DEVELOPMENT OF TECHNOLOGIES AND MACHINERY FOR THE PRODUCTION OF SUGAR BEET IN LATVIA

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INTRODUCTION

Sugar beet growing and sugar production in Latvia is a tradition with more than 75 year long history. In the Soviet Union it was the most northern region where this crop was grown. The production of sugar beet was mechanized except its thinning and weeding. Its cultivation was carried out by means of 12-row seeders and cultivators (there were successful experiments on a 36-row complex made up of a tractor-mounted coupling that consisted of three 12-row machines: seeders and cultivators). The beet harvesting generally proceeded by 6-row mobile leaf and root gatherers that loaded the leaf and the roots into the vehicles moving side by side with the gatherers. The most power-consuming and expensive processes in sugar beet production are soil tillage and crop harvesting. The first makes 180-320 kWh/ha [5], the second – 65-80 kWh/ha [3] with the corresponding costs – 45-58 USD/ha and 220-300 USD/ha.

A new situation in the sugar beet production arose in the early 1990-ties. Due to the land denationalisation in Latvia, tens of thousands of peasant farms appeared, including those where the beet was sown and cultivated on small areas without appropriate machinery.

The purpose of this study is to offer a brief review and an estimate of sugar beet production technologies and machinery, and their development.

OBJECTS AND METHODS

Objects of the study are technologies and machinery of sugar beet production, their energy and labour consumption as well as expenses. In order to determine these indices conventional methods are used [3, 5].

RESULTS AND DISCUSSION

In order to remove the acute deficiency in sugar, a national programme was drawn up in 1991 to improve self-provision of Latvia with sugar, as well as a conception was adopted for the development of sugar beet growing and production of sugar from sugar beet [6], which were successfully accomplished. They worked out a complex solution for the problem: clarification of soil resources that are suitable for sugar beet cultivation; measures for the reclamation and raising the fertility of soil; development of modern sugar beet cultivation technologies without the thinning of its sprouts and manual weeding of the plantations, mechanised harvesting, cleaning and loading the roots; modernisation of the existing sugar refineries (increasing their daily output and the output of sugar); organisation of the sugar market.

Later sugar beet growing in Latvia gained rapid development, and sugar beet production sharply increased surpassing the pre-war, as well as the former post-war level almost twice. However, due to the excessive amount of sugar its production was limited (quota were introduced) since the year 2000, which stopped the further growth of sugar beet growing. Yet improvements of technologies and provision of rural farms with new, modernised machines are still in progress.

The development of machine technologies and machinery for the sugar beet production in Latvia keeps pace with the development in the countries of Western Europe (Germany, Denmark, Sweden) and have the following characteristic features:

– careful basic and pre-sowing soil preparation with measures for the weed extermination and application of the necessary doses of balanced fertilisers,

– wide application of pre-sowing and post-sowing herbicides for the weed extermination, as well as chemicals against pests and diseases,

– precise sowing of high-quality single-germinating seeds (the sorts Kiva, Vanesa, Casandra, Axel etc.) at extreme (16-18 cm) distances and careful introduction of seeds into soil,

– cutting the consumption of labour connected with inter-space loosening, even its complete rejection,

– harvesting by means of combines equipped with high-capacity storage hoppers and means for unloading the roots into vehicles (the in-line method) or into heaps (the reloading method); vehicle loading from clamps by means of loaders-cleaners (for the dirty beet) or bucket (front-end) loaders (for comparatively clean beet).

The sugar beet production scale highly varies from farm to farm: from 1 ha and 25 tons to 900 ha and 30000 tons. These areas affect technology only a little, yet they are more reflected in the nomenclature of the machinery used.

The development of the technical basis of the sugar beet growing farms is characterised by the following principal features:

– modernisation of the energetic basis – provision with modern, more-

powerful (66-220 kW) tractors (MTZ-952, MTZ-1523, Valmet-Valtra, John Deer, Case, Massey Ferguson, New Holland, Fendt Favourite Vario etc.). In contrast to the previous ones (MTZ-80/82, T-150K, Kirovets), these new tractors are more efficient, economical, comfortable than other, more expensive tractors,

– introduction of up-to-date soil tillage machines: 3-10-body reversible ploughs (Kverneland, Lemken, Ferguson) with flat semi-helicoidal wide-cut (45-50 cm) bodies [5], with the total working width from 1.5 to 4.5 m; combined drags-looseners, the working width 6-12 m; combined cultivators (Compactor, Germinator), the working width from 6 to 14 m; combined power-harrows (Kverneland, Amazone), the working width 4-6 m,

– application of mineral fertilisers is carried by means of machines equipped with disk-blade (centrifugal) distributors (Bogballe, Amazone) or a pneumatic sowing apparatus (usually as part of combined soil tillage-fertilising aggregates),

– the beet sowing takes place by 12-row seeders (there are also 6-row machines) with a cell-seed (Accord, Schmotzer) or pneumatic (Becker, Kleine) distributors,

– the application of herbicides and other chemicals is generally carried out by tractor-mounted sprinklers (Hardy) with the working width of 12-24 m,

– there are 12 and 6-row cultivators (Schmotzer with implements for a strip-like introduction of herbicides, Gaspardo with a sub-layer applicator, Kongskild) for inter-row loosening (if it is done),

– as a rule, 2-row hitched-up sugar beet harvesters are used (Stoll, Kleine, Tim, Yuko). There are also 3-row harvesters put out by the same companies. On large sugar beet growing farms (SIA Lielmezotne, Uzvara-Lauks) there is a perspective for the use of 6-row mobile combine harvesters (Holmer). All the beet gathering aggregates mentioned above are run by one operator, which is highly important for the peasant farms having few workers,

– there are corresponding loaders-cleaners (SPS-4.2A, Tyrgod, Ropa L 8.200) for additional cleaning and loading of the roots from the field heaps (clamps). Ropa L 8.200 is the most efficent cleaner-loader, having a 6 m working width and a long loading conveyer. By this mean it is possible to load beets from the field heaps located alongside the roads into the vehicle on the road. This prevents undesirable compaction of soil by hight pressure wheels of the transportation means.

During soil preparation and sowing the main attention is centred on the creation of conditions that ensure high field germination rate (over 60%) of the seeds, which is a prerequisite for the required plant density and uniform distribution allowing to gain good yields and high-quality [1, 2]. In the harvesting period the main attention is put on minimal losses of the crops: the correct height of topping, the complete digging and gathering of the roots [4]. At a correct setting of the machines and optimum mode of the work, the losses in

the sugar-yielding mass will not exceed 2-3%; however, if the recommended rules are neglected, they may grow considerably.

On the whole, depending on the prognosticated yield and conditions, the total labour consumption in sugar beet production constitutes 60-70 man h/ha (2.2-2.6 man h/t) and the costs – 650-800 USD per hectare (22-26 USD/t). At the existing purchasing price 32-34 USD/t (the payment for the beet delivered within Quote A) the beet production pays back if the yield is 20-22 t/ha [7]. In recent years the average yield of sugar beet in Latvia is 28-32 t/ha but on the best farms – 40-50 t/ha. Thus sugar beet is a highly profitable crop.

The maximum part in the structure of the production costs – on average 52% goes to maintenance costs. The costs of mineral fertilisers make 19%, those of herbicides and other chemicals – 16%, seeds – 13%. The greatest share in the structure of maintenance costs – 50% falls on depreciation deductions from the machinery, repairs and maintenance require 18%, fuel and lubricants – 12%, wages with extra fees – 20% [7].

In order to lessen the impact of the depreciation deductions on the cost of labour, the expensive machines (seeders and, particularly, combine harvesters) should be loaded to the maximum during the whole season. So, for instance, the seasonal efficiency of the sowing machines should not be lower than 10-12 ha per furrow, that of the tractor-mounted harvesters – 40 ha [3], but for mobile combine harvesters it should be – 80-90 ha. Consequently, during a season a 12-row seeder should cover 120-140 ha as a minimum, a 2-row harvester – 80 ha, but a 6-row mobile combine harvester – 480-540 ha. On the whole, such an efficiency is achieved on all sugar beet growing farms, but on advanced farms it is significantly higher. For instance, SIA Uzvara-Lauks and Lielmezotne have gained a seasonal efficiency of 120-130 ha working with 2-row and 540 ha – with 6-row harvesters in two shifts, but in the year 2002 Uzvara-Lauks with a 6-row mobil combine Holmer has harvested 960 ha (the whole sugar beet growing area).

Harvesting is one of the most power-consuming and expensive processes in sugar beet production. It requires 65-80 kWh/ha of energy, corresponding to 20-35 kg/ha of fuel, and the costs reach 220-300 USD/ha. Studies have been carried out in order to obtain energetic and economic estimation of sugar beet harvesting processes, their structure; and to find the ways of reducing fuel consumption and harvesting costs, simultaneously raising the efficiency of harvesting machines.

Energetic estimation was carried out using technologies and harvesters of two types: two-phase harvesting (a leaf harvester-loader in combination with a root harvester-loader, and single-trip combine harvesting without gathering and loading leaves. The energetic estimation of these machines operating on loamy soils is presented in Tables 1, 2 and 3.The diagram (Figure 1) shows the harvesting costs and their structure depending on the harvester seasonal loading.

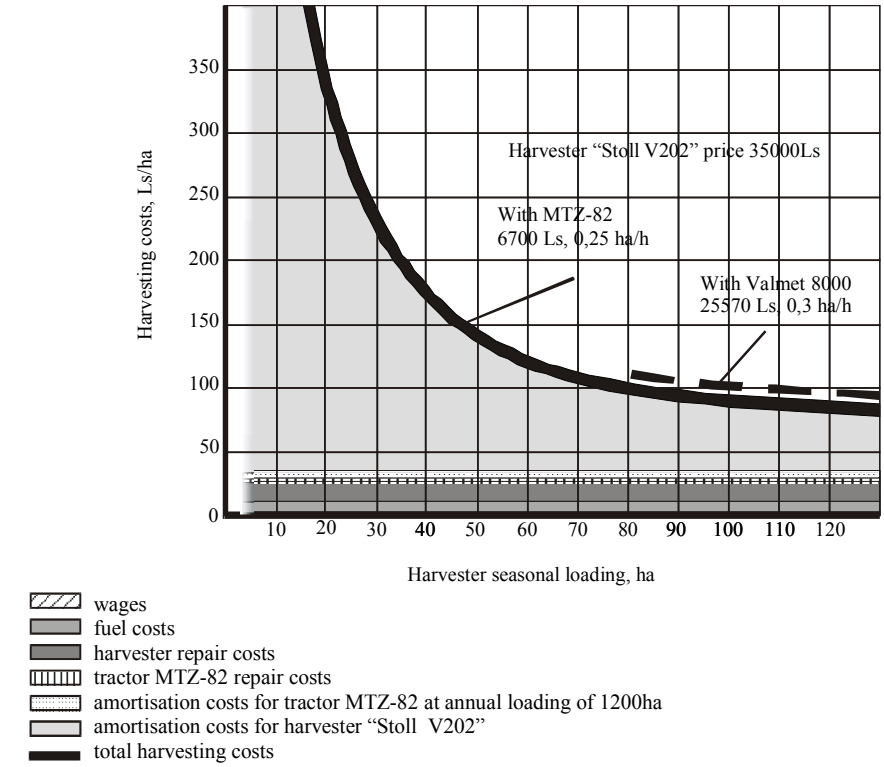

Fig. 1. Dependence of sugar beets harvesting costs on the harvester "Stoll V202"seasonal loading (1Ls ≈1.7 USD)

It is obvious that the expenditure on wages, fuel, repairs and amortisation of the tractor do not depend on the seasonal loading of the harvester whereas the depreciation deductions for harvester amortisation sharply decrease approximately to 80 ha (40 ha per row), when the harvester loading increases. At further loading the rate of the decrease in expenditure falls. At a seasonal harvester loading of 80 ha the harvesting costs reach about 100 Ls/ha (170 USD/ha), and their structure is as follows: wages 4%, fuel expenses 8%, expenses on the tractor repairs 5%, its amortisation 6%, expenses on the harvester repairs 13%, but its amortisation 64% considerably exceeds the sum of all the other expenditure. At the seasonal loading of 40 ha the costs grow up to 175 Ls (306 USD) and the depreciation deductions reach 80% but at the seasonal loading of 120 ha the costs decrease to 83 Ls (145 USD) and the depreciation costs – to 57%.

A similar picture of harvesting costs appears in the work with analogical machines of other brands. This shows that for lowering the sugar beet harvesting costs the harvesters should be run at maximum loadings.

The farmers' experience witnesses that by extending the harvesting season (starting the season earlier and finishing it later) and using the entire working

day the annual output of the 2-row beet harvester may reach 120 ha, but of the mobile 6-row one – 600 ha and more.

The energy capacity of sugar beet harvesting, the efficiency of the machines, the fuel consumption and costs are noticeably affected by harvesting conditions. The costs are the lowest when working at the normal soil humidity – 16-22%.

These factors also depend on the biological properties of beets: the position of the leaves on the top of the beet and soil adherence to the side roots. If the bottom of the leaves is at a different height, their complete cutting off without increasing the losses of the root mass is impossible. This requires removing the leaf remnants from the tops (e.g. by the leaf remover OGD-6A) with extra fuel consumption of 10-12 kg [6].

Table 1.Energetic estimation of leaf harvesters: the 3-row trailed SC1-301 and the 6-row self-propelled 6 ORCS.M (Czechy)*

Parameter	Value of the parameter				
Brand of the machine unit	MTZ-82 + SC1-301			6-ORCS.M	
Technical parameters:					
working speed, m/s	1.17	2.00	2.87	1.60	2.20
number of rows		3		6	
working width, m	1.35	1.35	1.35	2.7	2.7
direct productivity, ha/h	0.57	0.97	1.39	1.56	2.14
Energetic parameters:					
engine power, kW	14.3	23.9	34.3	59.0	70.0
take-off power of the tractor, kW					
operating mode	7.0	10.8	14.8	35.9	39.4
idling mode	5.4	5.4	5.4	29.6	29.6
engine loading rate, %	26	43	62	73	87
skidding, %	3.5	3.7	3.9	4.0	4.2
draft resistance, kN	2.1	2.4	2.6	-	-
specific draft resistance, kN/m	1.6	1.8	1.9	-	-
specific energy consumption, kWh/ha	25.1	24.6	24.7	37.8	32.7
specific fuel consumption, kg/ha	11.2	8.1	6.8	9.74	7.94

Table 2. Energetic estimation of root harvesters: the 3-row trailed SC2-301 (Czechy)and the 6-row self-propelled 6 KS-6B (CIS)*

Parameter	Value of the parameter					
Brand of the machine unit	MTZ-82 + SC2-301			KS-6B		
Technical parameters:						
working speed, m/s	1.47	1.98	2.37	1.33	1.91	2.45
number of rows		3			6	
working width, m	1.35	1.35	1.35	47	47	46
digging depth, cm	6-8	6-8	6-8	6-8	6-8	6-8
direct productivity, ha/h	0.71	0.96	1.15	1.29	1.86	2.38
Energetic parameters:						
engine power, kW	28	36	45	59	81	98
take-off power of the tractor, kW						
operating mode	16.8	21.0	24.5	31	39	44
idling mode	7	7	7	17	17	17
engine loading rate, %	51	65	82	55	75	98
skidding, %	3.9	4.1	4.5	6.3	7.0	7
draft resistance, kN	3.0	3.2	3.8	-	-	-
specific draft resistance, kN/m	2.2	2.4	2.8	-	-	-
specific energy consumption, kWh/ha	39.4	37.5	39.1	45.7	43.5	41.2
specific fuel consumption, kg/ha	11.2	10.1	9.6	14.1	12.4	11.0

* The data are borrowed from the Baltic Machine Testing Station.

Table 3. Energetic estimation of the trailed sugar beet harvester "Stoll V 202"*

Parameter	Value of the parameter				
	Idling mode	Harvesting			Unloading
Technical parameters:					
working speed, m/s	1.69	0.86	1.41	2.22	
working width, m		0.9	0.9	0.9	
digging depth, cm		6-8	6-8	6-8	
direct productivity, ha/h		0.28	0.46	0.72	
Energetic parameters:					
engine power, kW	17.1	19.1	30.3	46.6	6.6
take-off power of the tractor, kW	4.2	8.4	12.1	16.8	6.3
engine loading rate, %	31	35	55	84	12
skidding, %	3.0	6.8	7.2	7.6	
draft resistance, kN	3.4	7.1	7.4	7.8	
specific draft resistance, kN/m		7.8	8.2	8.7	
specific energy consumption, kWh/ha		68	66	65	
specific fuel consumption, kg/ha		23	19	16	

* The data are borrowed from the Baltic Machine Testing Station.

Separate sorts of beet, such as Mezotne hybrid beet, grown formerly in Latvia and Lithuania, have many side roots that attach much soil, therefore its removal requires more energy and about 7 kg/ha of fuel. At present Western sorts, for instance, KVS (Gala, Kawetina, Perla) are grown free from these disadvantages, thus simpler and cheaper devices can be used for their harvesting and cleaning with lower energy consumption.

CONCLUSIONS

1. Due to the introduction of up-to-date technologies and machinery, the production of sugar beet in Latvia has gained significant development during the resent years. Sugar beet growing has turned into one of the most economical and profitable branches of plant cultivation.

2. Sugar beet harvesting requires 65-80 kWh/ha of energy and, correspondingly, 20-35 kg/ha of fuel consumption, which makes 170-220 USD at sufficient loading.

3. To minimise the fuel consumption and costs, the engine should be run at full power and the machine at a corresponding speed. This raises labour efficiency, and saves up to 20% of fuel and costs. In the total cost structure of sugar beet harvesting the major costs fall on the depreciation (amortisation) deductions of the harvesting machine.

4. To lower depreciation costs, the machines should be operated at a maximum seasonal loading. For an up-to-date tractor-mounted two-row sugar beet harvesters it is minimum 80 ha in a season, for six-row mobile ones – 500-600 ha. It is achieved on the farms which have mastered the efficient use of these machines.

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SUMMARY

Due to the introduction of modern machine technologies and machinery, the production of sugar beet in Latvia has gained significant development during the recent years. Sugar beet growing has turned into one of the most economical and profitable branches of plant cultivation. The most power-consuming and expensive processes in sugar beet production are soil tillage and crop harvesting which make an important proportion of all expenses. The labour consumption in sugar beet production constitutes 60-70 man h/ha (2.2-2.6 man h/t) and the costs – 650-800 USD per hectare (22-26 USD/t). Total costs involve: 52 % of maintenance costs, 19 % of mineral fertilisers, 16 % of herbicides and other chemicals and 13 % of seeds costs. Depreciation on machinery makes the greatest share (50%) of maintenance costs. Repairs and maintenance require 18 %, fuel and lubricants - 12 %, wages with extra fees - 20 %. In order to lessen the impact of the depreciation deductions on the cost of labour, the expensive machines (seeders, combine harvesters) should be loaded to the maximum during the whole season.