

Technologies and Varieties of Fodder Beet in Organic Farming

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1. Introduction

In the organic farming system where the concentrate feeds are purchased a crop rotation for producing none only forage has been found to be expensive in relation to forage production costs, fossil energy inputs and the loss of production while crops are being established. The aim of organic farming is to create coexistence of multilateral, biologically and ecologically balanced weeds with low biomass production and strong culture crop. In weeds regulation we use preventive measures (seed rotation, late sowing, parallel growing of covering under sowings etc.), but also direct regulation methods, i.e. harrowing and line weeding (Petr et al., 1992).

Fodder beet is a crop for which cultivation areas are reduced, since in 2000 the sown area of 7597 hectares, but in 2007 decreased to 807 ha in the Czech Republic. A slight increase can be recorded in the year 2008 - 845 ha. Even though the area of fodder beet reduced this crop has an irreplaceable role in maintaining biodiversity in agro ecosystems. Therefore, at present there is a new application in organic farming, which is among the good fore crop.

Fodder beet areas in all over the world are not great. But it is a pity, because this crop has very high feed quality. Nowadays fodder beet could find new use in organic farming, especially as excellent feed for dairy cattle and energy crops. In ecological production of fodder beet we have some unsolved questions concerning i.e. weeds reduction, beet competitiveness improvement and optimal stand density. Fodder beet is a wide-row crop with slow initial development, which decreases its competitiveness in relation to weeds.

This crop has very high feed quality. Fodder beet could find new use in ecological farming, especially as excellent feed for dairy cattle (Kodeš et al., 2001).

Energy crops with wide ratio of nutrients - fodder beet, semi-sugar beet and sugar beet - provide more energy in comparison with cereals or forage crops. Fodder beet provides maximum amount of energy per one hectare and presents easily digestible feed (Kosař, 1985).

The most important factor determining nutritional quality of feeds is digestibility. Its value significantly influences amount of nutrients and of energy available for animal (Mudřík et al., 2006).

In feed can be determined combustible heat (gross energy). Gross energy (BE) is determined in calorimeter by complete combustion of feed in oxygen atmosphere and is expressed in mega joules (MJ). Energy value of feed for cattle is determined in MJ as NELs (for lactation cattle) and NEVs (for growing cattle - weight gain above 800 g/day). For energy content determination it is also necessary to determine metabolized energy content for cattle (MEs) (Zeman, 2002).

Besides the traditional use of fodder beet as the dietary food new ways of use appear. It is the use in bioenergetics, such as the production of bioethanol (Reed et al., 1986; Mähnert and Linke, 2009; Chochola, 2007; Pulkrábek et al. 2007) and biogas (Scherer, et al., 2009; Klocke et al., 2007). Use of fodder beet as a source of renewable energy results from the fact that it provides more energy than cereals and fodder crops (Urban et al., 2005; Hnilička et al., 2009; Martínez-Pérez et al., 2007).

The aim of our research was to compare and to recommend chosen varieties of fodder beet organic growing based on production ability evaluation. In three years experiments (2005 - 2007) small-plot trials were established (in four repetitions on plots with harvest area of ten square meters) with fodder beet on certified and controlled ecological area.

2. Methodology

The aim of our research was to compare and recommend 1. various growing technologies and 2. chosen varieties of fodder beet for organic growing based on production ability evaluation and to compare their feed value. In three years experiments based in 2005 - 2007 small-plot trials were established with fodder beet on certified and controlled ecological area of Experimental station of Department of Crop Production of Czech University of Life Sciences in Prague - Uhřetěves.

Six cultivars of fodder beet were used in experiment - especially volume types (Lenka, Hako, Jamon and Monro) and compromise type (Kostelecká Barres, Starmon) and sugar beet cultivar Merak (Table 1). Only in 2007 variety Bučanský žlutý válec (volume type) compensated variety Kostelecká Barres.

During vegetation stands were kept in non-weed state by inter-row hoeing and by manual hoeing and weeding in rows. No chemical protection against fungal diseases was used.

Number of plants per plot was determined before harvest. Harvest was performed by manual collection of roots, which were weighed in a field. Average weight of one root was determined and also total yield per hectare was recorded.

2.1 Growing technologies

In three-year trials various growing technologies of fodder beet differ with row distance (45 cm and 37.5 cm), plant distance in row (18 and 25 cm) and weed regulation were compared. Ranking with weeds, attack by leaf diseases, chlorophyll content and yield of roots were evaluated.

The aim of the project was to reach fodder beet stand structure optimization in ecologic growing regarding weed infestation, leaf diseases and production.

Weeds regulation problematics was solved by stand organization change. In order to achieve former rows covering we tested reduction of interrow distance from 45 cm to 37.5 cm. In our experiments changes caused by different stand organization and further treatments (Table 1) per number of vascular bundle circles and production indicators were evaluated. During vegetation weed infestation and degree of leaf diseases were evaluated.

| Row distance | Plant distance in row | Canopy density | Weed regulation |
|--------------|-----------------------|---------------------------|--|
| 45 cm | 18 cm | 100 thou.ha ⁻¹ | without weeds |
| 45 cm | 18 cm | 100 thou.ha ⁻¹ | line weeding (as necessary) + 1x digging in row during singling |
| 45 cm | 18 cm | 100 thou.ha ⁻¹ | line weeding (as necessary) + 1x digging in row before canopy connection |
| 37.5 cm | 18 cm | 120 thou.ha ⁻¹ | without weeds |
| 37.5 cm | 18 cm | 120 thou.ha ⁻¹ | line weeding (as necessary) + 1x digging in row during singling |
| 37.5 cm | 18 cm | 120 thou.ha ⁻¹ | line weeding (as necessary) + 1x digging in row before canopy connection |
| 37.5 cm | 25 cm | 100 thou.ha ⁻¹ | without weeds |

Table 1. Canopy organization variants and weed regulation

2.2 Varieties and energy

Six fodder beet varieties and one sugar beet variety were compared in three-year experiments at ecological area (in 2005 and 2006 Lenka, Hako, Kostelecká Barres, Jamon, Monro, Starmon and sugar beet Merak, in 2007 Bučanský žlutý válec site of Kostelecká Barres) (Table 2).

| Variety | Type | Rezistance | Properties |
|----------------------|----------------|------------------------|--|
| Merak | sugar beet N/S | rhisomania, cercospora | 2003 - diploid |
| Lenka | cubical | - | 1992 - 2n, monogerm, yellow bulb, cylindrical form with blunt root termination |
| Hako | cubical | - | 1977 - 3n, multigerm, light yellow bulb with orange shade, cylindrical with sudden termination |
| Kostelecká Barres | compromise | - | 1937 - multigerm, orange bulb with olive shape, 1/3 - 1/2 in ground |
| Jamon | cubical | - | 1997 - 3n, monogerm, yellow bulb |
| Monro | cubical | - | 1994 - 3n, monogerm, red bulb |
| Starmon | compromise | rhisomania | Monogerm, yellow bulb |
| Bučanský žlutý válec | cubical | | multigerm, cylindrical bulb, yellow coloured with orange shade, 1/3 in ground |

Table 2. Variants of variety experiment

The energy content was investigated office on the basis of combustion calorimetry methods. Combustion calorimetry as one of the many destructive biological method has a wide range of applications from production and environmental plant physiology, which can be

evaluated not only individual products but also the vegetation and ecosystem. Its foundation is the stress physiology of plants to determine the effect of exposure to stressors plants and then to detect the resistance of plant species or varieties. Important place in the combustion calorimetry quickly evaluate alternative sources of renewable bio-energy. Nor can it ignore the question of the nutritional value of feed and thus the quality of feed and fodder (primary sources, but the final product).

Obtained values of gross and net energy serves as the basis for calculations of energy balance of plant breeding, feed livestock, but also for establishing the energy efficiency of production, since the units of energy are all the same in comparison with bank transfers, and therefore it is preferable to determine the efficiency of production of individual commodities or the whole enterprise just over the energy balance.

The results were evaluated by statistical program SAS using analysis of variance at significance level $\alpha = 0.05$. Confirmatively different values are marked with different letters (a, b, c, d).

3. Results and discussion

3.1 Technologies

Modification in stand organization (reduction of interrow distance and stand density increasement) did not bring confirmative changes in leaf diseases infestation of plants in 2005 (Table 5). During 2006 - 2007 stand organization and weeds regulation influenced plants infestation with leaf diseases.

Statistical evaluation of harvest results in 2005 did not prove influence of interrow distance change and stand density on roots yield (Table 4). Average weight of one root was influenced by stand organization (Graph 1) and weed infestation regulation (Table 3, graph 2). Number of vascular bundles was not influenced by stand organization.

Weeds regulation method confirmatively influenced plants infestation with leaf diseases in 2005. Variants, in which weeds in row were not regulated, but they were regulated only in interrow, have been during vegetation confirmatively more infested with leaf diseases. At the end of vegetation more infested were beet leaves in non-weed variants.

Before harvest in 2006 the least statistically confirmative infestation was found in non-weed variant with wider rows (34%) and the highest infestation was found in variant with narrow rows with line weeding and hoeing (39%). Diseases infestation in 2006 in all monitored variants at the end of vegetation reached in average only 35%.

In 2007 differences before harvest disappeared, leaf diseases infestation was non-confirmative among compared variants. In total average of all monitored variants diseases infestation reached 64% at the end of vegetation in 2007.

Roots production (graph 3 and 4) was during 2005 and 2006 significantly influenced by weeds regulation method (Table 4). In 2005 with both stand densities (determined by different interrow distances - 45 cm and 37.5 cm) the highest yield was reached by control variant without weeds.

In 2006 the highest yield was reached by variant with wider rows with hoeing (86.8 t.ha⁻¹), control variant with narrow rows without weeds (83.8 t.ha⁻¹). The worst were variants with narrow rows with line weeding, narrow rows with line weeding and hoeing and narrow rows without weeds with higher distance between plants in row.

| Row distance (cm) | Technology | 1 bulb average weight (g) | | | |
|---------------------|--------------------------|---------------------------|------|------|---------|
| | | 2005 | 2006 | 2007 | average |
| 45 | without weeds | 1095 | 1080 | 1042 | 1090 |
| 45 | line weeding | 204 | 1200 | 976 | 667 |
| 45 | line weeding and digging | 596 | 1300 | 964 | 982 |
| 37.5 | without weeds | 884 | 1330 | 842 | 806 |
| 37.5 | line weeding | 213 | 1120 | 918 | 739 |
| 37.5 | line weeding and digging | 586 | 1180 | 940 | 784 |
| 37.5 (25 cm in row) | without weeds | 1051 | 1490 | 1157 | 1233 |

Table 3. One bulb average weight – technologies compare

Average weight of one root was the highest in 2006 in non-weed variant with narrow rows and higher distance of plants in row (1490 g). Number of vascular bundles was not influenced by stand organization (Table 4). Yield values, weight of one root and number of vascular bundles were not statistically confirmative in 2006.

Higher yields in 2007 were reached in variants with narrow rows in comparison with wider rows. The highest yield was reached by variant of narrow rows with hoeing. Differences among obtained yields were not confirmative.

In 2007 average weight of one root was the highest in non-weed variant with narrow rows and higher distance between plants in row (1160 g). Number of vascular bundles was not influenced by stand organization. Values of one root weight were not statistically confirmative among compared variants.

| Row distance (cm) | Technology | Yield (t.ha ⁻¹) | | | |
|---------------------|--------------------------|-----------------------------|--------------------|--------------------|---------|
| | | 2005 | 2006 | 2007 | average |
| 45 | without weeds | 114.0 ^c | 79.1 | 87.9 | 93.7 |
| 45 | line weeding | 17.2 ^a | 74.4 | 87.2 | 59.6 |
| 45 | line weeding and digging | 59.4 ^b | 86.8 | 79.6 | 75.3 |
| 37.5 | without weeds | 102.5 ^c | 83.8 | 94.8 | 93.7 |
| 37.5 | line weeding | 23.9 ^a | 70.7 | 94.9 | 63.2 |
| 37.5 | line weeding and digging | 66.5 ^b | 72.5 | 97.0 | 78.7 |
| 37.5 (25 cm in row) | without weeds | 108.9 ^c | 72.8 ^{ns} | 92.3 ^{ns} | 91.3 |

Table 4. Yield of bulbs – technologies compare

Regarding relatively small weed infestation, roots production was more influenced by stand organization than by weeds regulation method. Generally higher yield was reached by variants with narrow rows in comparison with wide-rows variants. Nor can it ignore the

question of the nutritional value of feed and thus the quality of feed and fodder (primary sources, but the final product).

| Row distance (cm) | Technology | % of attacked leaves before harvest | | | | | |
|---------------------|--------------------------|-------------------------------------|--------------|------|--------------|------|--------------|
| | | 2005 | significancy | 2006 | significancy | 2007 | significancy |
| 45 | without weeds | 99 | <i>c</i> | 34 | <i>c</i> | 65 | <i>a</i> |
| 45 | line weeding | 94 | <i>bc</i> | 37 | <i>abc</i> | 65 | <i>a</i> |
| 45 | line weeding and digging | 85 | <i>ab</i> | 35 | <i>abc</i> | 65 | <i>a</i> |
| 37.5 | without weeds | 82 | <i>ab</i> | 35 | <i>b</i> | 64 | <i>a</i> |
| 37.5 | line weeding | 92 | <i>abc</i> | 38 | <i>ab</i> | 63 | <i>a</i> |
| 37.5 | line weeding and digging | 89 | <i>abc</i> | 39 | <i>a</i> | 66 | <i>a</i> |
| 37.5 (25 cm in row) | without weeds | 80 | <i>a</i> | 33 | <i>c</i> | 64 | <i>a</i> |
| | | | | | | ns | |

Table 5. Plant attack by leaf diseases – technologies compare

In case of fodder beet organically growing it is possible to achieve high yields, but only with a thorough weeding throughout the vegetation. Row spacing or pitch variation in weed-free yield of roots was not much influenced.

All compared variants without weeds reached in the three-year average high yields of roots above ninety tonnes per hectare. This indicates the need for weeding during the growing period.

Weed infestation significantly reduced root yields. In average of three years provided the lowest yields income variations, where only line weeding were done. Weed infestation not only reduced yields but also decreased the weight of the tubers.

Significant influence of year was discovered. In 2005 exchange of canopy organization did not exchange plant attack by leaf diseases and bulb yield and way of weed regulation had significant influence to plant attack by leaf diseases and bulb production. In 2006 exchange of canopy organization exchanged plant attack by leaf diseases. Bulb yield was influenced by way of weed regulation. In 2007 exchange of canopy organization did not influence to plant attack by leaf diseases but it influenced the bulb production. Higher yield were reached at the variants of narrower rows.

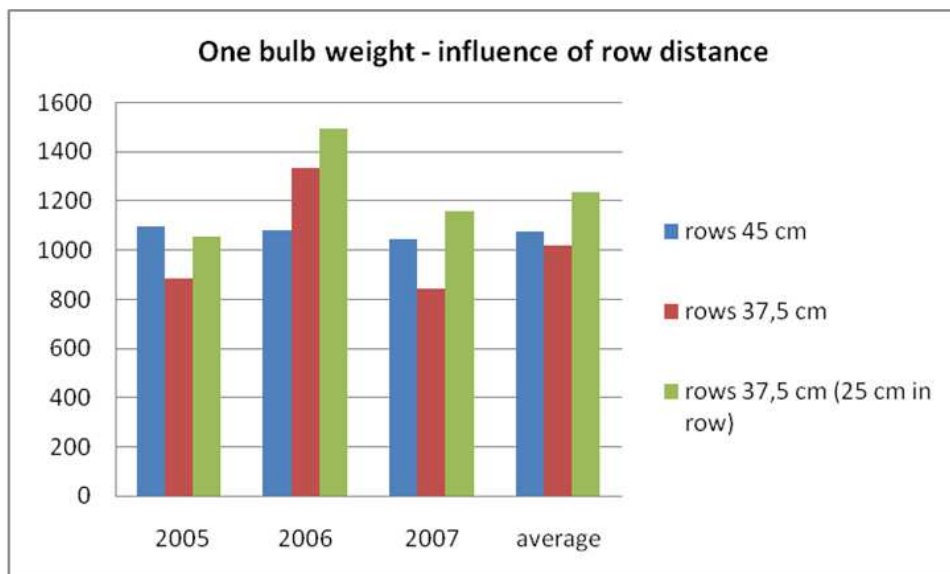


Fig. 1. One bulb weight (g) - influence of row distance

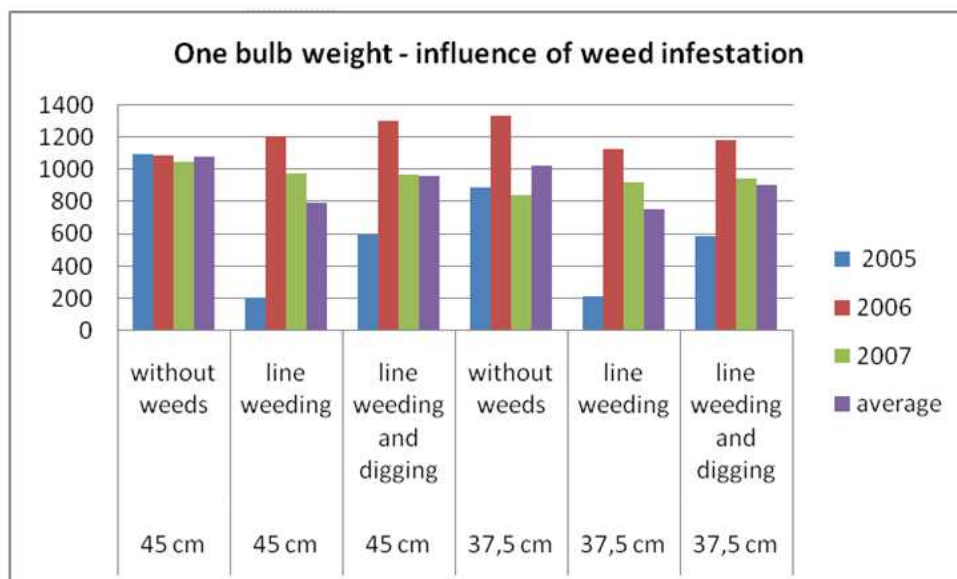


Fig. 2. One bulb weight (g) - influence of weed infestation

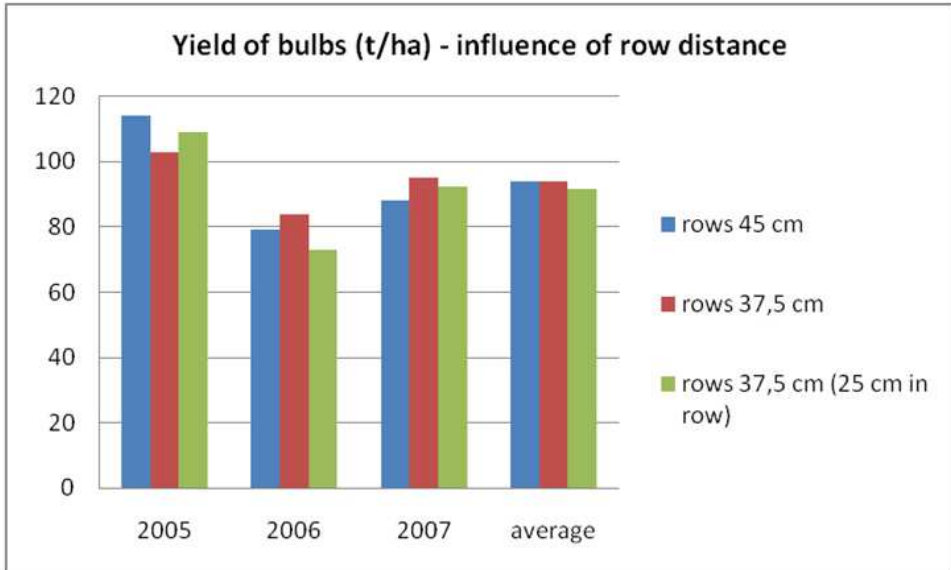


Fig. 3. Yield of bulbs - influence of row distance

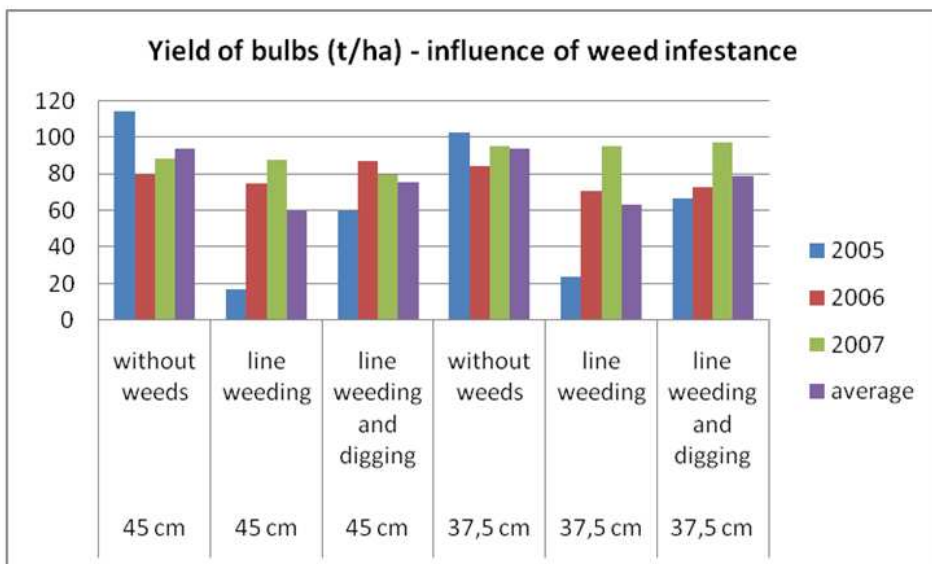


Fig. 4. Yield of bulbs - influence of weed infestation

3.2 Varieties and energy

3.2.1 Varieties

Yields of roots were strongly influenced by year of growing and by number of plants in harvest (Table 6, graph 5). Due to timely sowing and favourable weather conditions in 2005 beet emerged well. In 2005 after singling we obtained balanced and high numbers of plants at individual plots. Long winter, late start of spring and drought in the period after sowing in 2006 caused lower emergence. In 2006 total numbers in individual variants were relatively low in order to achieve relative uniformity between plots. In 2007 due to rainfall deficiency in period after sowing the plants emerged slowly and the canopy was off balance.

In 2005 cultivars Monro, Starmon, Hako and Kostelecká Barres reached yields of roots above one hundred tons per hectare, while in 2006 and 2007 none of varieties exceeded this level (Table 8). In 2006 the highest yields were reached in cultivars Hako and Jamon. In 2006 the highest yield of roots reached varieties Hako and Jamon, in 2007 Bučanský žlutý válec and Hako. In average of three years the most yielding cultivar was Hako (graph 7).

| Variety | Plant number in harvest | | |
|----------------------|-------------------------|------|------|
| | in thousands per hectar | | |
| | 2005 | 2006 | 2007 |
| Merak | 106 | 41 | 100 |
| Lenka | 85 | 49 | 77 |
| Hako | 102 | 64 | 74 |
| Kostelecká Barres | 110 | 38 | |
| Bučanský žlutý válec | | | 80 |
| Jamon | 94 | 64 | 93 |
| Monro | 104 | 65 | 92 |
| Starmon | 101 | 64 | 46 |

Table 6. Plant number in harvest - varieties compare

Weight of one root (Table 7, graph 6) was determined so by genetic dispositions of varieties and the canopy density and weather conditions. In average of three years varieties Lenka, Kostelecká Barres and Hako were the highest weight of one root.

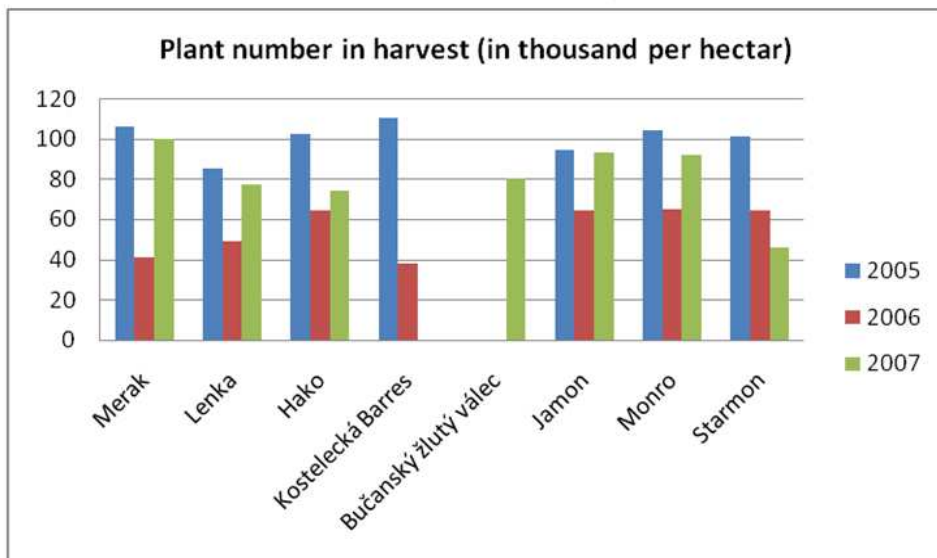


Fig. 5. Plant number in harvest - variety comparison

| Variety | Average weight of one bulb (g) | | | |
|----------------------|--------------------------------|------|------|---------|
| | 2005 | 2006 | 2007 | average |
| Merak | 790 | 930 | 701 | 807 |
| Lenka | 1078 | 1640 | 1133 | 1284 |
| Hako | 1047 | 1430 | 1215 | 1231 |
| Kostelecká Barres | 955 | 1570 | | 1263 |
| Bučanský žlutý válec | | | 1177 | 1177 |
| Jamon | 944 | 1420 | 914 | 1093 |
| Monro | 1051 | 1160 | 945 | 1052 |
| Starmon | 1055 | 1120 | 1287 | 1154 |

Table 7. One bulb average weight - varieties compare

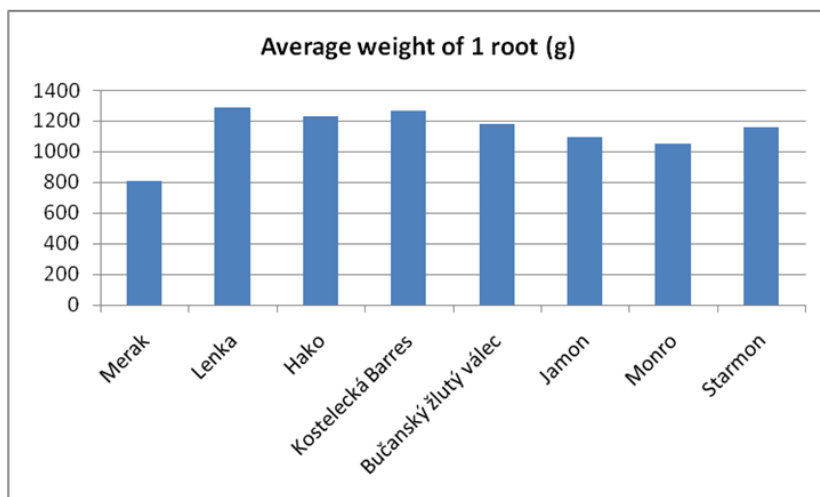


Fig. 6. Average weight of 1 root – variety comparison

| Variety | Yield of bulbs | | | | | | average |
|----------------------|-----------------------|--------------|------|--------------|------|--------------|---------|
| | (t.ha ⁻¹) | | | | | | |
| | 2005 | significancy | 2006 | significancy | 2007 | significancy | |
| Merak | 83.3 | <i>a</i> | 37.6 | <i>c</i> | 69.2 | <i>bc</i> | 63.4 |
| Lenka | 90.9 | <i>abc</i> | 79 | <i>ab</i> | 86.3 | <i>a</i> | 85.4 |
| Hako | 106 | <i>cd</i> | 91.5 | <i>a</i> | 89.4 | <i>a</i> | 95.6 |
| Kostelecká Barres | 104.3 | <i>bcd</i> | 61.8 | <i>bc</i> | | | 83.1 |
| Bučanský žlutý válec | | | | | 91.3 | <i>a</i> | 91.3 |
| Jamon | 88.6 | <i>ab</i> | 87.5 | <i>ab</i> | 84.2 | <i>ab</i> | 86.8 |
| Monro | 108.9 | <i>d</i> | 74.6 | <i>ab</i> | 86.4 | <i>a</i> | 90.0 |
| Starmon | 106.3 | <i>cd</i> | 70.1 | <i>ab</i> | 71.0 | <i>c</i> | 82.5 |

Table 8. Yield of bulbs – varieties compare

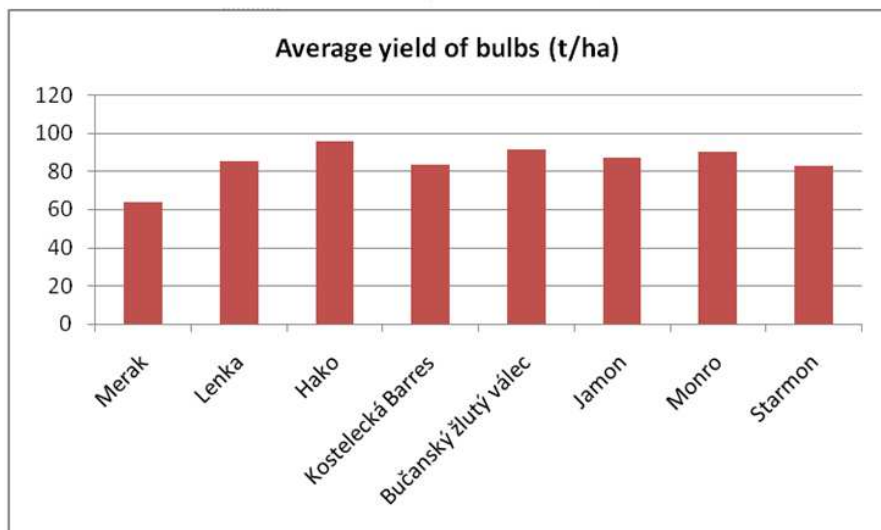


Fig. 7. Average yield of bulbs - variety comparison

| Variety | % of attacked leaves before harvest | | | | | |
|----------------------|-------------------------------------|--------------|------|--------------|------|--------------|
| | 2005 | significancy | 2006 | significancy | 2007 | significancy |
| | 59 | <i>a</i> | 2 | <i>c</i> | 5 | <i>b</i> |
| | 89 | <i>b</i> | 22 | <i>c</i> | 45 | <i>a</i> |
| Hako | 99 | <i>b</i> | 26 | <i>ab</i> | 46 | <i>a</i> |
| Kostelecká Barres | 94 | <i>b</i> | 30 | <i>ab</i> | | |
| Bučanský žlutý válec | | | | | 46 | <i>a</i> |
| Jamon | 91 | <i>b</i> | 29 | <i>a</i> | 43 | <i>a</i> |
| Monro | 94 | <i>b</i> | 36 | <i>a</i> | 60 | <i>a</i> |
| Starmon | 90 | <i>b</i> | 28 | <i>ab</i> | 56 | <i>a</i> |

Table 9. Plant attack by leaf diseases – varieties compare

3.2.2 Energy

3.2.2.1 The energy content of fodder beet

The content of energy in bulb of beet has been investigated by combustion calorimetry. The method is based on a complete burning of plant material in 100% oxygen atmosphere. The burning of the sample was used parabolic calorimeter IKA C200 (company IKA, Germany). To determine the net energy (energy content of ash-free) on the dry matter of sample.

From the experimental genotypes showed a variety Jamon, Lenka and Starmon lower energy content than the average value was calculated net energy of all observed varieties, which was 16.93 kJ.g⁻¹. From Figure 1 shows that the lowest energy content showed a variety Jamon (16.54 kJ.g⁻¹) and the highest variety Lenka (16.87 kJ.g⁻¹). On the other hand, higher energy content in comparison with the average variety, should Monro (17.17 kJ.g⁻¹) and Hako (17.28 kJ.g⁻¹). The results obtained are in contradiction with the conclusions (Golley, 1961; Novák and Hnilička, 1996; Hnilička, 1999; Bláha et al., 2003; Hnilička et al., 2010). The authors note that monitored between genotypes of wheat, corn, but in general there are differences in energy content. Consistent with these findings indicates Honsová et al. (2007) that among the genotypes of fodder beet there are conclusive difference in energy content. In contrast, according Hnilička et al. (2005) and Urban et al. (2005) were surveyed between beet genotypes found conclusive difference.

Besides the variety in energy content was influenced by vintage bulb beet growing, as documented by graph 9. Based on the results of statistical analysis by Tukey HSD test was taken on a significance level $\alpha = 0.05$ alternative hypothesis statistically conclusive differences between the years of cultivation. The above analysis shows conclusively that statistically the lowest average net energy content was obtained in 2007 in comparison with other experimental years. This year, the average energy content of 16.71 kJ.g⁻¹, as documented in graph 8. On the other hand, the highest gross calorific value were measured in 2006, when the average net energy of bulb was 17.12 kJ.g⁻¹. Effect of volume on the energy content of corn is confirmed as working (Fuksa et al., 2006), beet (Urban et al., 2005; Hnilička et al., 2005) and fodder beet (Honsová et al., 2007).

| year | Energy content (kJ.g ⁻¹) | Yield of bulb (t.ha ⁻¹) | Energy yield (GJ.t ⁻¹) |
|---------|--------------------------------------|-------------------------------------|------------------------------------|
| 2005 | 16.72 ^{a, b} | 80.52 ^a | 1345.54 ^a |
| 2006 | 16.95 ^b | 89.12 ^b | 1511.83 ^b |
| 2007 | 17.12 ^{a, b} | 94.50 ^c | 1617.09 ^c |
| average | 16.93 | 88.05 | 1491.49 |

Legend: a, b, c - statistically significant difference on the border

Table 10. Plant a Statistical analysis by Tukey HSD test the impact of volume on observed characteristics.

Table 10 shows the results of statistical analysis of genotype and response to the annual energy content. From the statistical analysis at a significance level $\alpha = 0.05$ shows conclusively that the lowest energy content was found in 2007 in a variety Starmon (16.38 kJ.g⁻¹), while the highest value of net energy this year was found in a variety Hako (17.62 kJ.g⁻¹). Similarly, the lowest energy content in 2005 was set at a variety Starmon (16.47 kJ.g⁻¹) and highest for variety Hako (17.61 kJ.g⁻¹). In 2006, the interval of the measured values of net energy from 16.53 kJ.g⁻¹ (Jamon) to 17.53 kJ.g⁻¹ (Monro).

3.2.2.2 The energy yield of fodder beet

The values for the energy contained in the unit of dry matter and economic yield of the main product is possible to calculate the energy yield.

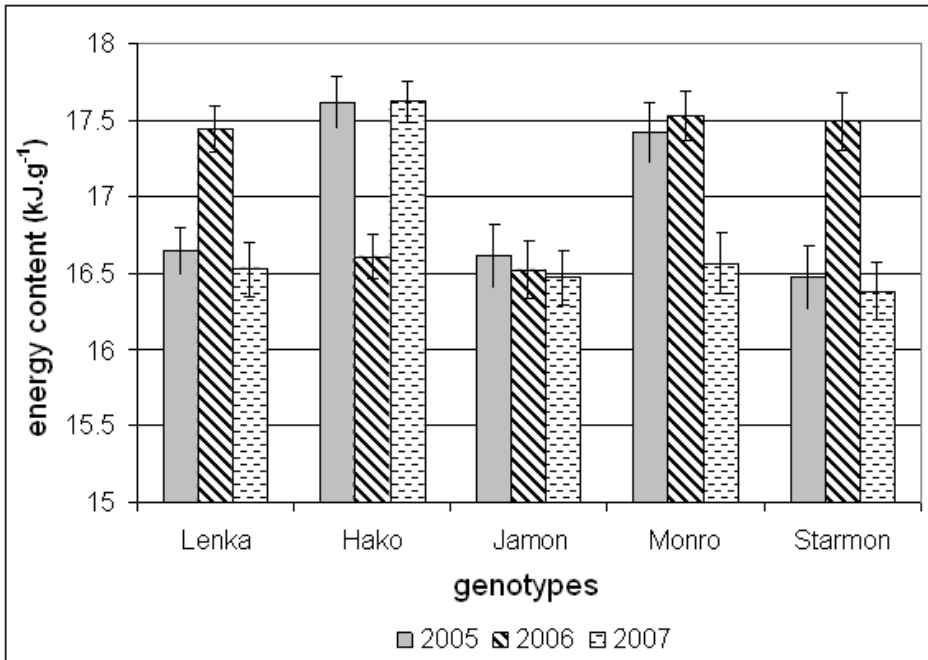


Fig. 8. The influence of genotypes and year onto energy content by bulb of beet (kJ.g⁻¹)

Based on the results of statistical analysis by Tukey HSD test was taken on a significance level $\alpha = 0.05$ alternative hypothesis statistically conclusive differences calculated values of energy yield between genotypes observed varieties, as documented in graph 4. From this graph it is clear that the observed varieties had the lowest yield variety Starmon (1354 GJ.ha⁻¹), while the highest variety Hako (1697.97 GJ.ha⁻¹).

The results of these statistical methods are also evident that the varieties Starmon, Jamon and Monro were lower than the average yield, which was within the tested varieties 1491.48 GJ.ha⁻¹. On the other hand, the variety Hako and Lenka should yield higher than average. The lower yield of varieties Starmon is due not only to low energy, but also statistically proven to yield of bulb the lowest. The Hako variety was found completely opposite trend is the highest yield of bulb and the highest content of energy-rich substances in bulb. According Hnilička et al. (2001) and Honsová et al. (2007) is the energy yield of wheat and fodder beet also influenced by genotype. This conclusion was confirmed also in the case of fodder beet.

Yield was also as its basic ingredients influenced by vintage, the statistically significant lowest average yield was calculated in 2007, which amounted to 1345.54 GJ.ha⁻¹. Conclusively highest yield of bulb was in 2006 (1617.09 GJ.ha⁻¹), see Figure 5. These differences are mainly due to the fact that in 2006 he was demonstrably the highest energy content, but the lowest yield. Low energy yield value determined in 2007 is mainly due to conclusively lowest calorific value, expressed as net energy.

According to Austin et al. (1979) is the gross energy yield of biomass to sugar beet in Great Britain around 222 GJ.ha⁻¹ and the sugar cane fields of Queensland and the Transvaal 682

GJ.ha⁻¹. Similarly, the results were not confirmed by Mohammadi et al. (2008), who observed the yield of potatoes in Iran and provides its value 20.81 GJ.ha⁻¹. Energy output was also higher than in their work shows Koga (2009). The author states that energy sugar beet production is 346.1 GJ.ha⁻¹. This difference is probably due not only to the amount of revenue the main product, but also the energy content per unit of dry matter and its conversion from gross energy to net energy. The energy yield of fodder beet is located in the interval of values for sugar beet states (Hnilička et al., 2009).

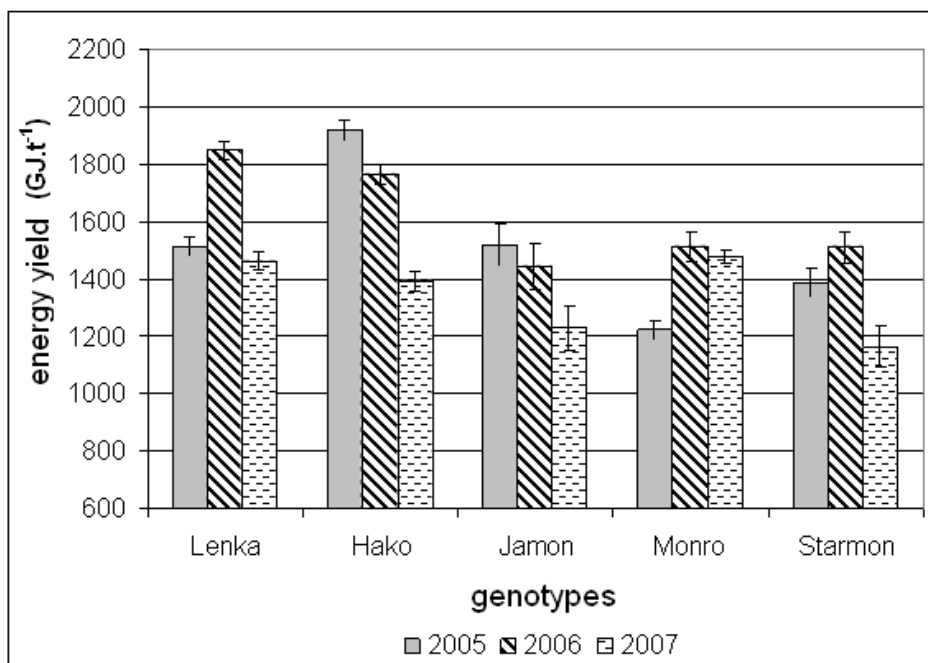


Fig. 9. The influence of genotypes and year onto energy yield by bulb of beet (GJ.t⁻¹)

Table II shows the results of statistical analysis of genotype and response to the annual energy yield. From the statistical analysis by Tukey at a significance level $\alpha = 0.05$ shows conclusively that the lowest yield was recorded in 2007 for a variety Starmon (1162.41 GJ.ha⁻¹), where also was the value of all monitored years and varieties lowest. The highest energy yield this year was found in a variety Monro (1480.05 GJ.ha⁻¹). In 2005 was set at the lowest yield varieties of Monro (1221.19 GJ.t⁻¹) and highest for variety Hako (1917.68 GJ.ha⁻¹). This value was also the maximum value. In 2006, the interval of the energy yield of bulb by fodder beet 1445.52 GJ.ha⁻¹ (Jamon) to 1849.18 GJ.ha⁻¹ (Lenka).

The levels of energy production of the main product in the range of values for vegetation such as grass state Hirata et al. (1989). Energy production of the main product of sugar beet is higher than for wheat, winter barley and rape (Przybyl, 1994) and also higher than two to eight cuts fescue by Spasov and Kornyšev (1989).

Relationship of dependent variables (yield) on the used independent variables (yield and energy content) is a multidimensional linear regression model described in 99.9%, as

evidenced by fully determinant coefficient (multipl. R^2). The calculated regression characteristics show statistical significance of all the variables (yield, energy content and an absolute member of regression equation). Given a regression model can therefore be described by the equation:

$$\text{Yield} = -1500.51 + 87.88 \cdot 17.08 + \text{energy content} \cdot \text{yield} \quad (1)$$

Based on the calculated values of energy yield, we can say that there are genotypic differences in this characteristic, because the varieties Starmon, Jamon and Monro had lower yield compared to varieties Lenka and Hako. Lower yield of bulb varieties Starmon is due not only to low energy, but also low-yield of bulb. In contrast, the Hako variety was found completely opposite trend. Organic farming methods it is possible to achieve high yield of energy from both monogerm, so at polygerm varieties.

In all three years (2005 – 2007) high yields of fodder beet roots were reached. In average of three years the most yielding cultivar was Hako (95,6 t.ha⁻¹). It confirmed that French cultivars Monro, Starmon and Jamon are very yielding and regarding quality of seed they are suitable also for modern technologies of growing. Evaluated cultivars of fodder beet are suitable also for growing in organic farming. Yields of roots were strongly influenced by year of growing and by number of plants in harvest.

To the most yielding varieties belonged variety Hako, which in 2005 and 2006 gave the highest yield of bulbs and in 2007 it was the second belong Bučanský žlutý válec. High yield in 2005 had varieties Monro, Hako and Kostelecká Barres, in 2006 Hako and Jamon and in 2007 Bučanský žlutý válec and Hako. Statistically significant differences were determined among years of growing and among varieties.

Energetic value in dry matter was detected. The differences among years of growing and varieties were detected. Energy value of fodder beet bulbs was statistically significant to the variety and year of growing. In comparison of the varieties the highest energetic value had varieties of fodder beet Starmon and Jamon. The variety of sugar beet Merak had higher energetic value of one kilogram roots than the fodder beet.

Based on calculated values of energy yield of forage beet growing in ecological technology we can state, that we can reach higher energy yield of root in both of tested cultivars. The influence of year was evidenced.

4. Conclusion

4.1 Technologies

In case of fodder beet organically growing it is possible to achieve high yields, but only with a thorough weeding throughout the vegetation. Row spacing or pitch variation in weed-free yield of roots was not much influenced.

All compared variants without weeds reached in the three-year average high yields of roots above ninety tonnes per hectare. This indicates the need for weeding during the growing period.

Weed infestation significantly reduced root yields. In average of three years provided the lowest yields income variations, where only line weeding were done. Weed infestation not only reduced yields but also decreased the weight of the tubers.

Significant influence of year was discovered. In 2005 exchange of canopy organization did not exchange plant attack by leaf diseases and bulb yield and way of weed regulation had

significant influence to plant attack by leaf diseases and bulb production. In 2006 exchange of canopy organization exchanged plant attack by leaf diseases. Bulb yield was influenced by way of weed regulation. In 2007 exchange of canopy organization did not influence to plant attack by leaf diseases but it influenced the bulb production. Higher yield were reached at the variants of narrower rows.

4.2 Varieties and energy

In all three years (2005 – 2007) high yields of fodder beet roots were reached. In average of three years the most yielding cultivar was Hako (95,6 t.ha⁻¹). It confirmed that French cultivars Monro, Starmon and Jamon are very yielding and regarding quality of seed they are suitable also for modern technologies of growing. Evaluated cultivars of fodder beet are suitable also for growing in organic farming. Yields of roots were strongly influenced by year of growing and by number of plants in harvest.

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Energetic value in dry matter was detected. The differences among years of growing and varieties were detected. Energy value of fodder beet bulbs was statistically significant to the variety and year of growing. In comparison of the varieties the highest energetic value had varieties of fodder beet Starmon and Jamon. The variety of sugar beet Merak had higher energetic value of one kilogram roots than the fodder beet.

Based on calculated values of energy yield of forage beet growing in ecological technology we can state, that we can reach higher energy yield of root in both of tested cultivars. The influence of year was evidenced.

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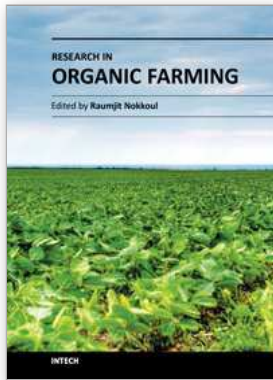
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This book has emerged as a consequence of the difficulties we experienced in finding information when we first started researching. The goal was to produce a book where as many existing studies as possible could be presented in a single volume, making it easy for the reader to compare methods, results and conclusions. As a result, studies from countries such as Thailand, Spain, Sweden, Lithuania, Czech, Mexico, etc. have been brought together as individual chapters, and references to studies from other countries have been included in the overview chapters where possible. We believe that this opportunity to compare results from different countries will open a new perspective on the subject, allowing the typical characteristics of Organic Agriculture and Organic Food to be seen more clearly. Finally, we would like to thank the contributing authors and the staff at InTech for their efforts and cooperation during the course of publication. I sincerely hope that this book will help researchers and students all over the world to reach new results in the field of Organic Agriculture and Organic Food.

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