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DENSITY STUDIES ON *Stevia rebaudiana* (BERTONI) IN EGYPT

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ABSTRACT

The fresh leaf yield and quality i.e. total soluble carbohydr- ates and stevioside (the main sweetening agent) of stevia under six plant densities of 24000 to 48000 plants/fed. resulted from the treatment combinations of three inter-row spacing (58.3, 70.0 and 87.5 cm) and two intra-row spacing (15 and 20 cm) using two seed types (seedlings resulted from tissue culture and root rizomes) of the variety Spanti from Spain imported were evaluated in Giza Experimental Station, Agricultural Research Center during the period of September 1998 to July 2000, where a ten successive cuts were carried out. Results revealed that:

For seedlings, plant population density of 40000 plants/fed (70x15 cm) gave the highest leaf yield (4.304 tons/fed.). However, for rizomes planting, plant population of 36000, 40000 and 48000 plants/fed.(58.3 x 20cm, 70 x 15cm and 58.3 x 20cm), respectively, yielded the highest leaf yield (7.158, 7.226 and 7.793 tons/fed.).

For both seedling types, increasing or decreasing the population density beyond that induced significant reduction in fresh leaf yield.

Total soluble carbohydrate and stevioside content in the leaves were not significantly affected by either inter or intra row spacing or their interaction with cutting times.

Fresh Leaf yield was increased gradually and significantly in successive cuts for both seed types and this increased was more pronounced in summer cuts and in the latest cuts. On the other hand, cutting time insignificantly affected leaf content of total soluble carbohydrate and stevioside.

INTRODUCTION

There is a great deal of interest in naturally occurring substitutes for potential use in diabetic and diebetic foods, beverages and medicines. Several commercially available high potency sweetness, with hundreds or even thousands the sweetening intensity of sucrose are obtained from plants and are used in several countries. Perhaps the best-known compounds of this type are the sweet diterpene glycosides from *Stevia rebaudiana* such as Stevioside. 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 table sugar. (Richard, 1996; Kinghorn and Kim 1997 and Duseinov and Yu, 1999). Dzyuba (1998) added that the sweetener from stevia leaves has a good taste and is suitable for use in food products.

Therefore, studying the effect of variations in inter and intra-row spacing on stevia productivity for the first times under Egyptian conditions proved to be of vital importance. However, the review of the literature indicates that the highest yieldof stevia leaves was obtained at 70 x 25cm and the lowest one at 50 x 45cm spacing (Gvasaliya *et al.*, 1990). Number of plants per unit area (plant density was discussed in Brazil, by Donalisio *et al*

(1982), In China, by Shu and Wang (1988), in Indonesia by Basuki (1990), in Georgia by Gvasaliya *et al.* (1990) and in Uzbekistan by Duseinov and Yu (1999).

Harvest of successive cuts also received attentions of some of above mentioned envestigators.

Because of the lack of information on the optimum plant population for maximum stevia production under Egyptian condition. Therefore, this paper will deal with the stevia plant density per unit area with cutting dates and their arrangements (inter and intra-row spacing).

MATERIALS AND METHODS

Two field trials were carried out in Giza Experimental Station, Agricultural Research Center during the period from Sept. 1998 till July 2000, using two seed types of stevia variety named Spanti imported from Spain, the first seed type was seedlings aged two months produced from tissue culture technique and the other one was root rizomes aged two years. Seedlings and rizomes were grown in all possible combinations of three inter- row spacing of 58.3, 70.0 and 87.5cm (12, 10 and 8 rows/2 Kassabs (7m) and two intra- row spacing i.e. 15 and 20cm.

The 6 treatment combinations for each seed types were arranged in a randomized complete block design with four replications. The 3x2 treatment combinations gave 6 plant densities of 5.71-11.13 plants/m^2 (24000-48000 plants/fed.). Seedlings and rizomes were transplanted in the permanent experiment site on June 5, 1998 and ten successive cutting dates treatments were taken on the following dates:

1-Sept. 5, 1998.	2-Dec. 5, 1998.	3-March5, 1999.
4-May 5, 1999.	5-July 5, 1999.	6-Sept. 5, 1999.
7-Dec. 5, 1999.	8-March 5, 2000.	9-May 5, 2000.
10-July 5, 2000.		

Plot dimension was 7 x 3.5m (24.5m^2). Nitrogen fertilizer (30kg N/fed.) was added in the form of Urea (46.5 %N) in two equal doses. The first was applied 15 days after transplanting or cutting and the other one was applied 15 days later. Moreover, 15 kg P_2O_5 /fed in the form of calsium super phosphate (15% P_2O_5) was applied in single dose during soil preparation.

Other cultural practices were done at levels to assure optimum production. Cuttings were carried out at 3-5cm above soil surface on above-mentioned dates.

The middle rows in each plot (to avoid the border effect) were used to determine fresh leaf yield. Total soluble carbohydrates was determined according to AOAC (1990) after drying leaves in an electric oven and leaves stevioside content was calculated according to the equation of Nishiyama *et al.* (1991) .

Analysis of variance was computed for each trait (percentage data were transformed to Arcsin before statistical analysis) and means were compared using L.S.D at 5% level of probability according to Waller and Duncan (1969).

RESULTS AND DISCUSSION

1-Effect of inter and intra-row spacing on fresh leaf yield/fed. :

Data presented in Tables 1,2,3 and 4 show that inter and intra-row spacing significantly affected fresh leaf yield /fed. for both seed types (seedling and root rizomes).

Averag leaf yield over all the ten successive cutting was maximized when seedlings and rizomes were grown in 70cm and 58.3cm rows , respectively, (Tables 1and 3).

Furthermore, narrow spaced plants within rows (15cm) outyielded the wide one (20cm). Leaf yield recorded 2.988 and 2.732 ton/fed. in seedling plantation for 15 and 20cm spacing within rows as compared with the corresponding values of 6.952 and 6.280 ton/fed for root rizomes plantation (Tables 2 and 4). The obtaine results are partly similar to those of Gvasaliya *et al.* (1990) who reported that the highest stevia yield was obtained at 70x25 cm and the lowest at 50x45 cm spacing.

The interactions between either row-and hill spacing and cutting dates were significant for leaf yield of plants resulted from seedlings or rizomes (Tables 1-4).The highest yield of leaves (6.714 and 9.538 tons), resulted from the last cutting with 70cm and 58.3cm row-spacing for seedling and rizomes planting, respectively.

Inter and intra-row spacing and their interaction with cutting dates had no significant effect on leaf contents of total soluble carbohydrates and stevioside for both seed types (Tables 5 to 12). These results indicated that stevia plants could make wide adjustments to growing spacings between and within rows producing similar leaf quality attributes.

The obtained range of plant density is in accordance with these reviewed in Brazil by Donalisio *et al.* (1982), in China by Shu and Wang (1988), in Indonesia, by Basuki (1990), in Georgia, by Gvasaliya *et al.* (1990) and in Uzbekistan, by Duseinov and Yu (1999).

2-Effect of cutting time on leaf yield and quality:

Data in tables 1 and 3 revealed that cutting date had a significant effect on leaf yield of both seed types. It is worth to mention that leaves yield of summer cuts (March, May and July) for both seed types surpassed those of winter ones (September and December). Such effect may be due to that stevia thrived in a warm humidand sunny climate (Jia, 1984; Matejka, 1992; Ermakov and Kochetov, 1994; Richard, 1996 and Allam *et al.,* 2001).

Data also cleared that leaf yield was increased gradually in successive cuts in both winter and summer but this increase was more pronounced in latest cuts as compared with the early ones. Such effect may be due to the augmentation of basal buds, new tillers and branches that developed with sequence cuts. In this connection, Shyu *et al.* (1994) found that harvesting date had a significant effect on tiller number, fresh and dry weight of stevia leaves.

3-Interaction between plant density and cutting times.

Leaf yield, total carbohydrates and stevioside content as affected by the second order interactions are presented in tables (13-18).

1,2,3,4

5,6,7

8,9,10

11,12,13

14,15

16,17

It is worth to mention that, the differences in leaf yield between seedling and rizomes may be due to , the fact that the used seedlings of 2 months age had a single stem while, rizomes aged two years had augmented basal buds which gave from the beginning many tillers.

Differences among cutting times in total soluble carbohydrate and stevioside content in the leaves were not significant (Tables 5,7,9 and 11). However there was a tendency of both traits to increase with the ealiest three cuttings as compared with the other successive ones, reflecting the lower temperature prevailing during Sep., Dec. and March which in turn stimulate carbohydrate accumulation.

Table (19): Summary for the significance of between and within rows spacing and their interactions.

Factor	Seeds type					
	Seedlings			Root rizomes		
	Fresh leaves yield (ton/fed.)	Total soluble carboh-ydrate	Stevioside %	Fresh leaves yield (ton/fed.)	Total soluble carboh-ydrate	Stevioside %
Inter row spacing (B)	**	N.S	N.S	**	N.S	N.S
Intra row spacing (W)	**	N.S	N.S	**	N.S	N.S
Cutting time (C)	**	N.S	N.S	**	N.S	N.S
Interactions						
B x W	**	N.S	N.S	*	N.S	N.S
B x C	**	N.S	N.S	**	N.S	N.S
W x C	N.S	N.S	N.S	N.S	N.S	N.S
B x W x C	**	N.S	N.S	**	N.S	N.S

The highest leaf yield, 6.963 and 9.032 tons/fed resulted from the last cutting with 40000 plant (70x15cm spacing) for seedling plantion and from 48000 plants/fed (58.3x15cm spacing) for rizomes plantion. Carbohydrates and stevioside content in the leaves were not significantly affected by the different interactions.

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دراسات على الكثافة النباتية للاستيفيا في مصر

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اجري هذا البحث خلال الفترة من سبتمبر ١٩٩٨ وحتى يوليه ٢٠٠٠ بمحطة أبحاث مركز البحوث الزراعية بالجيزة بهدف دراسة تأثير ٦ كثافات نباتية تتراوح ما بين ٢٤ إلي ٤٨ألف نبات/فدان على إنتاجية نباتات الاستبفيا من محصول الأوراق الخضراء وجودة هذه الأوراق ومحتواها من الكربوهيدرات الذائبة الكلية ومركب الاستيفوسيد باستخدام نوعين من تقاوي الاستيفيا للصنف المستورد سبنتاى الوارد من اسبانيا (شتلات عمر شهرين ناتجة من مزارع الأنسجة وريزومات جذور نباتات عمرها عامين) وقد أمكن الحصول على الكثافات النباتية من توافيق ثلاثة مسافات بين الخطوط هي ٥٨,٣، ٧٠,٠ و ٨٧,٥سم (١٢، ١٠و ٨ خطوط/٢قصبة) ومسافتين بين النباتات هي ١٥و ٢٠سم. هذا وقد تم حش نباتات الاستيفيا ١٠ مرات خلال فترة التجربة. وتشير نتائج التحليل الاحصائي إلي ما يلي:

في حالة استخدام الشتلات في الزراعة فأن أعلى محصول للأوراق الخضراء /فدان (٤,٣٠٤ طن/فدان) أمكن الحصول عليه عند كثافة نباتية (٤٠٠٠٠ نبات/فدان) بتوزيع فراغي ٧٠سم بين الخطوط و ١٥سم بين الشتلات بينما في حالة استخدام ريزومات الجذور في الزراعة فأن

أعلى محصول من الأوراق الخضراء (٧,١ ٥٨، ٧,٢٢١ و ٧,٧٩٣ طن/فدان) أمكن الحصول عليه عند كثافات نباتية (٣٦٠٠٠، ٤٠٠٠٠ و ٤٨٠٠٠نبات/فدان) بتوزيع فراغي ٥٨,٣ × ٢٠سم ، ٧٠ × ١٥سم و ٥٨,٣ × ١٥سم على الترتيب.

هذا وقد لوحظ حدوث نقص معنوي في محصول الأوراق الخضراء للفدان في حالة زيادة أو نقص الكثافة النباتية عن المشار إليها.

أوضحت النتائج أن المسافات بين الخطوط أو بين الجور لم يكن لها تأثير معنوي علي صفات جودة الأوراق (محتواها من الكربوهيدرات الذائبة الكلية ومركب الاستيفوسيد) وقد يرجع هذا إلي أن نباتات الاستيفيا تمكنت من موائمة نفسها تحت ظروف الكثافة النباتية المستخدمة وبالتالي أعطت قيما متقاربة لصفات جودة الأوراق.

زاد محصول الأوراق في كلا نوعي التقاوي المستخدمة بتتابع عمليات الحش كما لوحظ تفوق صفة محصول الأوراق في حشات الصيف عن حشات الشتاء. وعلى العكس من ذلك فإن صفات جودة الأوراق لم تختلف معنويا بين الحشات المتتالية. هذا ويرجع التباين في محصول الأوراق بين نوعي التقاوي المستخدمة إلي أن ريزومات الجذور عمر عامين تحتوي في البداية علي العديد من البراعم القاعدية والتي تنمو معطية عدد من الفروع بينما في حالة الشتلات فإن البداية هي ساق واحدة غير متفرعة قاعديا.

Table (1): Effect of between row spacing on leaf yield ton\fed (Plants originated from seedlings).

Between rows (B)	Cutting dates(C)										Mean
	5/9/98	5/12/98	5/3/99	5/5/99	5/7/99	5/9/99	5/12/99	5/3/2000	5/5/2000	5/7/2000	
87.5 cm	1.941	2.011	2.108	2.312	2.737	2.381	2.395	2.718	3.237	4.356	2.620
70.0 cm	2.956	3.361	3.510	3.794	4.216	3.697	4.017	4.432	5.100	6.714	4.180
58.3 cm	1.402	1.474	1.541	1.694	2.087	1.731	1.782	2.013	2.278	3.311	1.931
Mean	2.099	2.282	2.386	2.600	3.013	2.603	2.731	3.054	3.539	4.794	

L.S.D at 5% For B : 0.105 C : 0.097 BC : 0.331

Table (2): Effect of within row spacing on leaf yield ton\fed (Plants originated from seedlings).

Within rows (W)	Cutting dates (C)										Mean
	5/9/98	5/12/98	5/3/99	5/5/99	5/7/99	5/9/99	5/12/99	5/3/2000	5/5/2000	5/7/2000	
15 cm	2.161	2.275	2.485	2.689	3.092	2.661	2.841	3.141	3.613	4.918	2.988
20 cm	2.037	2.289	2.287	2.511	2.934	2.545	2.621	2.967	2.464	4.669	2.732
Mean	2.099	2.282	2.386	2.600	3.013	2.603	2.731	3.054	3.039	4.794	

L.S.D at 5% For W: 0.100 C: 0.097 WC : N.S.

Table (3): Effect of between row spacing on leaf yield ton\fed (Plants originated from root rizomes).

Between rows (B)	Cutting dates (C)										Mean
	5/9/98	5/12/98	5/3/99	5/5/99	5/7/99	5/9/99	5/12/99	5/3/2000	5/5/2000	5/7/2000	
87.5 cm	4.926	5.053	5.294	5.652	6.202	5.140	5.230	5.747	6.384	7.138	5.677
70.0 cm	5.862	5.757	6.415	6.771	7.322	6.128	6.360	7.009	7.475	8.362	6.746
58.3 cm	6.498	6.795	7.087	7.420	8.152	6.789	7.047	7.729	8.201	9.538	7.526
Mean	5.762	5.869	6.266	6.614	7.225	6.019	6.212	6.828	7.354	8.346	

L.S.D at 5% For: B: 0.146 C: 0.118 BC: 0.463

Table (4): Effect of within row spacing on leaf yield ton\fed (Plants originated from root rizomes).

Within rows (W)	Cutting dates (C)										Mean
	5/9/98	5/12/98	5/3/99	5/5/99	5/7/99	5/9/99	5/12/99	5/3/2000	5/5/2000	5/7/2000	
15 cm	6.056	6.078	6.608	6.966	7.513	6.328	6.557	7.184	7.751	8.483	6.952
20 cm	5.469	5.659	5.923	6.263	6.938	5.710	5.867	6.472	6.956	7.542	6.280
Mean	5.762	5.869	6.266	6.614	7.226	6.019	6.212	6.828	7.354	8.013	

L.S.D at 5% For : W: 0.194 C: 0.118 WC : N.S.

Table (5): Effect of between row spacing on leaf carbohydrates content (Plants originated from seedlings).

Between rows (B)	Cutting dates (C)										Mean
	5/9/98	5/12/98	5/3/99	5/5/99	5/7/99	5/9/99	5/12/99	5/3/2000	5/5/2000	5/7/2000	
87.5 cm	42.321	42.258	42.210	42.198	42.119	41.742	41.907	41.866	41.775	41.697	42.009
70.0 cm	41.807	41.658	41.531	41.444	41.459	41.405	41.286	41.477	41.407	41.227	41.475
58.3 cm	42.737	42.642	42.585	42.456	42.298	42.206	41.861	41.670	41.628	41.533	42.162
Mean	42.288	42.186	42.109	42.033	41.959	41.784	41.685	41.671	41.603	41.502	

L.S.D at 5% For B : N.S. C : N.S. BC : N.S.

Table (6): Effect of within row spacing on leaf carbohydrates content (Plants originated from seedlings).

Within rows (W)	Cutting dates (C)										Mean
	5/9/98	5/12/98	5/3/99	5/5/99	5/7/99	5/9/99	5/12/99	5/3/2000	5/5/2000	5/7/2000	
15 cm	42.240	42.092	41.998	41.881	41.838	41.590	41.712	41.682	41.609	41.517	**41.816**
20 cm	42.336	42.279	42.219	42.184	42.078	41.990	41.657	41.660	41.597	41.488	**41.948**
Mean	42.288	42.186	42.109	42.033	41.958	41.790	41.685	41.671	41.603	41.502	

L.S.D at 5% For W : N. S. C : N.S. WC : N. S.

Table (7):Effect of between row spacing on leaf carbohydrates content (Plants originated from root rizomes).

Between rows (B)	Cutting dates (C)										Mean
	5/9/98	5/12/98	5/3/99	5/5/99	5/7/99	5/9/99	5/12/99	5/3/2000	5/5/2000	5/7/2000	
87.5 cm	43.675	43.450	43.187	43.075	42.925	42.750	42.700	42.512	42.662	42.500	42.944
70.0 cm	43.450	43.188	42.950	42.812	42.763	42.625	42.475	42.412	42.150	42.012	42.684
58.3 cm	43.637	43.700	43.550	43.462	43.250	43.075	43.000	42.663	42.638	42.637	43.161
Mean	43.588	43.446	43.229	43.117	42.979	42.817	42.725	42.529	42.483	42.384	

L.S.D at 5% For: B: N.S. C: N.S. BC: N.S.

Table (8): Effect of within row spacing on leaf carbohydrates content (Plants originated from root rizomes).

Within rows (W)	Cutting dates (C)										Mean
	5/9/98	5/12/98	5/3/99	5/5/99	5/7/99	5/9/99	5/12/99	5/3/2000	5/5/2000	5/7/2000	
15 cm	43.867	43.708	43.433	43.333	43.150	43.092	42.892	42.633	42.383	42.300	43.079
20 cm	43.308	43.183	43.025	42.900	42.808	42.542	42.558	42.425	42.583	42.467	42.780
Mean	43.588	43.446	43.229	43.117	42.979	42.817	42725	42.529	42.483	42.384	

L.S.D at 5% For: W: N.S. C: N.S. WC:N.S.

Table (9): Effect of between row spacing on leaf stevioside content (Plants originated from seedlings).

Between rows (B)	Cutting dates (C)										Mean
	5/9/98	5/12/98	5/3/99	5/5/99	5/7/99	5/9/99	5/12/99	5/3/2000	5/5/2000	5/7/2000	
87.5 cm	36.327	36.143	36.021	36.068	35.999	35.922	35.776	35.737	35.639	35.060	35.869
70.0 cm	35.681	35.520	35.365	35.337	35.290	35.239	35.130	35.333	35.257	35.122	35.327
58.3 cm	36.647	36.541	35.910	36.349	36.184	36.115	35.725	35.533	35.488	35.388	35.988
Mean	36.218	36.068	35.765	35.918	35.824	35.759	35.544	35.534	35.461	35.190	

L.S.D at 5% For : B : N.S. C : N.S. BC : N.S.

Table (10): Effect of within row spacing on leaf stevioside content(Plants originated from seedlings).

Within rows (W)	Cutting dates (C)										Mean
	5/9/98	5/12/98	5/3/99	5/5/99	5/7/99	5/9/99	5/12/99	5/3/2000	5/5/2000	5/7/2000	
15 cm	36.201	35.970	35.473	35.795	35.691	35.678	35.572	35.546	35.468	35.038	35.643
20 cm	36.235	36.166	36.057	36.041	35.957	35.839	35.514	35.522	35.454	35.341	35.814
Mean	36.218	36.068	35.765	35.918	35.824	35.759	35.543	35.534	35.461	35.190	

L.S.D at 5% For : W: N.S. C : N.S. WC: N.S.

Table (11): Effect of between row spacing on leaf stevioside content (Plants originated from root rizomes).

Between rows (B)	Cutting dates (C)										Mean
	5/9/98	5/12/98	5/3/99	5/5/99	5/7/99	5/9/99	5/12/99	5/3/2000	5/5/2000	5/7/2000	
87.5 cm	37.888	37.637	37.575	37.388	37.238	37.087	36.925	36.888	36.675	36.575	37.188
70.0 cm	37.213	36.988	36.875	36.700	36.675	36.387	36.387	36.263	36.150	35.975	36.561
58.3 cm	37.475	37.188	37.100	37.013	36.813	36.700	36.500	36.425	36.287	36.188	36.769
Mean	37.525	37.271	37.183	37.034	36.909	36.725	36.605	36.525	36.371	36.246	

L.S.D at 5% For: B: N.S. C: N.S. BC: N.S.

Table (12): Effect of within row spacing on leaf stevioside content (Plants originated from root rizomes).

Within rows (W)	Cutting dates (C)										Mean
	5/9/98	5/12/98	5/3/99	5/5/99	5/7/99	5/9/99	5/12/99	5/3/2000	5/5/2000	5/7/2000	
15 cm	37.525	37.267	37.208	37.067	36.992	36.792	36.542	36.550	36.400	36.275	36.862
20 cm	37.525	37.275	37.158	37.000	36.825	36.658	36.667	36.500	36.342	36.217	36.817
Mean	37.525	37.271	37.183	37.034	36.909	36.725	36.605	36.525	36.371	36.246	

L.S.D at 5% For: W: N.S. C: N.S. WC: N.S.

Table(13): Interaction effect of plant density and cutting dates on leaf yield tons/fed (Plants originated from seedlings).

No. of Plants		Between rows cm (B)	Within rows cm (W)	Cutting dates (C)										Mean
m^2	Fed. (10^3)			5/9/98	5/12/98	5/3/99	5/5/99	5/7/99	5/9/99	5/12/99	5/3/2000	5/5/2000	5/7/2000	
5.71	24	87.5	20	1.864	1.903	1.995	2.203	2.636	2.304	2.273	2.583	3.221	4.211	2.519
7.14	30	70.0	20	2.857	3.515	3.352	3.642	4.064	3.606	3.838	4.311	4.900	6.465	4.055
7.62	32	87.5	15	2.017	2.118	2.221	2.421	2.837	2.458	2.517	2.853	3.253	4.500	2.720
8.57	36	58.3	20	1.391	1.448	1.515	1.687	2.101	1.725	1.753	2.007	2.270	3.330	1.923
9.52	40	70.0	15	3.054	3.206	3.667	3.946	4.367	3.787	4.196	4.552	5.299	6.963	4.304
11.43	48	58.3	15	1.413	1.500	1.566	1.700	2.072	1.737	1.810	2.019	2.286	3.292	1.940
Mean				2.099	2.282	2.386	2.600	3.013	2.603	2.731	3.054	3.538	4.794	

L.S.D at 5% For: BW: 0.273 BWC :0.549

Table (14):Interaction effect of plant density and cutting dates on leaf yield tons/fed (Plants originated from root rizomes).

No. of Plants		Between rows cm (B)	Within rows cm (W)	Cutting dates (C)										Mean
m^2	Fed. (10^3)			5/9/98	5/12/98	5/3/99	5/5/99	5/7/99	5/9/99	5/12/99	5/3/2000	5/5/2000	5/7/2000	
5.71	24	87.5	20	4.712	4.808	5.041	5.392	5.908	4.936	4.990	5.507	6.076	6.786	5.416
7.14	30	70.0	20	5.434	5.653	5.917	6.241	6.804	5.666	5.860	6.465	6.822	7.798	6.266
7.62	32	87.5	15	5.141	5.298	5.548	5.911	6.495	5.344	5.470	5.987	6.692	7.490	5.938
8.57	36	58.3	20	6.261	6.515	6.810	7.155	8.101	6.528	6.752	7.443	7.972	8.043	7.158
9.52	40	70.0	15	6.287	5.860	6.912	7.302	7.840	6.590	6.860	7.552	8.129	8.927	7.226
11.43	48	58.3	15	6.736	7.075	7.363	7.685	8.203	7.049	7.342	8.015	8.431	9.032	7.693
Mean				5.762	5.868	6.265	6.614	7.225	6.019	6.212	6.828	7.354	8.013	

L.S.D at 5% For BW : 0.336 BWC : 1.061

Table (15): Interaction effect of plant density and cutting dates on carbohydrates content (Plants originated from seedlings).

No. of Plants		Between rows cm (B)	Within rows cm (W)	Cutting dates (C)										Mean
m^2	Fed. (10^3)			5/9/98	5/12/98	5/3/99	5/5/99	5/7/99	5/9/99	5/12/99	5/3/2000	5/5/2000	5/7/2000	
5.71	24	87.5	20	42.353	42.410	42.330	42.443	42.322	42.200	42.043	42.012	41.880	41.783	42.178
7.14	30	70.0	20	41.916	41.802	41.715	41.630	41.565	41.548	41.395	41.459	41.438	41.265	41.573
7.62	32	87.5	15	42.288	42.106	42.090	41.953	41.915	41.283	41.771	41.720	41.670	41.611	41.841
8.57	36	58.3	20	42.740	42.625	42.613	42.478	42.348	42.185	41.533	41.509	41.472	41.415	42.092
9.52	40	70.0	15	41.698	41.513	41.346	41.257	41.352	41.262	41.176	41.495	41.375	41.289	41.376
11.43	48	58.3	15	42.733	42.657	42.557	42.433	42.248	42.226	42.189	41.830	41.783	41.650	42.231
Mean				42.288	42.186	42.109	42.032	41.958	41.784	41.685	41.671	41.603	41.502	

L.S.D at 5% For: BW: N.S. BWC: N.S.

Table (16): Interaction effect of plant density and cutting dates on carbohydrates content (Plants originated from root rizomes)

No. of Plants		Between rows cm (B)	Within rows cm (W)	Cutting dates (C)										Mean
m^2	Fed. (10^3)			5/9/98	5/12/98	5/3/99	5/5/99	5/7/99	5/9/99	5/12/99	5/3/2000	5/5/2000	5/7/2000	
5.71	24	87.0	20	43.000	42.750	42.550	42.425	42.325	42.050	42.075	41.875	42.225	41.975	42.325
7.14	30	70.0	20	43.200	42.875	42.775	42.650	42.625	42.425	42.350	42.300	42.600	42.450	42.625
7.62	32	87.5	15	44.350	44.150	43.825	43.725	43.525	43.450	43.325	43.150	43.100	43.025	43.563
8.57	36	58.3	20	43.725	43.925	43.750	43.625	43.475	43.150	43.250	43.100	42.925	42.975	43.390
9.52	40	70.0	15	43.700	43.500	43.125	42.975	42.900	42.825	42.600	42.525	41.700	41.575	42.743
11.43	48	58.3	15	43.550	43.475	43.350	43.300	43.025	43.000	42.750	42.225	42.350	42.300	42.933
Mean				43.588	43.446	43.229	43.117	42.979	42.817	42.725	42.529	42.483	42.383	

L.S.D at 5% For BW : N.S. BWC : N.S.

Table (17): Interaction effect of plant density and cutting dates on stevioside content (Plants originated from seedlings).

No. of Plants		Between rows cm(B)	Within rows cm (W)	Cutting dates (C)										Mean
m^2	Fed. (10^3)			5/9/98	5/12/98	5/3/99	5/5/99	5/7/99	5/9/99	5/12/99	5/3/2000	5/5/2000	5/7/2000	
5.71	24	87.5	20	36.239	36.303	36.228	36.311	36.215	36.088	35.918	35.888	35.748	35.650	36.059
7.14	30	70.0	20	35.811	35.672	35.577	35.447	35.424	35.363	35.242	35.315	35.288	35.108	35.425
7.62	32	87.5	15	36.415	35.983	35.813	35.825	35.783	35.755	35.633	35.585	35.530	34.470	35.679
8.57	36	58.3	20	36.655	36.524	36.365	36.364	36.233	36.065	35.383	35.363	35.325	35.265	35.954
9.52	40	70.0	15	35.550	35.367	35.152	35.226	35.155	35.115	35.017	35.350	35.225	35.135	35.229
11.43	48	58.3	15	36.639	36.559	35.454	36.334	36.135	36.165	36.067	35.703	35.650	35.510	36.022
Mean				36.218	36.068	35.765	35.918	35.824	35.759	35.543	35.534	35.461	35.190	

L.S.D at 5% For: BW:N.S. BWC: N.S.

Table (18): Interaction effect of plant density on stevioside content (Plants orignated from root rizomes)

No. of Plants		Between rows cm (B)	Within rows cm (W)	Cutting dates (C)										Mean
m^2	Fed. (10^3)			5/9/98	5/12/98	5/3/99	5/5/99	5/7/99	5/9/99	5/12/99	5/3/2000	5/5/2000	5/7/2000	
5.71	24	87.5	20	37.325	37.050	37.025	36.775	36.625	36.500	36.500	36.325	36.075	36.000	36.620
7.14	30	70.0	20	37.525	37.275	37.100	37.000	36.875	36.550	36.700	36.575	36.475	36.325	36.840
7.62	32	87.5	15	38.450	38.225	38.125	38.000	37.850	37.675	37.350	37.450	37.275	37.150	37.755
8.57	36	58.3	20	37.725	37.500	37.350	37.225	36.975	36.925	36.800	36.600	36.475	36.325	36.990
9.52	40	70.0	15	36.900	36.700	36.650	36.400	36.475	36.225	36.075	35.950	35.825	35.625	36.283
11.43	48	58.3	15	37.225	36.875	36.850	36.800	36.650	36.475	36.200	36.250	36.100	36.050	36.548
Mean				37.525	37.271	37.183	37.033	36.908	36.725	36.604	36.525	36.371	36.246	

L.S.D at 5% For BC : N.S. BWC : N.S.