Lina Marija Butkevičienė

SKIRTINGU LAIKU SĒTŲ ŽIEMININIŲ RAPSŲ IR JŲ HIBRIDŲ VYSTYMOSE IR DERĖJIMO DĖSNINGUMAI

Daktaro disertacijos santrauka

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**Mokslinis vadovas**

Prof. habil. dr. Rimantas Velička (Aleksandro Stulginskio universitetas, žemės ūkio mokslai, agronomija – 01 A).

**Konsultantai:**

Doc. dr. Rita Pupalienė (Aleksandro Stulginskio universitetas, žemės ūkio mokslai, agronomija – 01 A);
Doc. dr. Marija Rimkevičienė (Aleksandro Stulginskio universitetas, žemės ūkio mokslai, agronomija – 01 A).

**Disertacija ginama Aleksandro Stulginskio universitete Agronomijos mokslo krypties taryboje:**

**Pirmininkas:**

Prof. habil. dr. Zenonas Dabkevičius (Lietuvos agrarinių ir miškų mokslų centras, žemės ūkio mokslai, agronomija 01 A).

**Nariai:**

Prof. dr. Natalija Burbulis (Aleksandro Stulginskio universitetas, žemės ūkio mokslai, agronomija 01 A);
Doc. dr. Steponas Raudonius (Aleksandro Stulginskio universitetas, žemės ūkio mokslai, agronomija 01 A);
Habil. dr. Juozas Benediktas Staniulis (Gamtos tyrimų centro Botanikos institutas, biomedicinos mokslai, biologija 01 B);
Prof. dr. Ingrida Šaulienė (Šiaulių universitetas, biomedicinos mokslai, ekologija ir aplinkotyra 03 B).

**Oponentai:**

Doc. dr. Aušra Blinstrubienė (Aleksandro Stulginskio universitetas, žemės ūkio mokslai, agronomija 01 A);
Prof. habil. dr. Vida Stravinskienė (Vytauto Didžiojo universitetas, biomedicinos mokslai, ekologija ir aplinkotyra 03 B).


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INTRODUCTION

Relevance of the subject. Oilseed rape (*Brassica napus* L.) is the primary raw material for vegetable oil production in the temperate climate zone and is the second most important oil crop in the world (Kumar et al., 2007; Butkute et al., 2006). With changing climate, oilseed rape is spreading further into Northern and Eastern Europe and at the same time remains a widely-distributed crop plant in Southern and Western Europe; however, its production area is starting to decline in South-Western Europe (Tuck et al., 2006; Peltonen-Sainio et al., 2009). Oilseed rape is grown worldwide in a wide range of climate environments, including even extreme conditions: it exhibits tolerance of low temperatures and small variations of precipitation amount (Diepenbrock, Grosse, 1995). This has been largely determined by the increasing demand for vegetable oil used in food industry as well as its application for meeting industrial needs. Due to the phytosanitary characteristics and weed suppressive ability, oilseed rape is valued as a perfect preceding crop, enhancing the productivity of the crop rotation (Velička ir kt., 2006).

The global climate has been warming recently, and a significant rise in average temperature has caused noticeable shifts in the dates of plant phenophases and has resulted in the lengthening of the crop growing season (Ahas et al., 2002; Walther, 2003). Agricultural production is one of the economic activities most vulnerable to hydrometeorological phenomena. In recent years, due to the global warming, the events of hydrometeorological phenomena adverse to agriculture have become increasingly more common as well as their increasing negative effects, especially obvious in crop production. Climate changes in Lithuania manifest themselves by increasing temperature variations in summer and winter and by decreasing amount of precipitation during the crop growing season. These factors are predominantly responsible for crop growth inhibition and yield reduction (Bukantis ir kt., 2008; Galvonaitė, Valiukas 2008; Rimkus, Bukantis, 2008). Plant growth and development significantly depend on the environmental factors, of which drought and extreme temperatures are one of the most common ones limiting crop productivity (Chaves et al., 2003; 2004; Flexas et al., 2004). Adverse environmental factors disturb physiological processes of plants. The effect of stress on plants depends on its duration, severity and genetic characteristics of plants (Alexieva et al., 2003; Hekneby, 2004). In the course of evolution, plants have adapted to survive in extreme conditions, which points to a really high plant adaptive capacity that has still been underused by agricultural plants.

Competitive ability and industrial value of important and promising agricultural crops in Lithuania are limited by their insufficient adaptive capacity – winter hardiness and cold tolerance. This problem has become especially acute in the context of climate change, contrasting and changeable wintering conditions, as plant species and varieties native to the countries with milder climates are being extensively introduced into Lithuania. Cold resistance is a complex trait, which is determined not only by individual genes but also by their interaction - structural relationships among many plant systems (Chinnusamy et al., 2007). Most researchers agree that the future agricultural production will have to consider climate changes and newly emerging extreme weather events (Rosenzweig et al. 2001; Tubiello et al., 2007).

When oilseed rape is grown according to intensive cultivation technology, one of the key problems is unstable winter oilseed rape wintering (over winter survival) which largely relies on plant development in the autumn, varietal characteristics, crop and soil management practices and meteorological factors (Velička, 2000). Its winter hardiness is weakened by temperature variations during the winter period: low positive temperatures
promote resumption of vegetation, and after sub-zero temperatures return, oilseed rape plants lose the capacity to re-harden. In winter, during the periods of recurring resumption of vegetation, changes occur in the amounts of biochemical compounds in plant tissues, which are critical for plant resistance to low temperatures (McClinchey, Kott, 2008; Novickienė et al., 2010).

Due to the abundance of varieties and their capacity to adapt to even considerably variable growing conditions, oilseed rape can be grown in a wide range of agroclimatic conditions (Bernotas, 2003). However, recently farmers have been opting to sow foreign winter oilseed rape varieties, which are characterised by high productivity but relatively insufficient winter hardiness.

Frequent temperature variations in winter cause reductions in winter rape productivity or even plant kill. Lithuania’s soil and climate conditions are suitable for producing high and stable winter rape seed yields; however, its productivity potential has still been underexploited and rape seed yield produced in Lithuania does not meet the growing demands of local and foreign markets.

**Hypothesis.** Over winter survival, nutrient accumulation in separate morphological plant parts and organogenesis of winter rape are influenced by the meteorological conditions, sowing time and varietal characteristics. In the autumn, in the course of winter rape vegetation or after resumption of vegetation, triggered by mild wintering periods, assimilating processes take place in plants, and the nature of these processes in the rosette and roots of conventional winter rape and its hybrids differs. With autumn-winter weather becoming warmer, winter rape, especially its hybrids, can be sown later than has been recommended so far, since they are able to accumulate a sufficient amount of nutrients and to properly prepare for wintering. Higher productivity of winter rape hybrids is determined not only by the peculiarities of their wintering but also by the structure of their yield elements.

**Experimental objective.** The study was aimed to establish the developmental regularities of winter rape and its hybrids under the conditions of autumn-winter period becoming warmer and variable in length, to estimate the peculiarities of their biopotential formation and to optimize the measures of adaptation to changeable climate conditions.

**Research tasks.** To achieve the experimental objective, the following tasks were set:

1. To assess the crop condition and composition of winter rape and its hybrids sown at different dates and to establish biometrical parameters of the crops ready for wintering.
2. To estimate the changes occurring during the autumn-winter period in the biometrical indicators of rosette of winter rape and its hybrids, sown at different dates.
3. To study the dynamics of carbohydrate synthesis and nutrient accumulation in separate morphological parts of winter rape during the autumn-winter period.
4. To determine photosynthetic indicators (net photosynthetic productivity, leaf area, chlorophyll content) in winter rape and its hybrids.
5. To assess over winter survival of winter rape.
6. At seed maturity stage, to estimate structural elements of yield, seed productivity and quality of winter rape and its hybrids, sown at different dates.

**Research novelty.** Differences and regularities of development and growth of different types of winter rape varieties (conventional and hybrid) during the autumn-winter period of variable length were established. On the basis of the established regularities, the factors which underlie the superiority of hybrid rape plants over conventional ones were
specified. Conventional winter rape, especially when sown at later dates, exhibits slower autumn growth and development, and during warm (mild) wintering periods tend to more intensively utilize nutrients, compared to hybrids.

**Theoretical and practical value of the results obtained.** The research results enable improvement of oilseed rape cultivation technology and establishment of optimal sowing time of conventional and hybrid varieties under changing climate conditions and provide prerequisites for winter rape productivity and competitiveness enhancement.

**Statements to be defended:**
1. Winter rape development until the end of autumn vegetation depends on sowing date and plant genotype.
2. The changes in nutrients in the rosette of winter rape and its hybrids plants occurring after resumption of vegetation during the wintering period differ and depend not only on the genotype and sowing date but also on the year’s weather conditions.
3. Different sowing time influences over winter survival of winter rape and its hybrids plants. Rape hybrids respond less sensitively to the delay in sowing date.
4. Sowing time exerts a greater effect on the seed yield of winter rape compared with winter rape hybrids.

**Approval and publication of the dissertation work.** The research results have been presented at: an international scientific conference „Climate change: agro- and forest systems sustainability“ (Babtai, Kaunas, 2011); scientific conference „Šiuolaikinių žemdirbystės sistemų aktualijos“ („Topicalities of the contemporary cropping systems“ devoted to commemorating prof. A. Stancevičius 90th birth anniversary (LUA, 2010); scientific conference „Aliejinių bastutinių šeimos augalų produktyvumo formavimas ir valdymas“ („Productivity formation and management of Brassicaceae family plants“) (LUA, 2009); international scientific conference „Rapsproduktion und verarbeitung: stand und mögliche perspektiven“: 5. Litauisch – Deutscher ölsaatentag“ (LUA, Akademija, Kaunas, 2009); scientific-practical conference „Žemdirbio vasara 2009“ („Farmer’s Summer 2009”) (Akademija, Kaunas, 2009); scientific conference „Jaunimas siekia pažangos 2009“ („Youth seeks progress 2009“) (LUA, Kaunas, 2009). The main results were presented in 9 scientific publications, where 2 are included in ISI WOS database in the journals with the citation index, 2 articles in the journals approved by the Lithuanian scientific publication list of the Department of Sciences and Higher Education, 5 articles in conference proceedings.

**Content and volume of the dissertation.** The dissertation is written in Lithuanian. It consists of the following sections: an introduction, literature review, conditions and methods, experimental results, conclusions, list of publications on the dissertation topic, list of the referentes. It comprises 115 pages, including 34 tables and 24 figures and a list of referentes with 129 items.
EXPERIMENTAL CONDITIONS AND METHODS

Experimental materials. Three different type winter rape (Brassica napus L. spp. oleifera biennis Metzg.) varieties: ‘Valesca’, ‘Sunday’ and ‘Kronos’ (hybrid) sown at different dates.

Experimental site.
Field experiments were carried out in 2007–2010 at the Experimental Station of Aleksandras Stulginskis University. The soil of the experimental site – limnoglacial silty loam on moraine clay loam Hapli-Epithypogleyic Luvisol.
Soil arable layer 23–27 cm. Water regime adjusted by closed drainage, micro relief leveled. Soil pH 6.5–7.2, total nitrogen 1.47–1.59 percent, humus 2.2–3.0 percent, available phosphorus 173–235 mg kg\(^{-1}\), available potassium 115–189 mg kg\(^{-1}\), available sulfur 5.6–26.4 mg kg\(^{-1}\) soil.

Experimental design.
2007–2008. The experiment involved one-factor experimental design and was conducted in four replications. Winter oilseed rape was sown in four terms and grown variety ‘Valesca’.
Factor A – sowing date: 1) August 10; 2) August 20; 3) August 30; 4) September 10.
2008–2009. The experiment involved two-factor experimental design and was conducted in four replications. Winter oilseed rape was sown in four terms and grown two varieties: ‘Sunday’ and ‘Kronos’ (hybrid).
Factor A – sowing date: 1) August 10; 2) August 20; 3) August 30; 4) September 10
Factor B – winter rape variety: ‘Sunday’ and ‘Kronos’ (hybrid).
2009–2010. The experiment involved two-factor experimental design and was conducted in four replications. Winter oilseed rape was sown in six terms and grown two varieties: ‘Sunday’ and ‘Kronos’ (hybrid).
Factor A – sowing date: 1) August 10; 2) August 20; 3) August 30; 4) September 5; 5) September 10; 5) September 15.
Factor B – winter rape varieties: ‘Sunday’ and ‘Kronos’ (hybrid).

Experimental methods.
1. Soil agrochemical properties. Soil agrochemical properties were determined before the experiment establishment. Soil samples collected from each replication from the 0–25 cm soil layer with soil auger. Agrochemical analysis performed by infrared analytical system PSCO/ISI IBM-PC 4250 according to calibrations assessed from the data bank (Rimkevičienė, 2000). Soil unit established according to the new Lithuanian soil classification (LTDK-99), consistent with the FAO UNESCO World soil map legend (Lietuvos dirvožemiai, 2001).
2. Evaluation of winter rape crop density before and after over-wintering. Rape density was assessed by calculating the plants at each replication in four places in 1 m\(^2\) in the autumn and spring.
3. Rape photosynthetic parameters (assimilation leaf area, net photosynthetic productivity, chlorophyll content).
Plant assimilating leaf area estimated during the autumn and spring periods (when temperatures for three successive days were \(\leq +2^\circ C\) in autumn and \(\geq +2^\circ C\) in spring. Samples of 10 plants were taken from each experimental plot their leaves scanned and area calculated using computer program ROOTEDGE (1998).
The net photosynthetic productivity was calculated using the formula (Bluzmanas et al., 1991):
\[ F_{pr} = M_2 - M_1 / L_0 + L_1 + T, \]

here: \( F_{pr} \) – net photosynthetic productivity, g m\(^{-2}\) day\(^{-1}\); 
\( M_2 - M_1 \) – dry weight increase per period, g; 
\( L_0 + L_1 \) – leaf surface area at the initiation and end of period, m\(^2\); 
\( T \) – period, days.

Photosynthetic pigments chlorophyll \( a \) and \( b \) in green leaves determined spectrophotometrically in 100 percent acetone extract by Wetshtein method with spectrophotometer ‘Genesys 6’ (ThermoSpectronic, USA) (Гавриленко и др., 2003).

4. **Rape biometric parameters** (leaf number, root collar diameter, apical bud height, etc.) evaluation. Winter rape biometric measurements were performed in autumn-winter period during resumed vegetation, every time after the temperature dropped to +2 °C for three successive days and in spring after the temperature increased up to +2 °C for three successive days. In different locations of each plot 10 plants were randomly selected for biometric measurements: the average aboveground part mass, root collar diameter, apical bud height, leaf number, root length and weight.

5. **Dynamics of carbohydrate synthesis and nutrient accumulation in different morphological parts of the rape in autumn-winter period.** After the temperature has dropped to +2 °C for three successive days from each plot we re randomly selected 10 plants for chemical composition analysis. The content of dry matter estimated in separate morphological plant parts: leaves, apical buds and roots drying at +105 °C. Total sugar and monosaccharide content estimated by Bertran method, total nitrogen – by Kjeldahl method, K, S – with infrared spectrometer PSCO / ISI IBM-PC 4250 according to the calibrated data set obtained by the chemical reference methods (Rimkevičienė, 2000).

6. **Rape biometric parameters, yield structure elements and seed yield evaluation.** After winter oilseed rape full maturity from each plot were randomly selected 20 plants for biometric parameters evaluation: the number of terminal and lateral branches, the number of siliques of apical inflorescence and lateral branches, the number of seeds per siliques and 1000 seed weight.

7. **Seed yield and quality evaluation.** Seed quality (crude proteins, crude fat, glucosinolates and erucic acid) evaluated with infrared spectrometer PSCO / ISI IBM-PC 4250 according to calibrated data set (Rimkevičienė, 2000).

8. **Research data statistical analysis.** Statistical significance of differences between treatments was evaluated using Fisher’s criterion and protected least significant difference test at \( P_{(level)} < 0.05 \) (program ANOVA). Relationships between indices evaluated by correlation-regression analyse using program STATENG (Tarakanovas, 2003).

**ANALYSES OF EXPERIMENTAL RESULTS AND DISCUSSION**

**Sowing date and variety effects on winter rape preparation for overwintering**

Winter rape crop state and biometrical indicators of the rosette. Not only meteorological conditions during the hardening period but also crop stand density and evenness parameters are major factors affecting agricultural crops’ overwintering. The stand density counts showed the number of winter rape plants per unit area in the autumn, before wintering to be more dependent on the meteorological conditions, especially moisture regime, than on sowing date. In 2007, the dry beginning of August inhibited emergence of winter rape sown at an early date; however, in the autumn at the end of vegetation, sowing date did not have any significant effect on the crop stand density. In 2008, two winter rape
varieties, a variety 'Sunday' and a hybrid variety 'Kronos' were cultivated and the autumn of this year was conducive to their emergence, growth and development. The plants of both varieties sown at the earliest date (August 10) emerged very quickly – within 3–4 days, however, the crop stand density of the earliest-sown winter rape was significantly lower than that of the crop sown on August 20 and September 10. This is related to relatively uneven seed emergence and competition between plants. Earlier-emerged, stronger plants tend to choke the ones that emerge later and are often gradually killed off. Variety did not have any significant effect on winter rape emergence. A significant varietal impact on crop stand density at the end of the growing season was established only in 2009. Rape seed sowing was impeded by excessive amount of rainfall, and significantly higher (by on average 35.7%) germinating power was exhibited by the hybrid variety.

In our research, it was found that sowing date had a significant influence on winter rape development (biometrical parameters) in the autumn. The plants sown on August 10 and 20 overgrew, their apical buds elongated too much, while the ones sown on August 30 and September 5, had a sufficient number of leaves, adequate apical bud height, root neck thickness, and root mass and length (Table 1). Plants’ resistance to low temperatures depends on their development stage in the autumn; however, the cold tolerance differs within a plant. Roots are the most cold tolerant and best protected against adverse factors, while the least cold tolerance is demonstrated by leaves and apical bud. Well-developed and deeply penetrated roots, even after cold-damage in winter, tend to better regenerate in spring compared with those distributed within the soil surface layer.

### Table 1. The biometric parameters of winter rape sown at different date before wintering, 2009

<table>
<thead>
<tr>
<th>The biometric parameters of winter rape</th>
<th>Variety (factor B)</th>
<th>Sowing date (factor A)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10 08</td>
</tr>
<tr>
<td>Winter rape rosette weight g</td>
<td>‘Sunday’</td>
<td>90.5a*</td>
</tr>
<tr>
<td></td>
<td>‘Kronos’</td>
<td>104.7a*</td>
</tr>
<tr>
<td>Number of leaves per plant units</td>
<td>‘Sunday’</td>
<td>8.1a*</td>
</tr>
<tr>
<td></td>
<td>‘Kronos’</td>
<td>9.8a*</td>
</tr>
<tr>
<td>Height of apical bud cm</td>
<td>‘Sunday’</td>
<td>6.5a*</td>
</tr>
<tr>
<td></td>
<td>‘Kronos’</td>
<td>7.7a*</td>
</tr>
<tr>
<td>Diameter of root collar mm</td>
<td>‘Sunday’</td>
<td>12.3a</td>
</tr>
<tr>
<td></td>
<td>‘Kronos’</td>
<td>12.3a</td>
</tr>
<tr>
<td>Root length cm</td>
<td>‘Sunday’</td>
<td>13.8a*</td>
</tr>
<tr>
<td></td>
<td>‘Kronos’</td>
<td>12.3a*</td>
</tr>
<tr>
<td>Root mass g</td>
<td>‘Sunday’</td>
<td>7.3a*</td>
</tr>
<tr>
<td></td>
<td>‘Kronos’</td>
<td>8.9a*</td>
</tr>
</tbody>
</table>

Note: means marked with different letters (a, b, c…; factor A – sowing date) and asterisk (*, factor B – variety) are significantly different (P<0.05).

In our study, in 2008, the early sown (August 10, 20) ‘Sunday’ grew more vigorously until the end of autumn vegetation, which was proved by a higher above-ground plant mass, higher number of leaves and a greater height of apical bud. However, winter rape hybrids exhibited thicker root collar, greater root length and mass. The next year, (2009) rape hybrids were noted for higher growth rate, and there were found significant differences in the values of biometrical indicators of the rosette for the crops sown in August.

The length of the growing season and the sum of active temperatures were the factors that determined winter rape development level in the autumn. The correlation-regression
analysis of data revealed strong and very strong linear relationships between the sum of plant-accumulated temperatures above +2 °C before overwintering and biometrical parameters of the rosette \( r = 0.85 - 0.99; P < 0.01 \).

**Dry matter.** The research findings from the three experimental years suggest that the highest content of dry matter (DM) at the end of autumn vegetation was accumulated by rape plants in the apical bud and roots (Table 2). With a delay in sowing date, the DM contents in morphological plant parts tended to decline for all rape varieties tested. Varietal effect on DM content in leaves was noted only in 2009 for the plants sown in September: of the crops sown on September 5, hybrid variety 'Kronos' had a higher DM content in leaves, while of those sown 5 and 10 days later, it was 'Sunday', which exhibited higher DM content in leaves. Both in 2008 and 2009, a higher DM content in apical bud was accumulated by 'Kronos', while 'Sunday' accumulated higher DM content in roots; however, the differences obtained were not always significant. As was shown by the correlation-regression analysis, the DM content in morphological plant parts at the end of vegetation was directly influenced by the sowing date. The decreasing sum of positive temperatures above +2 °C and number of sunny hours exerted a negative effect on the plants sown at later dates. They tended to accumulate lower DM contents than those sown at earlier dates because they tried to utilise each degree of positive temperature for biomass increasing.

**Table 2.** The content of dry matter in morphological plant parts at the end of autumn vegetation, 2008–2009

<table>
<thead>
<tr>
<th>Sowing date (factor A)</th>
<th>Dry matter %</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>leaf</td>
<td>apical bud</td>
<td>root</td>
</tr>
<tr>
<td>'Sunday'</td>
<td>'Kronos'</td>
<td>'Sunday'</td>
<td>'Kronos'</td>
</tr>
<tr>
<td>10 08</td>
<td>16.48a</td>
<td>16.33a</td>
<td>18.98a</td>
</tr>
<tr>
<td>20 08</td>
<td>14.88b</td>
<td>15.23b</td>
<td>18.40ab</td>
</tr>
<tr>
<td>30 08</td>
<td>15.00b</td>
<td>15.73b</td>
<td>16.63b*</td>
</tr>
<tr>
<td>10 09</td>
<td>12.95c</td>
<td>13.38c</td>
<td>16.43b*</td>
</tr>
</tbody>
</table>

Note: means marked with different letters (a, b, c...; factor A – sowing date) and asterisk (*, factor B – variety) are significantly different (P<0.05).

**Total sugar and monosaccharides.** During the experimental years, at the end of vegetation in the autumn, winter rape plants accumulated the highest concentrations of total sugar in apical bud and roots, while the highest concentrations of monosaccharides were accumulated in leaves (Table 3). This describes the course of assimilation taking place in the rosette before wintering. This indicates that initial assimilation was still occurring in leaves, where cell cytoplasm and chloroplast monosaccharides are synthesised into sucrose, major carbohydrate transported into apoplast. With a delay in sowing date, the total sugar content declined in the morphological plant parts for all winter rape varieties tested. Moreover, with a delay in sowing date, their assimilation slowed down for all varieties tested. Both in 2008
and 2009, sowing date did not have any significant effect on monosaccharides synthesis in the leaves of ‘Sunday’ and ‘Kronos’ and in the roots of ‘Sunday’ (except for the sowing date August 15, 2009). The variety impacted both the assimilation of total sugar and monosaccharides; however, the established differences were not always significant. Higher concentrations of these carbohydrates were accumulated by the hybrid variety ‘Kronos’.

Table 3. The effect of sowing date and variety on the total sugar content in morphological plant parts, 2008–2009

<table>
<thead>
<tr>
<th>Sowing date (factor A)</th>
<th>Total sugar %</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>leaf</td>
<td>apical bud</td>
<td>root</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Sunday’ (factor B)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 08</td>
<td>6.0b*</td>
<td>7.4a*</td>
<td>13.2a</td>
<td>15.2a</td>
<td>9.7a*</td>
<td>12.6ab*</td>
</tr>
<tr>
<td>20 08</td>
<td>6.4a*</td>
<td>7.6a*</td>
<td>11.7a</td>
<td>11.4b</td>
<td>8.3ab*</td>
<td>12.9a*</td>
</tr>
<tr>
<td>30 08</td>
<td>4.7b*</td>
<td>5.8b*</td>
<td>11.6a*</td>
<td>7.6c*</td>
<td>7.2bc*</td>
<td>11.2bc*</td>
</tr>
<tr>
<td>10 09</td>
<td>4.7b</td>
<td>5.7b</td>
<td>6.0b</td>
<td>7.4c</td>
<td>7.0c*</td>
<td>10.6c*</td>
</tr>
</tbody>
</table>

2008

2009

Statistically significant correlations were established between dry matter content and the length of period until the end of vegetation \( r = 0.63 – 0.92; P<0.05 \), the sum of positive temperatures above +2 °C \( r = 0.63 – 0.96; P<0.05 \) and duration of solar radiation \( r = 0.61 – 0.95; P<0.05 \); total sugar content and the sum of positive temperatures above +2 °C \( r = 0.63 – 0.95; P<0.05 \) and duration of solar radiation \( r = 0.61 – 0.94; P<0.05 \) during the preparation for wintering period.

Photosynthetic indicators of winter rape. The study done in 2008–2009 evidenced that the net photosynthetic productivity (NPP) was significantly influenced by both sowing date and variety. Plant growth and development are affected by both high and low positive temperatures. Our experiment was conducted at the end of autumn vegetation, when low positive temperature prevailed and day length was becoming shorter. At this time of the year there is no risk that due to the intensity of respiration, plant energy resources will be lost. However, a delay in sowing date, declining daily air temperature and reducing number of sunny hours had a negative effect on the NPP. With a delay in sowing date, the NPP significantly decreased for both varieties tested ‘Sunday’ and ‘Kronos’ (Fig. 1). In 2008, a significant varietal effect was established only for the winter rape sown on the first sowing date (August 10). For ‘Kronos’ variety, the NPP was by 21.0% higher than that for ‘Sunday’. When delaying the sowing date, the variety did not have any significant effect. In 2009, a significant varietal effect was established for the crops sown on August 10 and on all dates of September: the NPP established for ‘Kronos’ was by on average 1.4 times higher than that established for ‘Sunday’.
Fig. 1. The effect of sowing date and variety on the net photosynthetic productivity at the end of autumn vegetation, 2009
Note: means marked with different letters (a, b, c...; factor A – sowing date) and asterisk (*, factor B – variety) are significantly different (P<0.05).

Sowing date and that year’s weather conditions had a greater significant effect on assimilating leaf area compared with the varietal effects. With a delay in sowing date, leaf area declined more for ‘Sunday’ than for ‘Kronos’; however, a significant varietal effect was determined only in 2009 for the crops sown on August 20, August 30 and September 5: the assimilating leaf area for rape hybrids was on average 1.6 times larger compared with that of conventional variety ‘Sunday’ (Fig. 2).

Fig. 2 The effect of sowing date and variety on the assimilating leaf area at the end of autumn vegetation, 2009
Note: means marked with different letters (a, b, c...; factor A – sowing date) and asterisk (*, factor B – variety) are significantly different (P<0.05).

Adverse growing conditions cause a reduction in chlorophyll concentration and a change in chlorophyll a to b ratio. Higher temperatures are indispensable for effective photosynthesis, growth and development; however, higher-than-optimal temperature exerts a negative effect on the accumulation of photosynthetic pigments. In our experiments, winter rape development occurred in the conditions of day length shortening (with reducing
number of sunny days and declining air temperature). Both in 2008 and 2009, with a delay in sowing date, the content of photosynthetic pigments in winter rape leaves declined. In 2009, a delay in sowing date resulted in an increase in chlorophyll a to b ratio and significant differences were obtained. A significant varietal effect on chlorophyll a content was established only for the crops sown on August 10 and 20. Higher contents of pigments were identified in the leaves of 'Kronos'. No significant varietal effect on chlorophyll b content was established. Higher (more favourable for photosynthesis) ratio of these pigments was also established in the leaves of hybrid rape plants. Winter rape photosynthetic indicators (net photosynthetic productivity NPP, assimilating leaf area, content of photosynthetic pigments) at the end of autumn vegetation was directly dependent on the amount of precipitation (r = 0.44 – 0.84; P<0.05) and duration of solar radiation (r = 0.51 – 0.86; P<0.05) and the sum of positive temperatures above +2 °C until the end of vegetation (r = 0.44 – 0.88; P<0.05).

Changes in the biometrical and biochemical indicators occurring during plant wintering period in the rosette of winter rape, sown at different dates

Changes in the biometrical indicators of the rosette. When resumption of vegetation occurs during the overwintering period, the plants sown at early sowing dates shed part of leaves, while the ones sown at later dates try to produce rosettes adequate for good over winter survival. During this period, the mass of rosettes of plants sown on the first sowing date (August 10) reduced in all experimental years and for all varieties tested. The mass of rosettes of plants sown on August 20 and August 30 tended to increase; however, not for all varieties tested and not in all experimental years: ‘Valesca’ and ‘Sunday’ exhibited a trend towards increasing, while the rosette mass of ‘Kronos’ hybrids tended to decline, except for the treatments sown on August 30. This suggests that an increase in rosette mass during the resumption of vegetation was influenced not only by the year’s weather conditions but also by the variety. When sown on the latest dates (in September), the mass of rosettes tended to increase for all the three varieties tested.

After the first resumption of vegetation during overwintering, the number of leaves for ‘Valesca’ decreased irrespective of the sowing date. A more intensive growth of leaves for all sowing dates of ‘Valesca’ was noted only after the third resumption of vegetation in February. The leaves of ‘Sunday’ plants intensively grew in response to warmer temperatures – the variety both shed and produced more leaves. In 2009, the changes were especially distinct for the variety ‘Sunday’, sown in August. During the period of resumed vegetation, the number of leaves for this variety increased by on average 35.5 %. The number of leaves for ‘Kronos’ hybrids sown on August 10 and 30 increased by only 7.0 %, and for those sown on August 20, the number of leaves declined by 11.4 % (Fig. 3). Smaller changes in the number of leaves during this period occurred in the crops of ‘Kronos’. For winter rape sown in September, the variety did not have any significant effect; however, more intensive growth of leaves (16.4 %) was exhibited by ‘Sunday’ compared with ‘Kronos’ (11.8 %).
Fig. 3. Changes of rosette mass and leaf number of winter rape sown at different date during the resumption of vegetation in the cold period, 2009

Note: means marked with different letters (a, b, c...; factor A – sowing date) and asterisk (*, factor B – variety) are significantly different (P<0.05).

The warmer temperatures occurring during rape overwintering period in all experimental years revealed the same trend – growth of apical buds and increase in root neck diameter. The apical buds of 'Valesca' plants during the first two resumptions of vegetation varied insignificantly, their more marked growth was determined for early sown crops (August 10 and 20) and only after the third resumption of vegetation. An increase in root neck thickness occurred during each resumption of vegetation. At the end of autumn vegetation, the values of these parameters were higher for 'Kronos' variety; however, after resumption of vegetation 'Sunday' plants exhibited more intensive growth. In 2008, the values of these parameters varied in a similar way for both varieties: for 'Sunday' the apical bud and root neck increased by on average 7.8 %, for 'Kronos' the apical bud increased by 10.9 % and root neck by 4.0 %. In 2009, the superiority of 'Kronos' hybrids stood out: for 'Sunday' the height of apical bud increased by as much as 65.6 %, root neck diameter by 13.0 %, for 'Kronos' by 12.3 % and 7.8 % (Fig. 4). This was influenced by the period of resumption of vegetation, which was the warmest of all the three experimental years. As a result, it can be maintained that 'Kronos' hybrids exhibit a lesser response to resumption of vegetation during the cold period and do not dissipate nutrients for increasing of rosette biomass as is the case for 'Sunday' plants.
Fig. 4. Changes of height of apical bud and root collar diameter of winter rape sown at different date during the resumption of vegetation in the cold period, 2009
Note: means marked with different letters (a, b, c...; factor A – sowing date) and asterisk (*, factor B – variety) are significantly different (P<0.05).

Changes in the biochemical parameters. In all experimental years, dry matter content in the morphological parts of rape plants during resumption of vegetation in the cold period of the year varied differently and depended on the specific period’s weather conditions. During the regeneration period in winter, the growth of rape plants is resumed, and the research results show that winter rape is resistant to the cold-induced stress. In the first experimental year, the dry matter content in the morphological parts of 'Valesca' plants tended to decrease towards the end of winter, except for the leaves of plants sown at later dates (from August 30 to September 10) in which dry matter content increased. In the following year, after the regeneration period the plants tried to accumulate as much as possible dry matter in their morphological parts; dry matter decreased only in the roots of young plants (sown on August 30 and September 10). Such findings evidence that in winter when positive temperatures prevail, optimal conditions are created for plants, and younger plants that still have not achieved the stage of development characteristic of the end of autumn vegetation, regenerate more rapidly, do not accumulate dry matter but increase their biomass. During the last experimental year (2009–2010), after resumption of vegetation a greater reduction in dry matter was noted in 'Sunday' leaves, apical bud and roots (Fig. 5). The plants of 'Kronos' demonstrated a different response to a rise in winter temperature: they accumulated dry matter in apical bud and roots, a reduction was observed only in leaves. Not only different species but also varieties differ in their resistance to adverse conditions. In our experiment, dry matter was more intensively accumulated by 'Kronos'.
Our experimental evidence suggests that in response to temperature rise in winter, the plants of the hybrid variety 'Kronos' were not as fast to dissipate dry matter and still tried to accumulate it. The response of ‘Sunday’ was just the opposite: the plants started growing, at the same time utilising nutrients as if it was the beginning of spring vegetation and weakening their immunity during overwintering.

**Fig. 5.** Changes of dry matter content in the morphological parts of rape plants during resumption of vegetation in the cold period, 2009

Note: means marked with different letters (a, b, c...; factor A – sowing date) and asterisk (*, factor B – variety) are significantly different (P<0.05).

With temperatures going down, physiological processes in plants slow down, and at the end of autumn vegetation they reach the critical level. However, a rise in temperature to above zero triggers regeneration in plants. Intensive physiological processes take place – not only accumulation of nutrients and dry matter in vital organs but also their utilization.
Higher contents of dissolved saccharides reduce freezing temperature of cell fluid and increase their tolerance of negative temperature. In our study, the total sugar content in the leaves of all winter rape varieties tested decreased after resumption of vegetation during the overwintering period, while in ‘Valesca’ leaves an increase was noted after the third resumption of vegetation in February. A reduction occurred in the total sugar in apical bud, except for plants of ‘Kronos’ variety in 2008 sown on August 30 and in 2009 sown on August 20, where 5.2 % and 15.5 % increases were observed. For ‘Valesca’, the total sugar content in apical bud increased during the first two resumptions of vegetation, while during the third one it declined. In the roots of ‘Valesca’ plants, the total sugar declined only during the first resumption of vegetation, later it increased. In the roots of ‘Sunday’ plants, the total sugar content increased, except for the ones sown in 2009 on September 10 and 5 in which it declined. In ‘Kronos’ roots, in 2008 the total sugar content after resumption of vegetation reduced, except for the August 30 sowing date, and in 2009 it increased, except for the latest sowing date. In 2008–2009, with a delay in sowing date, the content of monosaccharides tended to decline only in the leaves of both varieties (‘Sunday’ and ‘Kronos’). In the apical bud and roots, monosaccharides content varied differently in response to temperature rise. In 2008, for both varieties, for sowing date I and II, monosaccharides content in apical bud declined, while for August 30 and September 10, an increase was noted. During this period, monosaccharides content hardly changed. In 2009, monosaccharides content in ‘Sunday’ apical buds of plants sown at early dates in August, declined; while in those sown in September an increase was determined. For ‘Kronos’ higher monosaccharides contents were established and they changed after resumption of vegetation irrespective of the sowing date. In the roots of ‘Sunday’, monosaccharides contents declined, except for sowing date II (August 20), while for ‘Kronos’ they declined only for plants sown on August 30 and September 10, an increase was identified for the other sowing dates. With the occurrence of warmer weather in winter, initial assimilation was still taking place in leaves, where cell cytoplasm and chloroplast monosaccharides were synthesised into sucrose, the major carbohydrate transported into apoplast (Šlapakauskas, 2006).

In our research, after a short spell of colder weather, the contents of both total sugar and monosaccharides declined in the leaves of all varieties tested. More marked increases in their contents were established only in roots. Higher carbohydrates content in plants increases their frost resistance (Obrist et al., 2001); however, the accumulating concentrations of sugars in rape plant leaves generally deteriorate their growth and trigger the onset of senescence (Gupta, Kaur, 2005). In our trial, this also affected plant development after resumption of vegetation, especially the plants of earlier sowing dates (August 10 and 20) started to shed older leaves and produce new ones in this way dissipating the nutrient reserves stored for overwintering. Our research evidence enables us to maintain that the absolutely higher total sugar content in hybrid rape apical bud and roots compared with ‘Sunday’ and not so intensive its reduction during the warm wintering period (in roots even an increase) indicate the superiority of hybrid winter rape plants over conventional ones during the overwintering period.

The state of winter rape crop and photosynthetic parameters of the rosette at the beginning of spring vegetation

It was noticed that after a long period of cold, upon the completion of vernalization in winter crops, plants lose their resistance to low temperatures and become cold-sensitive again.  As a result, changeable weather in spring and moisture excess generally cause more
damage than winter colds. Our research evidenced that plant over winter survival was more influenced by the sowing date. A significant varietal effect was established only in the final experimental year (2009–2010), which was the most adverse for winter rape overwintering and only ‘Kronos’ hybrids exhibited a better result.

In all experimental years, depending on the sowing date, winter rape of all varieties tested were differently prepared for overwintering: the crops sown on sowing dates I and II had the largest mass of the above ground plant part and number of leaves and the thickest root neck, the largest and longest roots. However, in different years, the apical buds of plants sown at the earliest sowing dates were over-elongated and were cold damaged during winter. The least mass of the above ground plant part and the smallest number of leaves and the least root neck thickness were identified for crops sown at the latest dates. The values of these parameters varied during wintering. In the spring of 2008, at the beginning of vegetation ‘Sunday’ plants had larger mass of the above-ground part and a greater root neck diameter, while ‘Kronos’ hybrids exhibited a greater height of apical bud and greater root length. In 2010, after especially adverse wintering conditions, greater values of biometrical parameters were established for ‘Kronos’.

Table 4. The biometric parameters of winter rape sown at different date at the beginning of vegetation in spring, 2009

<table>
<thead>
<tr>
<th>The biometric parameters of winter rape</th>
<th>Variety (factor B)</th>
<th>Sowing date (factor A)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10 08</td>
</tr>
<tr>
<td>Winter rape rosette weight g</td>
<td>‘Sunday’</td>
<td>11.3a*</td>
</tr>
<tr>
<td></td>
<td>‘Kronos’</td>
<td>19.2a*</td>
</tr>
<tr>
<td>Number of leaves per plant units</td>
<td>‘Sunday’</td>
<td>9.0a</td>
</tr>
<tr>
<td></td>
<td>‘Kronos’</td>
<td>9.0a</td>
</tr>
<tr>
<td>Height of apical bud cm</td>
<td>‘Sunday’</td>
<td>3.5a*</td>
</tr>
<tr>
<td></td>
<td>‘Kronos’</td>
<td>4.9a*</td>
</tr>
<tr>
<td>Diameter of root collar mm</td>
<td>‘Sunday’</td>
<td>11.2a*</td>
</tr>
<tr>
<td></td>
<td>‘Kronos’</td>
<td>13.0a*</td>
</tr>
<tr>
<td>Root length cm</td>
<td>‘Sunday’</td>
<td>13.8a*</td>
</tr>
<tr>
<td></td>
<td>‘Kronos’</td>
<td>19.4a*</td>
</tr>
<tr>
<td>Root mass g</td>
<td>‘Sunday’</td>
<td>6.0a*</td>
</tr>
<tr>
<td></td>
<td>‘Kronos’</td>
<td>10.4a*</td>
</tr>
</tbody>
</table>

Note: means marked with different letters (a, b, c...; factor A – sowing date) and asterisk (*, factor B – variety) are significantly different (P<0.05).

For the plants of Brassicaceae family, photosynthetic activity is an important element of their vital functions, which influences crop productivity and nutrient contents accumulated in them. The 2008–2009 winter season was conducive to winter rape overwintering; and yet some winter damage was done to the crops: the number of winter rape leaves and their area reduced, which had an effect on the NPP reduction for the crops of both varieties. The lowest value of this parameter was established for the crops of both varieties sown on the earliest date (August 10). Crop productivity depends on the accumulated amount of solar energy and on the energy coefficient used for photosynthesis. At the beginning of spring vegetation, winter rape plants had just started accumulating solar
energy and their NPP could change in response to other environmental factors during the growing season. In our experiment, the variety did have an effect on the NPP. A higher value of this parameter at the beginning of spring vegetation was noted for 'Kronos’ hybrids.

In 2009, at the beginning of spring vegetation the plants of both varieties sown on August 10 exhibited the greatest leaf area, compared with those sown at later dates. A significant varietal effect on leaf area also was identified for the crops sown on August 10: for 'Kronos’ hybrids it was significantly greater (71.3 %) compared with 'Sunday’ sown on the same date. ‘Sunday’ demonstrated a more intensive leaf growth rate after resumption of vegetation in winter compared to hybrids, because of which it sustained more severe winter damage and started growing leaves later in spring. Similar results were obtained in the following years.

At the beginning of spring vegetation, the content of photosynthetic pigments and their ratio declined, compared with that at beginning of wintering. In the spring of 2008, the sowing time and varietal effects on the content of photosynthetic pigments was negligible and the highest a to b ratio was identified for the crops sown at the earliest date (August 10). A more marked sowing date effect on chlorophyll a content was established in the spring of 2009 (Table 5). Higher contents of this pigment were noted for 'Kronos’ hybrids sown on August 10 and 30. No significant varietal effects on chlorophyll a content in rape leaves was found only for the crops sown on September 10.

**Table 5.** The effect of sowing date and variety on the photosynthetic parameters at the beginning of spring vegetation, 2009–2010

<table>
<thead>
<tr>
<th>Sowing date (factor A)</th>
<th>Net photosynthetic productivity (g m⁻² p⁻¹)</th>
<th>Assimilating leaf area (thousands m⁻² ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>'Sunday'</td>
<td>'Kronos'</td>
</tr>
<tr>
<td>10 08</td>
<td>-6.0c*</td>
<td>-1.6b*</td>
</tr>
<tr>
<td>20 08</td>
<td>-4.4b*</td>
<td>-1.4ab*</td>
</tr>
<tr>
<td>30 08</td>
<td>-0.4a</td>
<td>-1.0a</td>
</tr>
<tr>
<td>10 09</td>
<td>0.2a</td>
<td>0.4a</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td></td>
</tr>
<tr>
<td>10 08</td>
<td>-4.0c*</td>
<td>-2.8c*</td>
</tr>
<tr>
<td>20 08</td>
<td>-3.8c*</td>
<td>-2.6bc*</td>
</tr>
<tr>
<td>30 08</td>
<td>-2.9b</td>
<td>-2.8bc</td>
</tr>
<tr>
<td>05 09</td>
<td>-2.5ba</td>
<td>-2.1a</td>
</tr>
<tr>
<td>10 09</td>
<td>-2.1a</td>
<td>-2.5b</td>
</tr>
<tr>
<td></td>
<td>2010</td>
<td></td>
</tr>
</tbody>
</table>

Note: means marked with different letters (a, b, c...; factor A – sowing date) and asterisk (*, factor B – variety) are significantly different (P<0.05).

Earlier-sown crops generally exhibit better preparation for overwintering – this is especially obvious in the years with less rainfall. However, the crops sown too early, when the conditions are favourable in the autumn tend to overgrow: the stems start elongating, which makes them more vulnerable to winter cold. The cold-affected plants regenerate from lateral shoots and this was one of the reasons in our experiment why the early-sown (August 10) crops produced lower seed yield. The highest rapeseed productivity was in 2007 in the crops sown on August 30, in 2009 in the crops sown on August 20 and 30, and in 2010 even on September 5.
Significantly lower rapeseed productivity was recorded for late-sown crops (September 10), except for the year 2009 (Fig. 6). In the latter year, the seed yield of rape hybrids sown on September 10 did not differ significantly from those sown on August 20, 30 and September 5. Hybrid plants, characterised by a longer vegetation period, start flowering earlier and are able to better utilise moister when lower temperatures are still favourable for seed setting and development. In our study, significantly more productive were ‘Kronos’ hybrids: in 2009 significant differences were obtained having sown on the earliest (August 10) and the latest (September 10) dates; and in 2010, significantly lower seed yield was produced only having sown on the earliest date (August 10). ‘Valesca’ and ‘Sunday’ exhibited a more sensitive response to the sowing date, compared with ‘Kronos’.

**Fig. 6.** The effect of sowing date and variety on winter rape seed yield, 2009–2010. Note: means marked with different letters (a, b, c...; factor A – sowing date) and asterisk (*, factor B – variety) are significantly different (P<0.05).

Rape hybrids were found to respond less to the sowing date than conventional varieties (Fig. 6). When conventional varieties are grown and the sowing date is delayed, seed yield and its structural elements are more markedly influenced by the climate conditions rather than the varietal characteristics.

In our study, the hybrid variety ‘Kronos’ exhibited significantly higher seed productivity: in 2009 significant differences were established for the earliest (August 10) and latest (September 10) sowing dates, and in 2010 significantly lower seed yield was obtained only for the earliest (August 10) sowing date.
CONCLUSIONS

1. Sowing date and variety exerted significant effects on the biometrical parameters of winter rape crops ready for overwintering. With a delay in sowing date significant reductions occurred in the biometrical parameters (number of leaves, height of apical bud, root neck diameter) for both varieties tested. During the preparation for wintering period, a more intensive growth was noted for the rape hybrids, while after resumption of vegetation during wintering, 'Sunday' plants exhibited a more rapid growth rate.

2. With a delay in sowing date, significant reductions in dry matter and total sugar contents were identified in all morphological organs (leaves, apical bud and roots) of the rape plants tested. Statistically significant relationships were established between dry matter content and duration of the period until the end of vegetation \((r = 0.63–0.92; P<0.05)\), the sum of positive temperatures above +2 °C \((r = 0.63–0.96; P<0.05)\) and duration of solar radiation \((r = 0.61–0.95; P<0.05)\); total sugar content and the sum of positive temperatures above +2 °C \((r = 0.63–0.95; P<0.05)\) and duration of solar radiation \((r = 0.61–0.94; P<0.05)\) during the preparation for wintering period. During the same period, a higher dry matter content in leaves and apical bud as well as higher total sugar content in leaves and roots were accumulated by ‘Kronos’ hybrids compared with ‘Sunday’ plants.

3. Upon resumption of vegetation during overwintering, changes occurring in nutrient contents in winter rape plants depended on the variety, duration of resumption of vegetation at relatively low temperature (+2 °C), meteorological conditions and sowing date. Nutrient changes, determining plant over winter survival, occurred more favourably for ‘Kronos’ hybrids in which the dissipation of accumulated nutrients was not as intensive as in 'Sunday' plants, therefore the hybrid plants were more cold-resistant during wintering.

4. Winter rape photosynthetic parameters (net photosynthetic productivity – NPP, assimilating leaf area, photosynthetic pigments content) at the end of autumn vegetation were directly correlated with the amount of precipitation \((r = 0.44–0.84; P<0.5)\) and duration of solar radiation \((r = 0.51–0.86; P<0.05)\) and sum of positive temperatures above +2 °C until the end of vegetation \((r = 0.44–0.88; P<0.05)\). With a delay in winter rape sowing date, a significant decrease occurred in the NPP, assimilating leaf area and photosynthetic pigments content in leaves. The sowing date did not have any significant effect on the ratio of chlorophyll a to b; however, with a delay in sowing date a trend towards increasing of this ratio was revealed. Higher values of photosynthetic parameters were established for 'Kronos' hybrids for all sowing dates. In spring, after resumption of vegetation, higher values of photosynthetic indicators were recorded also for 'Kronos' hybrids.

5. Sowing date had an effect on winter rape over winter survival rate. It was found that in the case of delayed sowing date (August 30 and beginning of September), ‘Kronos’ hybrids exhibited a better over winter survival compared with ‘Sunday’ variety. A significant varietal effect on winter rape over winter survival was identified: after adverse wintering conditions, the best over winter survival was demonstrated by the winter rape hybrids sown at the earliest (August 10) and latest (September 5) dates. In spring, at the beginning of vegetation, ‘Kronos’ hybrids had higher values of rosette biometrical parameters (number of leaves, height of apical bud, root neck diameter).

6. Sowing time exerted a significant impact on winter rape seed yield structural elements. With a delay in sowing date, reductions occurred in the number of siliques, number of seeds per silique and 1000 seed weight. However, these changes were not as dramatic for rape hybrids as for 'Sunday' variety. Although in most cases there were found no significant differences between the different varieties, hybrid winter rape plants (especially sown on late dates) had a higher number of siliques and a higher 1000 seed
weight. Sowing date effects on rapeseed yield were significant: the highest seed yield was obtained for the sowing dates August 20 and 30, while the lowest for August 10 and September 10. When sown on the latter dates, the seed yield of the ‘Kronos’ hybrids was significantly higher compared with that of ‘Sunday’ variety. Sowing date did not have any significant effect on rape seed quality. Fat, protein and erucic acid contents in seeds were more dependent on the variety.

LIST OF PUBLICATIONS ON THE SUBJECT OF THE DISSERTATION

Articles in journals indexed in ISI WOS List database:
1. Velička, Rimantas; Pupalienė, Rita; Butkevičienė, Lina Marija; Kriaucūnienė, Zita. The influence of sowing date on winter rape over-wintering and yield in the middle Lithuania // Journal of Food, Agriculture & Environment. Helsinki : WFL Publisher. ISSN 1459-0255. 2011, Vol. 9, No. 3-4, p. 348-353. [ISI Web of Science; CAB Abstracts]. [Citav. rod (F): 0,517; bendr. cit. rod: 1,898]
2. Velička, Rimantas; Anisimovienė, N.; Pupalienė, Rita; Jankauskienė, Jurga; Butkevičienė, Lina Marija; Kriaucūnienė, Zita. Preparation of oilseed rape for over-wintering according to autumnal growth and cold acclimation period // Žemdirbystė–Agriculture Akademija, (Kėdainių r.) : Lietuvos žemdirbystės institutas, Lietuvos žemės ūkio universitetas. ISSN 1392-3196. T. 97, Nr.3 (2010), p. 69–76. [ISI Web of Science; CAB Abstracts]. [Citav. rod (F): 0,232; bendr. cit. rod: 1,35]

Articles in periodical and serial scientific journals, which are assessed in other international scientific informatikon databases:

Other publications:
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REZIUMĖ

Hiptotezė. Rapsų peržiemojimą, maisto medžiagų kaupimąsi atskirose jų morfologinėse dalyse bei organogenezę įtakoja meteorologinės sąlygos, sėjos laikas ir veislė. Rudenį, vykstant rapsų vegetacijai arba jai atsinaujinus šiltais žiemojimo laikotarpiais, rapsuose vyksta asimiliaciniai procesai kurių pobūdis rapsų ir jų hibridų skrotelėje bei šaknyse skiriasi. Šiltėjant rudens–žiemos periodui, rapsai, ypač jų hibridai, gali būti sėjami ir vėliau negu iki šiol rekomenduojama, nes spėja sukaupti pakankamą maisto medžiagų kiekį ir tinkamai pasiruošti žiemojimui. Didesnį rapsų hibridų produktyvumą lemia ne tik jų žiemojimo, bet ir derliaus elementų struktūros ypatumai.

Tyrimų tikslas. Nustatyti žieminių rapsų ir jų hibridų vystymosi dėsningumus skirtingos trukmės šiltėjančiu rudens–žiemos periodu, įvertinti jų biopotencialo formavimą bei optimizuoti prisitaikymo prie besikeičiančių klimato sąlygų adaptacines priemones (sėjų laiką).

Tyrimų uždaviniai.
1. Įvertinti skirtinę laiku pasėtų žieminių rapsų ir jų hibridų pasėlių būklę, sudėtį ir nustatyti pasiruošusių žiemotų rapsų biometrinius parametrus.
2. Įvertinti skirtinę laiku pasėtų rapsų ir jų hibridų skrotelės biometrinų rodiklių pokyčius rudens–žiemos periodui.
3. Ištirti anglievandenlių sintezės ir maisto medžiagų kaupimosi dinamiką atskirose rapsų morfologinėse dalyse rudens–žiemos periodu.
4. Nustatyti žieminių rapsų ir jų hibridų fotosintetinius rodiklius (grynųjų fotosintezės produktyvumą, lapų plotą, chlorofilo kiekį), rudens skrotelės tarpsnyje ir pavasario vegetacijos pradžioje.
5. Įvertinti rapsų peržiemojimą.
6. Įvertinti sėklų brandos tarpnyje, skirtingų laikų sėtų rapsų ir jų hibridų derliaus struktūros elementus, sėklų derlingumą ir sėklų kokybę.

**Mokslinis naujumas** – ištyrės rapų cheminės sudėties pokyčius nustatyta skirtingų veislių žiemių rapsų (rapsų ir jų hibridų) vystymosi ir augimo nevienodos trukmės rudens–žiemos periodu skirtumai ir dėsningumai. Nustatytų dėsningumų pagrindu išaiškintos rapų hibridų pranašumų priežastys. Žieminiai rapsai, ypač vėlyvesnės, sėjos rudenį auga ir vystosi lėčiau, o šiltaisiais žiemomis auga sukauptas maisto medžiagas negu rapsų hibridai.

**Darbo praktinė reikšmė.** Tyrimų rezultatai sudaro galimybę tobulinti rapsų augimo technologiją, bei nustatyti optimalų skirtumų tipo veislių rapsų sėjos laiką kintančio klimato sąlygomis, sudaro prielaidas didinti žiemių rapsų produktyvumą ir konkurencingumą.

**Disertacijos ginamieji teiginiai:**
1. Žiemių rapsų sėjos laikas ir veislė turėjo esminės įtakos žiemojusių augalų biometriniams parametrams. Vėlinant sėjos laiką abiejų tirtų veislių rapsų biometriniai rodikliai (lapų skaičius, viršūninio pumpuro aukštis, šaknies kaklelio skersmuo) esmingai mažėjo. Pasiruošimo žiemojusių augalų biometriniams parametrams priežastys priklauso nuo augalų genotipo ir sėjos laiko.

2. Atsinaujinus vegetacijai žiemojimo metu, rapų ir jų hibridų skretėje vykstantys maisto medžiagų pokyčiai skiriasi ir priklauso ne tik nuo genotipo ir sėjos laiko, bet ir nuo metų meteorologinių sąlygų.


4. Sėjos laikas daro didesnę įtaką rapsų sėklų produktyvumui.

**IŠVADOS**

1. Žiemių rapsų sėjos laikas ir veislė turėjo esminę įtakos žiemojusių augalų biometriniams parametrams. Vėlinant sėjos laiką abiejų tirtų veislių rapsų biometriniai rodikliai (lapų skaičius, viršūninio pumpuro aukštis, šaknies kaklelio skersmuo) esmingai mažėjo. Pasiruošimo žiemojusių augalų biometriniams parametrams priežastys priklauso nuo augalų genotipo ir sėjos laiko.

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4. Sėjos laikas daro didesnę įtaką rapsų sėklų produktyvumui.
P <0,05) bei teigiamų temperatūrų, didesnių nei +2 ºC, sumos iki vegetacijos pabaigos
(r = 0,44–0,88; P <0,05). Vėlinant žieminių rapsų sėjų, esmingai mažėjo grynasis fotosintezės produktyvumas, assimilacinis lapų plotas ir fotosintetinių pigmentų kiekis rapsų lapuose. Chlorofilų a ir b santykiai sėjų esminės įtakos neturėjo, tačiau vėlinant sėją nustatyta šio santykio didėjimo tendencija. Didesnės fotosintetinių rodiklių reikšmės nustatytos visais terminais sėtuohe 'Kronos' rapsų hibridų pasėluose. Pavasarį atsinaujinus vegetacijai pagal didesnius fotosintetinius rodiklius 'Kronos' veislės rapsai taip pat buvo pranašesni.


ABOUT THE AUTOR

Lina Marija Butkevičienė was born in Kaunas on June 24, 1966. In 1985, she finished the Alanta agricultural school with the qualifications of plant protection agronomist. From 1985 to 1986 she was employed as a plant protection agronomist at Daugšiagirs farm in Prienai district. From 1989 to 1993 she worked in a horticultural farm in Birštonas. Since 2000 she has been employed at the Lithuanian University of Agriculture’s Department of Soil Management. In 2001, she entered the Lithuanian University of Agriculture’s Faculty of Agronomy. In 2006, she graduated from the university with a bachelor’s degree in agronomy. In 2006–2008, she continued her studies at the same university and graduated with a master’s degree in agronomy. Since 2008 she has been a PhD student at the Lithuanian University of Agriculture’s Department of Soil management.

TRUMPOS ŽINIOS APIE DISERTANTĘ