Оригинален научен труд
Original Scientific Article

BIOLOGICAL CHARACTERISTICS AND PRODUCTIVE ABILITIES OF THE SWEET STEVIA (*Stevia rebaudiana* Bertoni)

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ABSTRACT

Varbanov M., Slavov K., Uchkunova K. & Kirolov K. (2008): Biological characteristics and productive abilities of the sweet stevia (*Stevia rebaudiana* Bertoni). Proceedings of the III Congress of Ecologists of the Republic of Macedonia with International Participation, 06-09.10.2007, Struga. Special issues of Macedonian Ecological Society, Vol. 8, Skopje.

The biological characteristics and requirements of the plant sweet stevia (Stevia rebaudiana Bertoni) were profoundly explored in three regions of Bulgaria – Shumen, Plovdiv and Sandanski. There are quantity and content indications /from 9 to 13 % of the sweet taste substances steviozid and rebaudiozid (from 283 to 386 kg·ha^{-1}). The dry leaf productivity from test areas in favorable growing conditions is from 250-669 kg·ha^{-1}, the production rate is higher in South Bulgaria.

Key words: biology, productivity rate, rebudiozid, steviozid, sweet stevia

Introduction

Stevia is a perennial grass plant from Asteraceae family, sort Stevia, where over 150 species are known. Only Stevia rebaudiana Bertoni contains sweet taste substances.

The origin of the sweet stevia is Paraguay. As a cultivated plant it was first grown in South America, near its natural habitat (Sumida et al. 1976; Seidemann 1976) later it was spread all over the world. It is grown in regions, where the temperature is always above 0°C, and it rapidly grows in temperatures - 20-25°C. The sweet stevia is a strong waterphilic plant (Sumida et al 1976), and is grown above sea level. In Bulgaria it can be grown only by watering; it gives seeds but small in number (Krumov & Varbanov 1984; Krumov et al. 1984c). It is cultivated mainly through seedlings.

The steviozid and rebaudiozids of diterpen nature that consist in the plant leaves (Krumov et al. 1984a; Sumida et al. 1976) find application in food, wine and tobacco industry (Sumida et al. 1976; Hideo & Tomoyoshi 1979; Togoshige & Iwaruma 1978). The steviozid is of the biggest quality (Krumov et al. 1984a; Bungard 1967; Seidemann 1976), which refined and in the proper concentration is 300 times sweeter than saccharose. The greatest amount of sweet substances can be contained in the phase of butonization (Sumida et al. 1976; Metivier & Viana 1979).

The research work connected with stevia started in 1978 in Shumen. It is growing because of the sweet taste substances in the leaves.

The first agriproduct is the dry leaves. The sweet taste substances are extracted from them – steviozid and rebaudiozid (Krumov et al. 1984a; Sumida et al. 1976), which are from 80 to 450 times sweeter than saccharose.

The aim of the present research work was to specify the biological and productive abilities of the sweet stevia Origin 22, selected in Japan (Sumida et al. 1976).

Materials and methods

The tests were carried out with origin 22, adapted in Shumen (Krumov et al. 1984a, 1984b, 1984c, 1984d, 1984e) where the seedlings were grown. The tests were carried out in fields by watering different soil types regarding the area of plant cultivation. The tests were carried out following the square method, the size of squares are 12,6 m^2 with four repetitions with parameters 50 x 20, 50 x 30, 50 x 40 and manuring 5 t·dka^{-1}.

The sweet substance content is to be determined by thin-layer chromatography and can be in-

dicated as a certain quantity of steviozid and rebaudiozid, respectively (Krumov et al. 1984a; Sumida et al. 1976).

Results and discussion

The plant sweet stevia grown in Bulgaria has short root system with two types of roots – suctorial and short where the reserve substances are stored. The upground part consists of main stalk and branching of first, second and third order. The stalks are formed from the nodes and internodes where the leaves are arranged and the stalk branching comes out of the base of their stem. The blossoms are white, small, arranged mostly in five in a raceme. The butonization in Bulgaria starts at the end of July – the beginning of August, the mass flowering is in September when the first seeds start to ripen. There is a variety in plant height, but the average height is 88-108 cm in a vegetation period of 112 days and from 104 to 140 cm in a vegetation period of 145 days (Tab. 4). In a shorter vegetation period of 60-80 days the height is 60-70 cm.

After reaching 50-60 cm in height the stevia plants partially start to lean and the total number of leaves simultaneously reduce to 2-3 times (Tab. 1) The leaf areal per hectare is normally from 40.000 to 120.000 m^2 and their fresh net weight is from 8.000 to 12.600 kg. The supporting system has a favourable effect on leaf protection as it keeps the stalks from leaning and leaf falling. The production of fresh upground mass is 13.500 -45.230 $kg \cdot ha^{-1}$ (Tab. 1 and 4). The total amount of dry leaves to the total dry upground mass is 43-53 % The dry leaves of a plant in the following parameters 50 x 30 vary from 70 to 77 g, and the production of dry leaves varies from 2400 to 3370 $kg \cdot ha^{-1}$ depending on the dates of planting and harvesting (Tab. 4). The using of supporting system (piles) considerably increases the production, approximately with hundred $kg \cdot dka^{-1}$, but makes the agriproduct dry leaves more expensive. (Tab. 1).

The stalks of the sweet stevia are soft and easy to chop and break. In a strong gush of wind a great part of the plants can be damaged so in order the plants to be protected the region must be care-

Tab. 1. Biological peculiarities and productive abilities of the sweet stevia in the region of Shume

Variant Planting distance, cm	Biological peculiarities				Productive abilities		
	Height of single plant cm	Green leaves of single plant number	Leaf area		Net /fresh/ weight		Dry leaf weight листа, $kg \cdot ha^{-1}$
			Of single plant. dm^2	per ha/m^2	total, $kg \cdot ha^{-1}$	leaves, $kg \cdot ha^{-1}$	
50 x 40 no support	88	1551	107	45 480	148 800	8 200	2 580
50 x 20 no support	99	1127	96	81 000	21 930	12 580	3 320
50 x 20 with posts	108	3229	135	114 800	31 880	14 450	4 340

Tab. 2. Temperature effect during the vegetation period on the sweet stevia dry leaf production in testing in different regions of the country $kg \cdot ha^{-1}$

Regions in Bulgaria	Vegetation period, in days in the field				
	60	80	100	112	150
	$kg \cdot ha^{-1}$	$kg \cdot ha^{-1}$	$kg \cdot ha^{-1}$	$kg \cdot ha^{-1}$	$kg \cdot ha^{-1}$
Shumen	480	980	1 470	3 000	3 670
Plovdiv	1 130	1 870	2 840	3 120	5 330
Sandanski	710	1 480	2 630	3 590	6 690

Tab. 3. Content of sweet glicozids (steviozid and rebaudiozid) of stevia dry leaves form tests in different regions of Bulgaria (in % to absolute dry weight)

Regions in Bulgaria	Vegetation period, in days in the field								
	60 days			80 days			112 days		
	Steviozid	Rebaudiozid	Total amount	Steviozid	Rebaudiozid	Total amount	Steviozid	Rebaudiozid	Total amount
Shumen	5,18	2,54	7,72	5,50	3,18	8,68	5,69	3,74	9,43
Plovdiv	6,23	3,48	9,71	6,74	3,77	10,51	7,06	4,23	11,29
Sandanski	6,28	2,82	9,10	7,35	4,00	11,35	8,13	4,72	12,85

Tab. 4. Effect of the planting and harvesting dates on the productivity rate of sweet stevia, field tests, Shumen

Variants Dates of planting-harvesting	Average for single plant			Productivity per ha		Surviving plants at the end of the vegetation period in %
	Plant height in cm	Fresh weight, g	Dry weight, kg	Fresh up-root part, kg	Dry leaves, kg	
3.05. – 24.06.	104	389	70,0	13 530	2 390	50,0
13.05. – 8.10.	113	433	76,6	16 260	2 870	55,0
21.05 – 14.10.	119	408	70,5	18 920	3 250	67,4
3.06 – 24.10.	140	445	74,1	20 240	3 370	67,8

fully chosen. From the beginning of planting to the end of the vegetation because of different reasons a great part of the plants are of no use. 15 to 60 % of them survive only (Tab. 4) and that depends mainly on the way of the seedling production, its planting and growing.

The yield of dry leaves depends on different factors – vegetation period duration (Tab. 2), planting and harvesting time (Tab. 4), using of supporting system (Tab. 1), planting density (Tab. 1), the growing location (Tab. 2). The most favourable time for planting in the region of Shumen is the second half of May, when the temperatures are usually above 10^0C (Tab. 4).

Comparing the yields from three regions of the country Shumen, Plovdiv and Sandanski it can be observed (Tab. 2) that in a vegetation period of 112 days the yields in the three regions are probably the same. At the end of the vegetation period the yields in Plovdiv and Sandanski are greater than the yields in Shumen. The stevia in Shumen grows most rapidly in August, in Plovdiv and Sandanski – in September, when it can store the main amount of biomass. The growing is closely connected with watering and temperatures and in South Bulgaria the weather conditions are more favourable in spring and autumn period. But the most favourable growing conditions for the sweet stevia can be observed in the region of Sandanski in a vegetation period of 110-150 days , and in a shorter vegetation period (about 100 days) the region of Plovdiv (Tab. 2). The major factor which strongly affects the productivity rate is temperature.

The same dependences were constituted in examining the sweet substances steviozid and rebaudiozid. The region of Sandanski has the highest average rate – 12, 85%, the lowest average rate in Shumen – 9, 43% as the variation in the single plants is quite explicit. The biological yielding of the sweet taste substances is higher in South Bulgaria and highest in Sandanski - 386 kg·ha^{-1} (Tab. 3).

According to the productivity rate of dry leaves the sweet stevia grown in favourable conditions in Bulgaria shows similar yielding but lacks sweet substance content (Sumida et al. 1976) in comparison with the sweet stevia grown in Japan and Paraguay.

Conclusion

1. The sweet stevia can be grown in Bulgaria in spring by seedlings of roots and seeds stored in winter.

2. The content rate of the sweet substances is the average of 9 and 13% and the total amount of steviozid and rebaudiozid is 283 – 386kg/ha.

3. The production rate of the dry leaves in the test areas in favourable conditions of growing in the regions varies from 2500 to 6690 kg/ha; in South Bulgaria the productivity rate is higher.

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