	0.26	0.48	0.81	0.52	0.28	0.52	0.83	0.56	0.54	0.81	0.87	0.74
	20 cm	0.48	0.62	0.84	0.65	0.28	0.36	0.61	0.42	0.24	0.38	0.56	0.39	0.25	0.49	0.58	0.44	0.51	0.79	0.85	0.71
	25 cm	0.41	0.44	0.59	0.48	0.25	0.31	0.50	0.35	0.22	0.28	0.42	0.31	0.24	0.47	0.54	0.41	0.49	0.67	0.73	0.63
Mean		0.47	0.59	0.79	0.62	0.28	0.38	0.61	0.43	0.24	0.38	0.60	0.41	0.26	0.49	0.67	0.47	0.51	0.75	0.81	0.69
General means of hill distance	15 cm	0.52	0.79	0.97	0.78	0.35	0.62	0.78	0.59	0.34	0.54	0.88	0.58	0.33	0.54	0.90	0.59	0.54	0.91	0.94	0.80
	20 cm	0.46	0.58	0.88	0.64	0.27	0.37	0.56	0.40	0.23	0.43	0.60	0.42	0.26	0.43	0.59	0.42	0.51	0.82	0.92	0.74
	25 cm	0.38	0.48	0.64	0.50	0.25	0.32	0.48	0.35	0.21	0.37	0.51	0.36	0.25	0.41	0.56	0.40	0.48	0.74	0.81	0.67
Mean		0.45	0.61	0.83	0.64	0.28	0.43	0.61	0.44	0.26	0.45	0.66	0.45	0.26	0.46	0.68	0.47	0.51	0.82	0.88	0.74

L.S.D.0.05% for:

Ridge width (R)	N.S																					
Hill distance (H)							0.09															0.04
Nitrogen (N)																						0.07
R x H																						0.03
R x N																						0.05
H x N																						0.07
R:H:N																						0.09

Table (7): Effect of ridge width, hill distance, nitrogen fertilizer rate and their interaction on leaves fresh weight per feddan (tons/cut) in 2006/2007 season.

Ridge width	Hill distance	Cutting (1)			Mean	Cutting (2)			Mean	Cutting (3)			Mean	Cutting (4)			Mean	Cutting (5)			Mean
		Nitrogen rate (kg/fed/cut)				Nitrogen rate (kg/fed/cut)				Nitrogen rate (kg/fed/cut)				Nitrogen rate (kg/fed/cut)				Nitrogen rate (kg/fed/cut)			
		0	30	45		0	30	45		0	30	45		0	30	45		0	30	45	
40 cm	15 cm	1.09	2.15	3.01	2.08	0.81	1.39	1.89	1.35	0.55	1.04	1.96	1.19	0.58	0.95	1.73	1.08	0.84	1.66	2.39	1.63
	20 cm	0.96	1.42	1.96	1.45	0.66	1.07	1.47	1.07	0.62	1.27	1.73	1.20	0.45	0.89	1.40	0.91	0.61	1.26	1.76	1.21
	25 cm	0.93	1.23	1.76	1.30	0.57	0.90	1.34	0.93	0.51	0.99	1.53	1.01	0.44	0.90	1.20	0.85	0.61	1.04	1.48	1.04
Mean		0.99	1.60	2.24	1.61	0.68	1.12	1.56	1.12	0.56	1.10	1.74	1.13	0.49	0.91	1.44	0.95	0.69	1.32	1.88	1.29
50 cm	15 cm	1.28	1.84	2.47	1.86	0.69	1.18	1.77	1.26	0.66	1.12	1.63	1.14	0.43	1.05	1.49	0.98	0.82	1.28	1.87	1.32
	20 cm	1.00	1.42	1.98	1.46	0.60	1.02	1.44	1.02	0.56	1.23	1.73	1.17	0.39	0.79	1.23	0.80	0.58	1.02	1.57	1.06
	25 cm	0.93	1.41	1.66	1.34	0.55	0.88	1.30	0.91	0.56	1.00	1.14	0.90	0.42	0.82	1.10	0.81	0.56	0.90	1.34	0.91
Mean		1.07	1.56	2.03	1.55	0.61	1.02	1.48	1.04	0.59	1.12	1.50	1.07	0.41	0.92	1.27	0.87	0.63	1.06	1.59	1.10
General means of hill distance	15 cm	1.13	2.00	2.74	1.97	0.75	1.29	1.80	1.28	0.60	1.08	1.79	1.16	0.50	1.00	1.61	1.04	0.83	1.47	2.13	1.48
	20 cm	0.98	1.42	1.97	1.45	0.63	1.05	1.45	1.04	0.59	1.25	1.73	1.19	0.42	0.84	1.31	0.86	0.59	1.14	1.66	1.13
	25 cm	0.94	1.32	1.71	1.32	0.56	0.89	1.32	0.92	0.53	0.99	1.33	0.95	0.43	0.91	1.15	0.83	0.55	0.97	1.41	0.97
Mean		1.03	1.58	2.14	1.58	0.65	1.07	1.52	1.08	0.57	1.11	1.62	1.10	0.45	0.91	1.38	0.91	0.66	1.19	1.73	1.19

L.S.D.0.05% for:

Ridge width (R)	N.S																					
Hill distance (H)																						0.12
Nitrogen (N)																						0.07
R x H																						0.13
R x N																						0.05
H x N																						0.13
R:H:N																						0.17

Table (8): Effect of ridge width, hill distance, nitrogen fertilizer rate and their interaction on fresh weight plants yield per feddan (tons) in 2005/2006 season.

Ridge width	Hill distance	Cutting (1)				Cutting (2)				Cutting (3)				Cutting (4)				Cutting (5)			
		Nitrogen rate (kg/fed/cut)			Mean	Nitrogen rate (kg/fed/cut)			Mean	Nitrogen rate (kg/fed/cut)			Mean	Nitrogen rate (kg/fed/cut)			Mean	Nitrogen rate (kg/fed/cut)			Mean
		0	30	45		0	30	45		0	30	45		0	30	45		0	30	45	
40 cm	15 cm	1.80	2.99	3.20	2.66	1.27	2.10	2.66	2.01	0.89	1.40	2.53	1.60	0.76	1.17	2.02	1.31	1.25	2.13	2.76	2.05
	20 cm	1.49	2.07	2.82	2.13	1.03	1.63	2.14	1.60	0.95	1.62	1.97	1.51	0.64	1.02	1.48	1.05	1.05	1.57	1.96	1.53
	25 cm	1.44	1.83	2.50	1.92	0.90	1.29	1.76	1.32	0.85	1.29	1.84	1.32	0.67	1.00	1.40	1.02	0.92	1.37	1.95	1.41
Mean		1.58	2.29	2.84	2.24	1.07	1.67	2.19	1.68	0.90	1.44	2.11	1.48	0.69	1.06	1.63	1.13	1.08	1.69	2.22	1.66
50 cm	15 cm	1.96	2.56	3.21	2.58	1.11	1.88	2.46	1.82	1.04	1.43	2.06	1.51	0.71	1.23	1.75	1.23	1.17	1.64	2.31	1.71
	20 cm	1.61	2.01	2.58	2.07	0.95	1.43	2.05	1.47	0.99	1.58	2.02	1.53	0.55	1.08	1.39	1.01	0.89	1.33	1.83	1.35
	25 cm	1.48	1.99	2.19	1.88	0.84	1.22	1.71	1.25	0.93	1.28	1.70	1.30	0.56	0.92	1.24	0.94	0.73	1.26	1.61	1.20
Mean		1.68	2.19	2.66	2.18	0.87	1.51	2.07	1.51	0.99	1.43	1.92	1.45	0.61	1.08	1.46	1.05	0.93	1.41	1.92	1.42
General means of hill distance	15 cm	1.88	2.77	3.20	2.62	1.19	1.99	2.56	1.91	0.97	1.41	2.29	1.56	0.74	1.20	1.88	1.27	1.21	1.89	2.53	1.88
	20 cm	1.55	2.04	2.70	2.10	0.99	1.53	2.10	1.54	0.97	1.60	1.99	1.52	0.59	1.05	1.44	1.03	0.97	1.45	1.89	1.44
	25 cm	1.46	1.91	2.34	1.90	0.87	1.26	1.73	1.29	0.89	1.28	1.77	1.31	0.62	0.96	1.32	0.97	0.82	1.31	1.78	1.31
Mean		1.63	2.24	2.75	2.21	1.01	1.59	2.13	1.58	0.94	1.43	2.02	1.46	0.65	1.07	1.55	1.09	1.01	1.55	2.07	1.54

L.S.D.0.05% for:

Ridge width (R)										N.S											
Hill distance (H)			0.19			0.18				N.S				N.S							N.S
Nitrogen (N)			0.31			0.28				0.24				N.S							0.42
R x H			N.S			0.11				0.18				0.15							0.14
R x N			0.15			N.S				0.17				0.13							0.10
H x N			0.11			0.17				0.16				N.S							0.21
RH N			0.27			0.13				0.15				0.19							0.23

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Table (9): Effect of ridge width, hill distance, nitrogen fertilizer rate and their interaction on fresh weight plants yield per feddan (tons) in 2006/2007 season.

Ridge width	Hill distance	Cutting (1)				Cutting (2)				Cutting (3)				Cutting (4)				Cutting (5)			
		Nitrogen rate (kg/fed/cut)			Mean	Nitrogen rate (kg/fed/cut)			Mean	Nitrogen rate (kg/fed/cut)			Mean	Nitrogen rate (kg/fed/cut)			Mean	Nitrogen rate (kg/fed/cut)			Mean
		0	30	45		0	30	45		0	30	45		0	30	45		0	30	45	
40 cm	15 cm	1.89	3.19	3.96	3.01	1.36	2.30	3.01	2.22	0.99	1.60	2.76	1.78	0.88	1.35	2.31	1.51	1.35	2.32	3.06	2.24
	20 cm	1.58	2.28	3.12	2.32	1.13	1.83	2.44	1.80	1.06	1.82	2.24	1.70	0.74	1.15	1.78	1.22	1.20	1.77	2.25	1.74
	25 cm	1.54	2.01	2.81	2.12	1.02	1.47	2.07	1.52	0.96	1.48	2.14	1.53	0.79	1.18	1.71	1.23	1.02	1.58	2.22	1.61
Mean		1.67	2.49	3.29	2.48	1.17	1.86	2.51	1.85	1.00	1.63	2.38	1.67	0.80	1.23	1.93	1.32	1.19	1.89	2.51	1.88
50 cm	15 cm	2.05	2.75	3.80	2.85	1.20	2.07	2.75	2.01	1.15	1.73	2.39	1.76	0.82	1.49	2.04	1.45	1.27	1.84	2.62	1.91
	20 cm	1.70	2.21	2.85	2.26	1.05	1.62	2.32	1.66	1.10	1.77	2.32	1.73	0.65	1.28	1.69	1.21	1.00	1.53	2.14	1.55
	25 cm	1.48	2.20	2.43	2.03	0.95	1.45	2.01	1.47	1.03	1.51	1.96	1.50	0.67	1.11	1.52	1.10	0.83	1.46	1.87	1.39
Mean		1.75	2.38	3.02	2.38	1.06	1.72	2.36	1.71	1.09	1.67	2.22	1.66	0.71	1.30	1.75	1.25	1.03	1.61	2.21	1.62
General means of hill distance	15 cm	1.97	2.97	3.88	2.94	1.28	2.18	2.88	2.11	1.07	1.66	2.57	1.77	0.85	1.42	2.17	1.48	1.31	2.08	2.84	2.07
	20 cm	1.64	2.24	2.98	2.29	1.09	1.73	2.38	1.73	1.08	1.79	2.28	1.72	0.70	1.22	1.73	1.21	1.10	1.65	2.19	1.64
	25 cm	1.51	2.10	2.62	2.08	0.98	1.46	2.04	1.49	0.99	1.49	2.05	1.51	0.73	1.15	1.61	1.16	0.93	1.52	2.05	1.50
Mean		1.71	2.44	3.16	2.43	1.12	1.79	2.43	1.78	1.04	1.65	2.30	1.66	0.76	1.26	1.84	1.29	1.11	1.75	2.38	1.74

L.S.D.0.05% for:

Ridge width (R)			N.S																		
Hill distance (H)			0.21			N.S				N.S				0.16							0.33
Nitrogen (N)			0.29			0.26				0.23				0.19							0.39
R x H			N.S			0.15				0.19				N.S							0.31
R x N			0.26			0.14				0.15				0.12							0.27
H x N			0.34			0.21				0.27				0.22							N.S
RH N			0.42			0.25				0.21				0.19							0.43

Table (10): Effect of ridge width, as a hill distance, nitrogen fertilizer rate and their interaction on total leaves dry weight per feddan (tons) total overall cuts in 2005/2006 and 2006/2007 seasons

Ridge width	Hill distance	2005/2006			Mean	2006/2007			Mean
		Nitrogen fertilization				Nitrogen fertilization			
		0	30	45		0	30	45	
40 cm	15 cm	2.15	3.40	4.60	3.38	2.93	4.16	4.41	3.83
	20 cm	1.72	2.65	3.42	2.61	2.33	3.52	4.13	3.32
	25 cm	1.53	2.48	3.22	2.41	1.67	2.52	3.64	2.62
Mean		1.80	2.84	3.76	2.80	2.31	3.40	4.07	3.25
50 cm	15 cm	1.92	3.02	4.25	3.06	2.39	3.92	4.32	3.54
	20 cm	1.76	2.64	3.44	2.61	2.11	3.31	4.02	3.14
	25 cm	1.60	2.17	2.78	2.18	1.64	2.63	3.40	2.55
Mean		1.76	2.61	3.49	2.62	2.05	3.28	3.91	3.07
General means of hill distance	15 cm	2.03	3.21	4.42	3.22	2.66	4.04	4.36	3.68
	20 cm	1.74	2.64	3.45	2.61	2.22	3.41	4.07	3.23
	25 cm	1.56	2.32	3.00	2.29	1.65	2.52	3.54	2.58
Mean		1.77	2.72	3.62	2.71	2.17	3.34	3.99	3.16

L.S.D.0.05% for:

Ridge width (R)		0.15		0.21
Hill distance (H)		0.26		0.29
Nitrogen (N)				
R x H		0.10		0.17
R x N		0.23		0.24
H x N		0.11		0.15
RHN		0.30		0.36

Table (11): Effect of ridge width, hill distance, nitrogen fertilizer rate and their interaction on stevioside yield per feddan (kg) as a total overall cuts in 2005/2006 and 2006/2007 seasons

Ridge width	Hill distance	2005/2006			Mean	2006/2007			Mean
		Nitrogen fertilization				Nitrogen fertilization			
		0	30	45		0	30	45	
40 cm	15 cm	335.67	602.21	925.14	621.00	400.17	721.50	932.38	684.68
	20 cm	250.41	459.42	647.05	452.29	327.20	575.00	745.30	549.16
	25 cm	224.84	412.36	576.54	404.58	233.26	395.29	632.53	420.36
Mean		270.30	491.33	716.24	492.62	320.21	562.93	770.07	531.40
50 cm	15 cm	288.60	508.11	788.50	528.47	343.22	640.27	785.80	568.76
	20 cm	258.88	432.32	624.68	440.29	295.99	506.74	668.69	490.80
	25 cm	219.57	334.03	458.68	337.42	204.40	386.57	561.50	384.15
Mean		255.75	426.48	623.95	435.39	281.53	511.79	671.99	466.24
General means of hill distance	15 cm	312.23	555.16	856.82	574.73	371.63	680.88	859.09	637.22
	20 cm	254.64	448.37	635.86	446.21	312.09	540.87	706.99	519.98
	25 cm	222.20	373.19	517.61	371.00	218.83	390.93	597.01	402.25
Mean		263.05	458.90	670.09	464.00	300.87	537.50	721.03	519.82

L.S.D.0.05% for:

Ridge width (R)		53.10		66.30
Hill distance (H)		77.13		81.11
Nitrogen (N)				
R x H		50.60		102.00
R x N		113.04		117.20
H x N		58.12		72.04
RHN		111.00		94.50

On the contrary, the raising effect of close hill on leaf area index, leaves dry weight per feddan and stevioside yield per feddan may be attributed to the closer hill caused increasing plant population per area unit which increased leaf area index per plant resulted in increasing net assimilation rate as well as enhancing dry matter production and stored in leaves, hence, leaves dry weight and stevioside yield per feddan increased.

Results presented in Tables (2 to 11) show clearly that the effect of nitrogen fertilizer rates was significant on all studied parameters at all cuts in both seasons. Plants fertilized by 45 kg N/feddan/cut gave the highest values of number of leaves per plant, leaf area index per plant, leaves dry weight per feddan and stevioside percentage compared to other nitrogen rates used at all cuts in both seasons. In addition, plants received 45 kg N/feddan/cut caused 104.52% and 83.87% increase in total leaves dry weight per feddan and 154.74% and 139.65% increase in stevioside yield per feddan/5 as compared with unfertilized plants (no added N) in 2005/2006 and 2006/2007 seasons, respectively these results are in the same Das et al (2007).

The increase in total leaves dry weight per feddan caused by the highest rate of nitrogen may be due to raising effect of nitrogen on number of leaves per plant and leaf area index per plant which led to increasing total leaves dry weight per feddan. In this connection, the increase in stevioside yield per feddan may be attributed to nitrogen increased stevioside percentage, whereas stevioside yield is a function of leaves dry weight per feddan multiply stevioside percentage, since these two traits increased by increasing nitrogen rate therefore stevioside yield per feddan increased.

The interaction effect between ridge width and hill distance was significant on all studied characters, except, number of leaves per plant at first, fourth and fifth cut in the first season as well as at second cut in the second season, leaf area index per plant at first and third cut in 2005/2006 season as well as at second cut in 2006/2007 season, leaves dry weight per feddan at second cut in the first season as well as at second and fourth cut in the second season and stevioside percentage at second and fourth cut in 2005/2006 season and at first and fifth cut in 2006/2007 season. Plants sown on wider ridge (50 cm apart) and largest hill (25 cm apart) gave the highest number of leaves per plant compared to all other treatments at all cuts in both seasons. On the other hand, plants sown on narrow ridge (40 cm width) and closer hill (15 cm spaced) gave the highest leaf area index per plant, leaves dry weight per feddan/cut, stevioside percentage, total leaves dry weight per feddan and stevioside yield per feddan in both seasons. This treatment (40 x 15 cm) increased total leaves dry weight per feddan by 55.05% and 50.20% and stevioside yield per feddan by 84.04% and 78.23% compared to the widest ridge and hill (50 cm x 25 cm) in 2005/2006 and 2006/2007 seasons, respectively.

The obtained results indicated that all measured characters significantly affected by interaction effect among ridge width and nitrogen fertilizer rates at all cuts in both seasons, except in number of leaves per plant at third cut as well as at first and fourth cut in 2005/2006 as well as 2006/2007 seasons, respectively and in leaf area index per plant at second

cut in the first seasons. Increasing nitrogen fertilizer rate from 0 to 45 kg N/feddan/cut for plants sown on ridge width 40 or 50 cm increased values of all studied traits at all cuts in both seasons. Plants sown on narrow ridge (40 cm width) and received 45 kg N/fed/cut gave the highest total leaves dry weight per feddan 3.76 and 4.07 ton and stevioside yield per feddan 716.24 and 770.07 kg compared to other treatments in this interaction in 2005/2006 and 2006/2007 seasons, respectively.

The interaction effect among hill distance and nitrogen fertilizer rate was significant on all studied traits at all cuts in both season, except in leaf area index per plant at third cut in the second season, leaves dry weight per feddan/cut at fourth cut in the second season and stevioside percentage at fifth cut in the first season. At all hill spacings, increasing nitrogen rate increased values of all studied characters at all cuts in both seasons. Fertilized plants sown on hill 25 cm apart by 45 kg N/fed/cut gave the highest number of leaves per plant at all cuts in both seasons. On the other hand, applying nitrogen at the rate of 45 kg N/fed/cut to plants sown on hill distance 15 cm gave the highest leaf area index per plant, leaves dry weight per feddan/cut, stevioside percentage, total leaves dry weight per feddan and stevioside yield per feddan in both seasons.

Data recorded in Tables (2-11) indicate that all studied parameters significantly affected by the interaction between ridge width, hill distance and nitrogen fertilizer rates at all cut sin both seasons, with exception, at fifth cut in the second season for leaf area index per plant, at first and third cut in the second season for leaves dry weight per fed/cut and at third cut in the second seasons for stevioside percentage.

Sowing stevia plants on ride width 40 cm, hill distance 15 and fertilized by 45 kg N/fed/cut gave the averages of all studied characters at all cuts in both seasons, except number of leaves per plant. The highest total leaves dry weight per feddan 4.60 and 4.41 ton and the highest stevioside yield per feddan 925.14 and 932.38 kg were found with plants sown on narrow ridge (40 cm) and closer hill (15 cm as well as fertilized by 45 kg N/fed/cut compared to all other treatments in 2005/2006 and 2006/2007 seasons, respectively.

Generally, it could be recommended that planting stevia plants on ridge width 40 cm and hill distance 15 cm as well as application 45 kg N/feddan/cut recorded the greatest yield of leave dry weight and stevioside per feddan under Kafr El-Sheikh condition.

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تأثير عرض الخط والمسافة بين الجور ومعدلات التسميد الآزوتى على النمو والمحصول وجودته في نبات الاستيفيا

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أجريت تجربتين حقليتين بقرية البكاتوش بمحافظة كفر الشيخ فى موسمى ٢٠٠٦/٢٠٠٥ و ٢٠٠٦/٢٠٠٧م لدراسة تأثير عرضين للخط (٤٠ ، ٥٠ سم) وثلاثة مسافات بين الجور (١٥ ، ٢٠ ، ٢٥ سم) وثلاثة معدلات للتسميد الآزوتى (بدن اضافة ، ٣٠ ، ٤٥ كجم ن/فدان/حشه) وتفاعلاتها على النمو والمحصول وجودته فى نبات الاستيفيا (صنف سبانتى). وصممت التجربة فى قطع منشقة مرتين فى ثلاث مكررات.

وتتلخص أهم النتائج المتحصل عليها فيما يلى:

- اعطى عرض الخط ٤٠ سم اعلى قيمة لكلا من دليل مساحة الاوراق/نبات الوزن الجاف للاوراق/فدان/حشه والنسبة المئوية للاستيفيوسيد والوزن الكلى للجاف للاوراق/فدان ومحصول الاستيفيوسيد/فدان فى كلا موسمى الدراسة. بينما اعطى عرض الخط ٥٠ سم اعلى قيمة لعدد الاوراق للنبات فى جميع الحشاش فى كلا الموسمين.
- اعطت النباتات المنزرعة على مسافات جور ضيقة (١٥ سم بين النباتات) اعلى قيم لكل الصفات المدروسة سابقة الذكر ما عدا عدد الاوراق للنبات والذى كان مرتفعا مع مسافة ٢٥ سم بين الجور فى كل الحشاش فى كلا الموسمين.
- أدت زيادة التسميد الآزوتى حتى ٤٥ كجم ن/فدان/حشه الى زيادة فى قيم جميع الصفات المدروسة فى كل الحشاش فى كلا الموسمين.
- اعطت النباتات المنزرعة على خطوط عرضها ٤٠ سم والمسافة بين الجور ١٥ سم اعلى قيم لكل الصفات المدروسة فى كل الحشاش فى كلا الموسمين ، ما عدا عدد الاوراق على النبات.
- أظهرت النتائج ان تسميد النباتات المنزرعة على خطوط عرضها ٤٠ سم بمعدل ٤٥ كجم ن/فدان/حشه اعطى اعلى متوسطات لكل الصفات المدروسة فى كلا الموسمين ما عدا عدد الاوراق على النبات حيث كانت اعلى عند عرض خط ٥٠ سم ، ٤٥ كجم ن/فدان/حشه.
- ادت اضافة ٤٥ كجم ن/فدان/حشه للنباتات المنزرعة على مسافات جور ضيقة (١٥ سم) الى زيادة جميع الصفات المدروسة فى كلا موسمى الدراسة ما عدا عدد الاوراق على النباتات والتي اعطت اعلى قيم عند الزراعة على مسافة جور ٢٥ سم مع اضافة ٤٥ كجم ن/فدان/حشه.
- لوضحت النتائج ان اعلى محصول للفدان من الوزن الجاف للاوراق ومحصول الاستيفيوسيد يمكن الحصول عليه من زراعة نباتات الاستيفيا على خطوط عرضها ٤٠ سم ومسافات جور ١٥ سم وتسميدها بمعدل ٤٥ كجم ن/فدان/حشه مقارنة بكل المعاملات الاخرى فى كلا موسمى الدراسة.