ANALYSIS OF TECHNOLOGIES EMPLOYED IN FARMS SPECIALISED IN SUGAR BEET PRODUCTION

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Abstract. The purpose of the work was to identify and analyse production system used in farms specialised in sugar beet growing in Lubelskie Region in order to determine directions for technological improvements. Evaluation of technologies used in sugar beet plantations was carried out for 3 years on the basis of completed questionnaires (standardised survey) and operation sheets. The researchers compared technological errors and positive measures taken by farmers in the scope of individual technologies. The suggestions concerning introducing technological innovations are being implemented in production conditions of the Region only to a little extent.

Key words: sugar beet, production technology, correctness analysis for operations/measures

Introduction

Sugar beets are cultivated in areas characterised by highest ratios of agricultural production valorisation. Voivodeships leading in sugar beet and sugar production are: *dolnośląskie* [Lower Silesian], *kujawsko–pomorskie* [Kuyavian–Pomeranian] and *lubelskie* [Lublin] [Ostroga 2010; Bzowska, Ostroga 2010]. Lubelskie Region is particularly predisposed to achieving high beet crops owing to its high quality soils and high agricultural valorisation ratio for space production (73.5 points), as well as favourable agrometeorological conditions.

Considering a sugar beet requirements and complexes of soil agricultural usability in the following administrative districts: Hrubieszowski, Lubelski, Zamojski, Krasnystawski and Tomaszowski, we may expect very high crops there. However, the average root crops exceed national average only a little (e.g. in 2008/09 - only by 3.8 $t \cdot ha^{-1}$), and they never reach crop rates reached in France or Germany (e.g. the average root crop during the 2009/10 campaign in France was 74.4 $t \cdot ha^{-1}$, and in Poland: 54.2 $t \cdot ha^{-1}$ [Sugar and Starch 2011].

The issues of proper agrotechny in sugar beet production are broadly discussed in numerous monographs, scientific publications and promotion instructions [e.g. Bzowska-Balakarz, Bieganowski 2008; Hołubowicz-Kliza 2007; Ostrowska, Artyszak 2005; Przybył 1998; Przybył et al. 2004; Šařec O., Šařec P. 2005]. Studies and scientific works connected with sugar beet production – conducted by the scientific centres (IPC, Warsaw University of Life Sciences – SGGW, Plant Breeding and Acclimatization Institute – IHAR, Universities of Life Sciences in Lublin and Poznań), and raw material departments

of individual concerns (exact experiments in respective areas of operation), as well as by seed, fertiliser and pesticide manufacturers, primarily refer to rationalisation and improvement of technological processes. These experiments are run in experimental fields or experimental farms, and obtained results do not reflect a situation in the country and in the region. Sugar beet cultivation studies carried out by sugar industry, planters associations, or industry organisations have sample character only, and are closely related to the operation strategy of a given organisation, which means that they are performed mainly for its own purposes.

In the fertile soils of Lublin Voivodeship, beet cultivation has many years of tradition; however, obtained crops are not satisfactory. Analysis of reasons for this fact – in production, not experimental conditions – may help to show a counteraction measures.

Research purpose, scope and method

The purpose of the work was to identify and analyse the production system in farms specialised in sugar beet cultivation in Lubelskie Region, aimed to characterise actions taken by raw material suppliers and to set directions for technological improvements.

Farm selection for the research was intentional. They were chosen in cooperation with employees of raw material departments in sugar factories on the basis of positive production results. Distribution of farms within the Voivodeship roughly matched distribution of all sugar beet plantations in the region (e.g. the largest area for sugar beet cultivation is in Hrubieszowski District, and most of examined farms were located there) [Ostroga 2010; Bzowska, Ostroga 2011]. Evaluation of technologies used in sugar beet plantations was carried out for 3 years on the basis of completed questionnaires (standardised interview) and operation sheets. A group of respondents consisted of 218 farmers. While assessing correctness of the operations performed in plantations, the researchers followed literature available in the subject matter.

Discussion of the research results

The average area of sugar beet plantation was 6 ha. Cultivation area in the examined farms was constant throughout research years due to their respective production limits. Cultivation structure in the examined farms was more favourable than generally in Lublin Voivodeship – 27.6% of farms had plantations larger than 5 hectares. Crop volume diversification was very high, proving varying production level in the examined farms [Bzowska-Bakalarz, Ostroga 2011; Ostroga 2010]. Analysis of successive operations carried out in sugar beet plantations allowed to observe three repeating cultivation variants (technologies) (tab. 1). The first of them (Technology I) involves many cultivation measures and fertilising in autumn season and deep ploughing before winter (in literature it is frequently called a conventional technology). A characteristic feature of the second technology (Technology II) is intercrop sowing after primary crop harvest, which is then pre-ploughed in autumn (Technology IIA), or spring (Technology IIB). The third variant (Technology III) represents a simplified technology with beet sowing in mulch from intercrop.

Generally, each year farmers were using similar technology of production. However, the exact analysis performed for the last research year (2008) on the basis of filled in operation sheets covered modifications introduced by farmers in successive years.

Table 1 compares all measures and operations carried out in the scope of individual technologies and specifies in brackets the number of farmers performing specific operations. Moreover, it lists selected machines, which are essential to ensure proper quality of a given operation. At the end, table 1 specifies average crop obtained when using particular technology.

Table1. Comparison of operations carried out in the scope of technologies I, IIA, IIB, III

Technology	Technology		Technology
I (173)	II A (27)	II B (11)	III (7)
Operations after forecrop harvest			
1. fertilising: cow dung (27); lime (7); mineral fertilisers (4); lime + cow dung (1)	1. fertilising: cow dung (4); lime (2); mineral fertilisers (1).		1. fertilising: cow dung (1); mineral fertilisers (1)
2. after-harvest cultivation: hoeing plough (83); reversible plough (1); stubble field unit (69); disk harrow (12); stubble field cultivator (5); subsoiling machine (3)	2. after-harvest cultivation: hoeing plough (15); stubble field unit (8); disk harrow (6); stubble field cultivator (4); cultivating-sowing unit (intercrop sowing) (5)		2. after-harvest cultivation: disk harrow (3); cultivator (1); reversible plough (1); hoeing plough (1); stubble field unit (1)
Operations between soil cultivation after harvest and ploughing before winter			
3. fertilising + fertiliser covering: - fertilisers: lime (4); cow dung (9); mineral fertilisers (4) - tools: cultivating unit (1); cultivator (8); subsoiling machine (1); harrow (4); plough (1); disk harrow (2)	3. fertilising + fertiliser covering: - fertilisers: mineral fertilisers (1); cow dung (2); lime (1) - tools: cultivator (1); disk harrow (1); plough + harrow (1);		3. fertilising + fertiliser covering: - fertilisers: lime (1); mineral fertilisers (3) - tool: plough (1); cultivator (1); harrow (1); cultivator + plough (1);
4. soil seasoning: harrow (51); cultivating unit (2); cultivator (1); harrow + cultivating unit (1); 2x harrow (1); harrow + cultivator + harrow (1); subsoiling machine (1)	4. soil seasoning: harrow (8); subsoiling machine (1); cultivating unit (1);		4. soil seasoning: harrow (1); plough (1)
-	5. intercrop sowing: fertiliser distributor (27), grain drill (6)		5. intercrop sowing: grain drill (4); fertiliser distributor (3);
-	6. harrowing (11)		6. harrowing (2)
Maintenance and cultivation operations carried out before winter			
5. fertilising: cow dung (29); liquid manure (1); mineral fertilisers (65); lime (5); lime + mineral fertilisers (3); lime + cow dung (1);	7. fertilising: cow dung (1); mineral fertilisers (7)	-	-

6. ploughing: reversible plough (23); field plough (150)	8. ploughing: reversible plough (7); field plough (20)	-	
7. fertilising + fertiliser covering: - mineral fertilisers (5) - tools: harrow (3); cultivating unit (2)	9. soil seasoning: harrow (3); cultivating unit (1)	-	-
8. soil seasoning: harrow (12); cultivating unit (2); harrow + unit (1)	-	-	-
Maintenance and cultivation operations carried out in spring until beet seeds sowing			
10. fertilising + fertiliser covering: - fertilisers: mineral fertilisers (3); cow dung (1); liquid manure (1) - tools: plough (2); harrow (3)		7. fertilising + fertiliser covering: - mineral fertilisers (2) - tools: plough (2)	7. fertilising + fertiliser covering: - mineral fertilisers (1) - tools: cultivating unit (1)
11. soil seasoning: harrow (43); cultivator (1)		8. soil seasoning: field plough (3); harrow (1)	8. soil seasoning: cultivating unit (1)
12. fertilising: mineral fertilisers (200), including full dose of PK (125); + lime (2)		9. fertilising: mineral fertilisers (11), including full dose of PK (8)	9. fertilising: mineral fertilisers (7), including full dose of PK (2)
13. soil seasoning: plough (3); harrow (15); cultivator (2); plough + harrow (1); plough + cultivator (1); harrow + cultivator (1)		10. soil seasoning: field plough (4); plough + harrow (2); harrow (1)	10. soil seasoning: disk harrow (1)
14. cultivation before sowing: 1x machine cultivation (190); 2x machine cultivation (10)		11. cultivation before sowing: 2x pre-sowing unit (2); 1x pre-sowing unit (9)	11. cultivation before sowing: 2x pre-sowing unit (1); pre-sowing unit (5); active harrow (1)
Operations: beet seeds sowing, fertilising, maintenance and root harvesting			
15. sowing - service (12);			
16. chemical protection: herbicides (218); fungicides (173); insecticides (3)			
17. top dressing with nitrogen (139)			
18. fertilising with microelements through leaves (124)			
Crop (th^{-1}) (for 16% sugar content) – average in Poland 48.1 echnology I 58.2; Technology IIA 56.9; Technology IIB 59.3, Technology III 61.24			

The largest technological differences are observed between forecrop harvest and soil cultivation before sowing. Subsequent operations are identical for all variants, therefore they have been discussed jointly for the whole examined group of farmers. Also, fertilising

and maintenance measures used in plantations have been evaluated jointly, without dividing into individual technologies.

Technology I

Technology I was used by 173 farmers (79%). In case of this technology, either mineral or organic fertilisers were applied prior to cultivation after harvest in 39 farm plots (23%) (in one of the farms liming was carried out jointly with cow dung fertilising) (tab. 1). Bringing cow dung so early into soil contributes to prompt fertiliser mineralization and nitrogen losses, therefore it is recommended to use this fertiliser in late autumn before deep ploughing. At the same time, phosphatic-potassic fertilisers should be used [Hołubowicz-Kliza 2007; Gutmański 2002; Ostrowska, Artyszak 2005].

In 48% of cases after-harvest cultivation was carried out using a hoeing plough. Often, this operation was carried out with a stubble field unit (40%), usually consisting of a cultivator with rigid arms and string shaft. Stubble field unit guarantees better mixing of crop residue with a soil and shallow distribution of weed seeds, which cannot be achieved in the case of stubble field cultivation with plough [Bzowska-Bakalarz, Bieganowski 2008; Przybył 2006; Ostrowska, Artyszak 2005]. Moreover, stubble field unit allows reducing energy consumption in this operation [Sęk, Przybył 1993].

In plantations using conventional technology the researchers observed high diversification in the number of autumn cultivation operations (between cultivation after harvest and ploughing before winter). In September and October, 54 (31%) farmers from the group of 173 carried out only shallow cultivation using a harrow, cultivator or cultivating unit (tab. 1). In the same period, three farmers (2%) decided to season soil several times with cultivating tools, and one cultivated soil with a subsoiling machine. In additional 17 cases (10%) cultivation operation involved mixing of applied fertilisers with a soil - for this purpose farmers used primarily a cultivator or tooth harrow (one of the farmers performed middle ploughing) (tab. 1). Before fertiliser sowing, six of these seventeen farmers (35%) levelled out field surface with a harrow, and one performed this operation after middle ploughing. As regards farmers using technology I, 57% of them did not carry out any other operations between cultivation after harvest and deep ploughing (apart from fertilising prior to ploughing before winter).

Before deep ploughing, a mineral or organic fertilising was applied in 57% (99) of plantations using technology I, while liming was applied in 5% (9) plantations. In the same time or close, four planters (2%) applied fertilisers (mineral or organic) and lime. This practice causes high nutrient losses [Bzowska-Bakalarz, Bieganowski 2008; Szewczuk 2005]. The most favourable time for liming is two years before beet sowing; it is also possible to use calcium fertilisers immediately after forecrop harvest, mixing them with soil using a cultivator [Ostrowska, Artyszak 2005; Gutmański 2002].

Ploughing before winter was carried out 25-30 cm deep, primarily using a field plough (87%). In the other 23 farms (13%) ploughing was carried out using a reversible plough. Reversible plough allows to reduce fuel consumption, increase productivity, and leaves levelled out surface without clearly visible furrows and crowns [Bzowska–Bakalarz, Bieganowski 2008; Ostrowska, Artyszak 2005, Przybył 2006]. A field prepared in this way may be seasoned in spring, before sowing, in a single cultivating unit run. Uneven field

surface left after deep ploughing requires an additional evening up with seasoning tools in order to reduce the number of seasoning operations in spring. This measure was chosen by 12% planters, and 3% of them preceded it with sowing of mineral fertilisers.

Spring operations carried out in plantations are discussed jointly for technology I and technology IIA, that is group of 200 farmers (92% of all respondents). Spring maintenance and cultivation measures taken by 44 planters (22%) in this group were started from field surface seasoning with a harrow or cultivator. For five planters (3%), the first measure was to apply fertilisers (phosphatic-potassic, cow dung or liquid manure) and to cover them immediately with soil (in two cases, unfortunately using a plough) (tab. 1).

All farmers using technology I or technology IIA were sowing mineral fertilisers in spring, before beet sowing, and two of them applied lime directly before this operation (tab. 1, item 12). Some planters (37%) applied nitrogenous fertilisers or nitrogenous fertilisers with supplementary phosphorus and potassium doses in mixed fertilisers (elementary volume of these ingredients was brought into soil in autumn). The other planters (63%) supplied soil with a complete dose of phosphatic-potassic fertilisers, along with nitrogenous fertilising. Phosphatic-potassic fertilising is recommended in autumn, due to the need for deeper mixing of supplied ingredients with soil [Szewczuk 2005; 2006]. Excessive nitrogen and potassium doses supplied before sowing may result in reduced beet sprouting and stock [Nowakowski 2007b; Hołubowicz-Kliza 2007].

23 farmers (12%) carried out the extra soil cultivating operation prior to cultivation before sowing. Eighteen out of these twenty three planters (78%) seasoned soil with a harrow or cultivator, and the other 22% used ploughing. In 95% cases cultivation before sowing involved single run of cultivating unit, 5% of farmers completed this measure twice.

Ploughing carried out in spring after having applied full doses of phosphatic-potassic fertilisers may eliminate the negative effect of high concentration of these ingredients on beet sprouting; however it brings other adverse consequences. The most serious of them include ground overdrying and cutting off soil pores allowing water infiltration to seeds [Szewczuk 2009]. It is recommended to minimise the number of spring machinery runs along field, which protects soil against excessive drying, powdering and compaction. In spring it is advised to run cultivation unit once or twice and penetrate soil down to sowing depth, therefore it is very important to leave field surface levelled out in autumn [Przybył 2006; Bzowska–Bakalarz; Bieganowski 2008; Hołubowicz–Kliza 2007]. Moreover, many cultivation measures taken in spring often contribute to delayed seed sowing dates, which in turn reduces vegetation period duration (harvest date depends on raw material receiving schedule established by sugar manufacturer). Vegetation period exceeding 180 days ensures a higher crop volume and improved root processing quality. High losses in root and sugar crop are the effect of reducing this period by delayed sowing or earlier harvest [Gutmański 2002].

Technology II

38 farmers (17%) used technology II (IIA and IIB jointly) in their plantations. Like in technology I, some farmers started their autumn operations from supplying soil with mineral (3%) or organic (11%) fertilisers, or lime (5%) (tab. 1 item 1). In this technology it is a recommended measure, because fertilising has a positive effect on crop of intercrop plants [Gutmański et al. 1999].

In 39% of plantations cultivation after harvest was carried out with a hoeing plough and in other cases with stubble field unit (21%), disk harrow (16%), and stubble field cultivator (11%) (tab. 1). In five plantations (13%) cultivation after harvest was combined with sowing intercrop plant seeds, as a result of using a cultivating-sowing unit.

From the group of 38 planters, 8% of farmers applied fertilisers (mineral or organic) and mixed them with a soil (tab. 1 item 3) following cultivation after harvest. Between stubble field skimming and sowing of intercrop plant seeds, another 11 planters (29%) seasoned their land using a harrow or cultivating unit (one farmer cultivated soil with a subsoiling machine). It is advantageous to use natural and mineral fertilising (complete or partial dose) under intercrop intended for green manure. This creates favourable conditions for better plant growth, and released ingredients are easily available for beets after pre-ploughing [Hołubowicz-Kliza 2007].

In the plantations using technology II, intercrop was sown in the third decade of July at the earliest, when planters combined cultivation after harvest with simultaneous sowing of mustard seeds. Planters performed this operation not later than on September 25. The plant chosen by farmers for intercrop was white mustard variety deadly for sugarbeet nematode [*Heterodera Schachtii*], which, besides its properties involving biological elimination of sugarbeet nematode, is characterised by quick leaf mass growth, resistance to drought and frost, and low price of seeds [Gutmański et al. 1999; Hołubowicz–Kliza 2007]. The main advantages of using intercrops include soil loosening, restoring its lumpy structure, and drawing and binding nutrient forms characterised by highest solubility. Additionally, papilionaceous plants are rich nitrogen source, however they are not commonly used due to the higher price of their seeds, required early sowing and low resistance to frost [Nowakowski 2006]. Scheduled time for sowing intercrop plant seeds is very important - its optimum (in case of mustard) is in mid-August. 50% of farmers using technology II sowed intercrops in recommended time. Two farmers (5%) sowed intercrop in the third decade of July, and the other 45% of planters - at the end of August and in September. Plants for green manure shall be sown as early as possible, so as to produce large organic mass [Hołubowicz–Kliza 2007].

The following equipment was used for sowing: fertiliser distributors (71%), grain drills (16%) and aftercrop drills (13%). Directly after seed sowing, 11 (29%) planters performed harrowing (tab. 1). Better sprouting and soil coverage with plants is obtained after seed sowing with drill seeders than for broadcast sowers, especially when there is no harrowing after sowing [Hołubowicz–Kliza 2007].

Observations of planters' practices allowed to divide technology II into two cultivation variants: IIA and IIB. In the first one (IIA), chosen by 27 farmers (12% of the whole group of 218 planters), intercrop plants were pre-ploughed before winter, while in the second one (IIB) (applied by 5% of planters) intercrop plants were left in field throughout winter, and ploughing was carried out not until spring. Thus, in case of technology IIB, the final operation in year preceding sugar beet cultivation involved sowing of stubble field intercrop (or possibly harrowing).

Group of eight planters (30%) using technology IIA delivered to soil nutrients contained in cow dung or mineral fertilisers prior to deep ploughing before winter. Ploughing was carried out primarily using a field plough (74%); in other cases reversible plough was used for that. Additionally, before winter 15% farmers levelled out fields using a harrow or cultivating unit.

Spring operations performed in plantations using technology IIA are discussed jointly with technology I. Among 11 planters using technology IIB, only 4 (36%) carried out fertilising in autumn (three of them used organic fertilisers), which resulted in the need to supply phosphorus and potassium to soil in spring. Two of these 11 planters (18%) sowed phosphatic-potassic fertilisers on intercrop plants in early spring and performed ploughing, and only after these operations they applied nitrogenous fertilisers (tab. 1). Next three planters (27%) pre-ploughed intercrop and then sowed full dose of nitrogenous and phosphatic-potassic fertilisers. The other 55% farmers ploughed the whole amount of mineral fertilisers sown on intercrop. Four farmers additionally seasoned soil with a harrow in spring.

The negative effects of applying in spring full doses of phosphatic-potassic fertilisers, ploughing and high number of cultivating runs of machines have been discussed in the description for technology I. An additional, undesired effect occurring in plantations during spring pre-ploughing of nitrogenous fertilisers with phosphatic-potassic fertilisers is the fact that nitrogen gets deep in soil. Nitrogen is an element, which quickly relocates into deeper soil profile layers, and thus in case of deep cultivation it moves as well, and it may be partially unavailable for beets [Nowakowski 2003]. Pre-sowing cultivation in 82% plantations using technology IIB involved single run of cultivating unit, and in 18% of cases this operation was carried out twice.

Technology III

Only 7 farmers (3% of the whole population) used in their plantations the simplified technology (cultivation variant III) with beet sowing in mulch from intercrop. This technology makes it possible to reduce production outlays by elimination of ploughing before winter. Completed studies confirm high energy and economic efficiency of this technology [Dobek, Piernicka 2005; Šařec O. Šařec P. 2005]. Moreover, the researchers observed advantageous influence of intercrops on reduction in soil density, both in arable and subarable layer [Nowakowski 2006].

Planters from the group using technology III to carry out first ploughing were using disk harrow (3 farmers – 43%), cultivator, stubble field unit, reversible plough and field plough (tab. 1). Two farmers (29%) performed fertilising prior to cultivation after harvest.

Three planters (43%) sowed mineral fertilisers after stubble field cultivation, and then mixed them with soil using cultivating tools (tab. 1 item 3). Lime sowing was carried out in the same time in one plantation. Lime was mixed with soil using a cultivator, and then pre-ploughed. Another two planters seasoned soil before intercrop sowing using a plough or harrow, and one sowed intercrop after first ploughing without any extra soil cultivation. Planters employing technology III started mustard sowing in the first days of September, and concluded it at the end of September. Intercrop sowing in mulch may be carried out slightly later than in green manure, however mustard sowing in last days of September hinders good soil covering with lichen [Gutmański 2002]. Fertiliser distributors (43%) and grain drills (57%) (tab. 1) were used to perform sowing operations. Two farmers seasoned their fields with a harrow immediately after seed sowing. Sites prepared in this way were left until spring.

One planter sowed phosphatic-potassic fertilisers in spring, and then covered them and intercrop with a soil using a cultivation unit, and finally applied nitrogenous fertilisers. Second one mixed intercrop plants with a soil and only after this operation he sowed nitrogenous and phosphatic-potassic fertilisers. Another one carried out cultivation with a disk harrow after mineral fertilising. Other farmers (71%) performed soil cultivation before sowing with a unit after delivering to intercrop a dose of either nitrogenous fertilisers or nitrogenous with mixed fertilisers (a double run of cultivation unit was used in one plantation, and single runs in the other ones). In one case the unit consisted of rotor harrow and shaft.

Sowing, plantation maintenance and fertilising for technologies I, II and III

Sowing of sugar beet seeds started in the first days of April and ended in the third decade of April. Delays were primarily due to high number of operations carried out in plantations in early spring.

Sowing was carried out only with 6-row single-seed drills (approximately 6% of planters used external seed sowing services) (tab. 1). "Ready" sowing every 18 cm was applied in 97% of plantations and the number of used sowing units was 1.2. According to the requirements specified in the contracting agreement, planter is obliged to purchase no less than 1.15 of sowing unit per 1 ha of plantation. Only 3% of farmers underrated seed sowing doses, in spite of demands set for them. Generally, evaluating sowing technology and the number of used sowing units, one may expect high plant stock. However, the average root stock was not subject to considerable changes over the research years and ranged within 86,000 – 89,000 plants per hectare. Currently, it is recommended to increase the stock to 90-100 thousand plants per hectare, which contributes to less weeding in plantations and guarantees better crop quality (higher sugar content and lower content of non-crystalline sugars and organic and mineral salts) [Ostrowska, Artyszak 2005].

Spraying against weeds was applied in all plantations, however the number of operation repetitions was different for individual fields. The majority of farmers (52%) performed herbicide spraying repeated three times. A similar trend in applying divided doses was observed in the first and second year of the research.

17% of farmers showed in their operation sheets for 2008 mechanical cultivation of strips between plant rows. The researchers observed gradual withdrawal from this operation among planters. In the first year of the research (2006) mechanical weed killing was carried out in 50% of plantations, and next year – in 44%. Gradual planters' withdrawal from this operation indicates that farmers chose chemical weed control. None of the planters used recommended mechanical and chemical plantation maintenance involving herbicide application in strips and mechanical weed elimination in strips between plant rows [Bzowska-Bakalarz, Bieganowski 2008]. Farms had no equipment suitable for this operation. 173 farmers (79%) applied fungicides in their plantations, and 20 (12%) of them performed this operation protecting against diseases twice. Pest control measures were taken only in three (1%) of all observed plantations.

All farmers carried out a nitrogenous fertilising before sowing in their plantations, and top dressing was provided in 139 fields - mainly using ammonium nitrate, and in 8 cases nitro-chalk. Therefore, 64% of farmers followed guidelines regarding correct agrotechny and sowed nitrogen in divided doses [Nowakowski et al. 1997]. In 98% of plantations, supplementary (top dressing) doses of nitrogenous fertilisers were supplied in one equipment run, four farmers (3%) divided fertiliser into 2 doses, and one applied nitrogenous fertilisers 3 times during beet vegetation period. The nitrogenous fertilising through leaves, more efficient compared to top dressing [Jasztołt 2005; Czuba et al. 1997], was used only by 2% of farmers - it was urea applied with microelements.

Fertilising with microelements through leaves was applied by 124 farmers (57%). Most of them (77%) performed this operation only once, and only two farmers - three times. The rest of farmers provided the plants with necessary microelements twice during vegetation period. When comparing to year 2006, the researchers observed considerable reduction in this fertilising type – by 33 %. It is a negative effect, because fertilising through leaves allows increasing basic fertilising efficiency, has favourable impact on the availability of individual ingredients and high level of their use, and on crop volume and quality [Chwil, Szewczuk 2003; Nowakowski 2007b; Czuba et al. 1997].

The assortment of fertilisers applied though leaves was very wide. The most commonly used fertilisers of this sort were: CukroVit Borowy [boron] (23%) and CukroVit Mikroelementowy [microelement] (21%), both applied in doses recommended by manufacturer. Boron prevailed among microelements supplied to the plants, as it was the main ingredient in four out of six most often used fertilisers applied though leaves (CukroVit Borowy, Solubor DF, Foliarel 21% Bor, Bormax). The average doses of these fertilisers ranged from 2 up to 5 $kg \cdot ha^{-1}$. Beets have high nutritious requirements compared to boron. Boron has particular impact on root cropping, and due to its very low content in 70% of soils within Poland (especially high deficiencies occur in Lublin Voivodeship) there is a need to supply an extra amounts of this element in form of fertilisers [Igras 2004]. Some planters (18%) combined plant protection measures with nutrient supplying via leaves, which allowed reducing the number of machinery runs along a field.

Roots were harvested from late September through the first days of November, according to the contracts concluded for receiving raw material. One-stage harvest was prevailing (95%), but 5% of farmers performed two-stage harvest using obsolete sets for beets (Orlik, Birkut), in one case beets were topped manually, and roots were gathered with *Bolko* potato harvester.

The majority of planters (77%) dug out roots using attachable 1-row (Neptun Z 413, Stoll V 100, Stoll V 50, Kleine 5002, etc.) or 2-row (Stoll V 202) harvesters. In the examined group of farmers only 18% used the service of beet harvesting with a self-propelled 6-row harvester, and one planter had his own machine of this type. However, compared to year 2006 the researchers observe growing interest in outsourced harvest services – the number of farmers using external services increased by 14%. It is a favourable effect

because one-stage harvest with self-propelled 6-row harvesters guarantees better crop quality, lower losses and less pollution [Przybył 2006a].

In the aspect of analysing the technology there is no way to omit evaluation of fertilising applied for sugar beets. It is a plant characterised by high nutritious requirements. Correct selection of nutrient doses should be based on obtained soil analysis results [Jaszczołt 2005]. Analysis of data acquired from questionnaires allows concluding that planters have knowledge on advantages of carrying out soil sample analyses. 74% of farmers declared carrying out this analysis in the first year of the research, and 85% in the second year. Verification of information acquired from sugar factories and chemical-agricultural stations revealed that only 59% of respondents carried out tests for nutrients content in soil during three years of the research. The average pH values for soils planned for beet growing were within recommended range (6-7.2). Depending on the year, lower limit of that range was exceeded in 37-38% of cases, whereas upper – in 13-15% of cases. The majority of planters sowed lime in field either one (40%), or two years (37%) before sowing the plant, and the rest of them carried out this operation either three years earlier or directly before beet growing.

The researchers observed systematic reduction in the number of plantations fed with organic fertilisers, which is alarming, since it may result in reduced quality of roots and deterioration of biological, physical and chemical properties of soil [Nowakowski 2006; Szewczuk 2006]. In the first year of the research, 76% of respondents were using fertilisers of this sort (cow dung, liquid manure, green manure). In the second year, this type of fertilising was applied in 68% of plantations, whereas in the last year – only in half (50%) of the examined fields. Also, the share of green manure use in fields planned for beet growing changed. In years 2006 and 2007, green manure constituted only 7% in farm plots fed with organic fertilisers. Whereas, the share of green manure in organic fertilisers increased to 31% in 2008. Both cow dung and intercrop were applied at the same time in 4.5% of plantations in 2006 and 8.4% of plantations in 2008. In the first two years of the research nitrogenous fertilisers were in 84-88% divided into two doses and supplied to plants in spring before and after sowing. Whereas, in 2008 only 64% of farmers applied nitrogen to plants before sowing and in form of top dressing.

The average nitrogen doses in pure ingredient grew from 124 to 134 kg·ha^{-1} N. However, the researchers observed reduction in mean phosphorus doses from 94 to 90 kg·ha^{-1} P_2O_5 and potassium from 168 to 153 kg·ha^{-1} K_2O. The ratio of ingredients N:P:K changed from 1:0.76:1.35 in 2006 to 1:0.67:1.14 two years later.

High percentage of farmers (64% in 2008) sowed full dose of phosphatic-potassic fertilisers in spring. This is considered unfavourable in beet plantations. In 2006 40% of planters sowed these fertilisers in spring period, therefore within three years of the research, the percentage of planters making this mistake increased by 24%.

Due to the lack of suitable equipment, farmers did not carry out spot fertilising in any of the plantations, involving supplying nutrients to soil during seed sowing. This method

allows reducing fertiliser doses compared to surface application technique [Nowakowski et al.1997; Nowakowski 2003].

Precise performance of spring cultivation operation to sowing depth (ca. 3 cm) is possible when using a unit, in which loosening section is located between two shafts [Przybył 2006; Ostrowska, Artyszak 2005] 11% of farmers used in their plantations the unit recommended for this operation.

In regulations specified in the contracting agreement planter is obliged to keep the proper agriscience and to keep detailed documentation of all operations carried out in individual plantations. However, studies show that only 60% of farmers keep documentation of cultivation works.

Summary

To sum up, tables 3 and 4 compare technological errors and favourable operations carried out by farmers as a part of individual technologies.

Table 3. Errors and positive changes in technology in the examined plantations

Specification	Technology				
	I (173)	IIA (27)	IIB (11)	III (7)	total (218)[1]
Errors					
Using lime along with organic or mineral fertilising	(7) 4%	0	0	0	(7) 3%
Cultivation after harvest carried out with a plough	(84) 49%	(11) 41%	(4) 36%	(2) 29%	(101) 46%
Middle ploughing in autumn	(1) 1%	0	(1) 9%	(3) 43%	(5) 2%
Full doses of phosphatic-potassic fertilisers in spring	(106) 61%	(19) 70%	(8) 73%	(2) 29%	(135) 62%
Too early (for after-harvest cultivation) applying of mineral or organic fertilisers	(32) 18%	na[2]	na[2]	na[2]	(32) 18%
Ploughing carried out in spring	(7) 4%	0	(11) 100%	na	(18) 9%
Lack of carried out soil analysis	(77) 44%	(8) 30%	(2) 18%	(3) 43%	(90) 41%
Lime application in spring	(2) 1%	0	0	0	(2) 1%
Two-stage harvesting technology using an obsolete set of machines	(9) 5%	(1) 4%	0	0	(10) 5%

Table 4. Positive changes in sugar beet cultivation technology in the examined plantations

Specification	Technology				
	I (173)	IIA (27)	IIB (11)	III (7)	total (218)[1]
Positive changes in respective technology					
Cultivation after harvest carried out with stubble field unit or cultivating–sowing unit	(69) 40%	(9) 33%	(4) 36%	(1) 14%	(83) 38%
Ploughing before winter carried out with reversible plough	(23) 14%	(7) 26%	0	na	(30) 14%
Field levelling out after winter ploughing carried out with field plough	(20) 11%	(4) 15%	0	na	(24) 11%
Fertilising before intercrop plant sowing	na	(4) 15%	(4) 36%	(5) 71%	(13) 29%
Limiting spring cultivation to one or two unit runs with ploughing to sowing depth (possibly harrow + cultivating unit)	(158) 91%	(26) 96%	0	(6) 86%	(190) 87%
Using natural fertilisers	(68) 39%	(4) 15%	(3) 27%	(1) 14%	(76) 34%
Proper date for sowing intercrop for green manure	na	(17) 63%	(2) 18%	na	(19) 50%
Intercrop application	0	(27) 100%	(11) 100%	(7) 100%	(45) 21%
Sowing in intercrop mulch	na	na	na	(7) 100%	(7)[3] 3%
Proper site and forecrop selection	(173) 100%	(27) 100%	(11) 100%	(7) 100%	(218) 100%
Carried out soil analysis	(96) 55%	(19) 70%	(9) 82%	(4) 57%	(128) 59%
Favourable liming time	(152) 88%	(26) 96%	(9) 82%	(6) 86%	(193) 88%
Using nitrogen in divided doses	(111) 64%	(15) 55%	(8) 73%	(5) 71%	(139) 64%
Proper number of sowing units	(168) 97%	(26) 96%	(10) 91%	(7) 100%	(211) 97%
Application of fertilising with microelements	(95) 55%	(19) 70%	(5) 46%	(5) 71%	(124) 57%
Harvesting with a modern, six-row harvester	(32) 18%	(5) 18%	0	(2) 29%	(39) 18%
The ratio of cultivating operations carried out in autumn to those carried out in in spring	1:0.6	1:0.5	1:1.2	1:0.7	-

note: number of farmers is given in brackets, na - not applicable,
1 - when computing percent number of farmers keeping to guidelines, the researchers were taking into account all farmers (218), however if any specified feature (disadvantage or advantage) cannot be used in a given technology (symbol 'na' in the table – e.g. ploughing in simplified technology) then the number of farmers using this technology is subtracted from the total of all farmers;
2 - operation recommended before intercrop sowing;
3 - sowing in intercrop mulch was performed only by farmers using technology III, however due to benefits obtained when using this technology the table specifies the percentage for carrying out this operation with reference to all farmers.

Completed studies have confirmed that employed sugar beet production technologies do not guarantee material crop volume at the level comparable to the European Union countries leading in this field, although obtained crops are higher than national average (tab. 1). Suggestions contained in scientific publications (integrated production, sowing in mulch, simplified technologies) [Przybył et al. 2004; Šařec O.; Šařec P. 2005] for introducing technological innovations are being implemented in production conditions only to a little extent. Farmers still base their production on conventional technology, although the completed studies prove that simplified technologies give an opportunity to increase crop, but also to reduce production costs. Model studies carried out at IBMER [Gawryś 2005] prove that economic efficiency ratios for conventional technology (in areas up to 5 ha) are admittedly higher than unity, but profit level for this technology is lowest compared to other technologies. Small plantations prevail in Lublin Voivodeship, and they do not give an opportunity to employ state of the art technologies, however cooperation among some farms would allow improving economic efficiency ratios for production.

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ANALIZA TECHNOLOGII STOSOWANYCH W GOSPODARSTWACH SPECJALIZUJĄCYCH SIĘ W PRODUKCJI BURAKÓW CUKROWYCH

Streszczenie. Celem pracy było rozpoznanie i przeanalizowanie systemu produkcji gospodarstw specjalizujących się w uprawie buraków cukrowych w regionie lubelskim zmierzające do ustalenia kierunków usprawnień technologicznych. Ocenę technologii stosowanych na plantacjach buraków cukrowych prowadzono przez 3 lata w oparciu o wypełnione kwestionariusze (wywiad standaryzowany) i karty technologiczne. Zestawiono błędy technologiczne i korzystne zabiegi wykonywane przez rolników w poszczególnych technologiach. Sugestie wprowadzania innowacji technologicznych realizowane są w warunkach produkcyjnych regionu w niewielkim stopniu.

Słowa kluczowe: burak cukrowy, technologia produkcji, analiza poprawności zabiegów

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