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PECULIARITIES OF OVERWINTERING OF HYBRID AND CONVENTIONAL CULTIVARS OF WINTER RAPESEED DEPENDING ON THE SOWING DATE

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Abstract. Field experiment on different sowing dates of two winter rapeseed cultivars (*Brassica napus* L. spp. and *oleifera biennis* Metzg.) was carried out in years 2009-2010 at the Experimental Station of the Aleksandras Stulginskis University (54°53' N; 23°50' E). The objective of the study was to evaluate the effect of winter rapeseed sowing date on the biometric parameters of rapeseed rosette: number of leaves, root collar diameter, height of apical bud, and its chemical composition: N:K ratio, amount of dry matter, total sugar in autumn before wintering, changes of chemical composition during the autumn-winter period, and overwintering. Sowing date significantly influenced all the examined indexes. According to the biometric parameters, the chemical composition of leaves, and the apical bud, winter rapeseed sown between August 30th and September 5th was best prepared for wintering and overwintered. Growth during the period of preparation for overwintering was more intensive. Changes in the chemical composition during the overwintering period were more favourable and the overwintering of winter rapeseed was better in the hybrid cultivar Kronos compared with cultivar Sunday.

Key words: biometric parameters, chemical composition, cultivar, overwintering, sowing date, winter rapeseed

INTRODUCTION

Oilseed rape is the most important cultivated crop grown for vegetable oil in temperate climates and the second leading source of vegetable oil in the world [Fried *et al*. 2002]. Lithuania is one of the north-easternmost countries in Europe for oilseed rape growth [Butkutė et al. 2006]. Meteorological conditions in autumn have a major effect on oilseed rape yield and quality [Muśnicki *et al*. 1999] and determine the sowing date [Montvilas and Mittas 2000]. It is proven that oilseed rape overwinters well at the 6-8 true-leaf stage if the apical bud is differentiated but not shot-up 30 mm, and the root

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column diameter is 8-10 mm [Velička 2002]. Each developed leaf requires about 10 calendar days or a sum of active temperatures of +60.0°C [Šidlauskas 1997].

Duchovskis [1998] stated that non-sufficient preparation for overwintering determines plant injuries during winter. Accumulation of proteins, saccharides, and other substances in the plant is a measure for cold protection [Anisimovienė *et al*. 2004, Verbruggen and Hermans 2008]. According to Kubacka-Zebalska and Kacperska [1999], significant and characteristic biochemical changes occur during plant exposure to cold. The content of soluble sugars in plant cells increases.

During preparation for the overwintering period, the concentration of cryoprotectants (sugars, lipids, hydrophilic proteins, prolines, and others) increases, whereas the amount of free water decreases in the cytoplasm. The most intensive accumulation of dry matter in winter rapeseed plants occurs 35-40 days after seed germination [Šidlauskas 2002]. In this period, winter rapeseed plants are at the five true-leaf stage and have the biggest leaf area (assimilation surface) [Montvilas 1999]. Intensive physiological processes, such as the accumulation of nutrients in vitally important plant organs, take place at this stage. With declining temperatures, physiological processes slow down, and at the end of autumn, growth reaches the critical limit [Mendham 1995]. When average day temperature drops down to ≤+2.0°C, growth of winter rapeseed stops [Upmanis 1972]. Lithuanian weather conditions with frequently alternating cold and thaws and circadian temperature fluctuations during the autumn-winter period determine cold-deaclimation (growth renewal) of winter rapeseed at the beginning of wintering. Deaclimation is fully reversible if it is not accompanied by induction of elongation growth [Rapacz 2002]. During renewed vegetative growth, winter rapeseed sown at later dates has sufficient time to prepare for overwintering [Velička *et al*. 2009].

Sowing time in the warming-up and lengthening autumn-winter period is changing. Data from previous research suggests optimal sowing time in central Lithuania from August 5th to August 10th [Bernotas 1999, Montvilas and Mittas 2000]. In a warmer autumn-winter period, delaying the sowing time (after mid-August) of winter rapeseed resulted in better overwintering and formation of the structural elements of the yield [Velička *et al*. 2009].

The aim of the study was to evaluate the effect of winter rapeseed sowing time on the biometric parameters and chemical composition of rapeseed rosette in autumn before wintering, changes in the chemical composition during the autumn-winter period, and overwintering.

MATERIAL AND METHODS

Field experiment on different sowing dates of two winter rapeseed cultivars (*Brassica napus* L. spp. and *oleifera biennis* Metzg.) was carried out in years 2009-2010 at the Experimental Station of the Aleksandras Stulginskis University (former Lithuanian University of Agriculture (54°53’ N; 23°50’ E). Soil on the experimental site was *Endocalcari-Epihypogleyic Cambisol* (*CMg-p-w-can*) [Lietuvos dirvožemiai 2001]. Experimental treatments were as follows: factor A – sowing dates: 1) August 10th, 2) August 20th, 3) August 30th, 4) September 5th, 5) September 10th, 6) September 15th; factor B – cultivar: 1) Sunday, 2) hybrid cultivar Kronos. The experiment treatments were set up randomly in four repetitions. The size of each plot was 30 m^2.

Chemical characteristics of the soil were as follows: pH – 6.7, 156 mekv·kg^{-1} total absorbed base, 1.59 g·kg^{-1} total nitrogen, 17.4 g·kg^{-1} organic carbon, 0.235 g·kg^{-1} available phosphorus, 0.189 g·kg^{-1} available potassium, 0.026 g·kg^{-1} available sulphur, 0.118 g·kg^{-1} total sulphur, and 0.0012 g · kg^{-1} boron. Agrochemical characteristics of the soil were established at the Experimental Station of the Aleksandras Stulginskis University (former Lithuanian University of Agriculture) using the computerized system of infrared rays spectrometer [Rimkevičienė 2000].

Conventional soil cultivation practices for winter rapeseed were applied. The field before sowing of winter oilseed rape was under bare fallow. Plant fertilization (N – 120, P – 26 and K – 75 kg·ha^{-1}) was performed as follows: P and K were applied in the autumn prior to sowing, and N was supplied in the spring after vegetation renewal. After sowing, rapeseed was sprayed with herbicide Butizan 400 (bentazon) – 2.5 dm^3·ha^{-1}. During the growth season, the crops were sprayed with insecticides three times: Karate Zeon (lambda cyhalothrinum) – 0.15 dm^3·ha^{-1}, Fastac (alfa-cipermetrina) 0.10 dm^3·ha^{-1}, Bulldock (beta-cyfluthrin) – 0.10 dm^3·ha^{-1}, and once with fungicide Folicur (tebuconazole) – 1.0 dm^3·ha^{-1} at the end of flowering.

In the autumn, when average air temperature was equal to or dropped below +2ºC for three successive days, when vegetation of winter rapeseed was over, ten plants were sampled randomly from each plot for the measurement of biometric parameters and chemical analyses. Crop density was estimated four times using 0.25 m^2 squares in each plot in the autumn before wintering and in the spring after vegetation renewal. Percentage of overwintered plants was calculated.

Different morphological parts of winter rapeseed (leaves and apical buds) were analysed as follows: dry matter determination after drying at 105ºC; total sugar with the Bertran method; total nitrogen with the Kjeldahl method; potassium and phosphorus using the computerized system of infrared rays spectrometer [Rimkevičienė 2000].

It is stated that vegetation of winter oilseed rape finishes when average day temperature drops down to ≤+2ºC for three or more successive days. Growth renews if average day temperature reaches ≥+2ºC for the same period. During the autumn-winter period, because of temperature fluctuations, the Authors observed one renewal of winter oilseed rape growth. At the end of the renewed growth period (in 2009 it was on November 4, according to the data from the Kaunas meteorological Station; three successive days with average day temperature ≤+2ºC), measurements of chemical analyses were repeatedly done.

Data from the Kaunas Meteorological Station was used for the description of the meteorological conditions during the experiment. In 2009-2010, average day temperature in autumn was higher and in winter lower compared with the annual average day temperature. Soil freeze was up to 70 cm, snow cover – 2-33 cm and lasted throughout the entire winter period.

Statistical significance of differences between the treatments was evaluated with the Fisher's protected least significant difference test at $P_{(level)}$ <0.05, and correlation--regression analyses were performed using the package of statistical programmes SELEKCIJA [Tarkanovas and Raudonius 2003].

RESULTS AND DISCUSSION

Plants of the hybrid cultivar Kronos sown at different dates exhibited more rapid growth in the autumn and produced more leaves than the plants of cultivar Sunday (Figure 1). The plants of both cultivars (Sunday and Kronos) produced a sufficient number of leaves before wintering, even at the sowing date of September 5th. Crop sown on September 10-15th produced a significantly lower number of leaves. The plants did not have enough time to produce a rosette with an adequate number of leaves for good wintering.

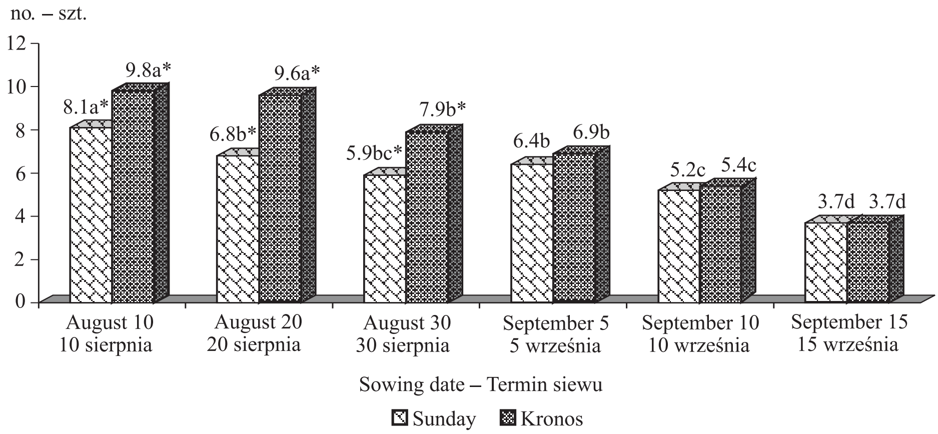

Fig. 1. Number of leaves in the rosette of winter rapeseed cultivars Sunday and Kronos at the end of growth in autumn 2009-2010

Rys. 1. Liczba liści w rozecie rzepaku ozimego odmiany Sunday i Kronos przed spoczynkiem zimowym okresu wegetacji 2009-2010

Plants exhibit good over-winter survival when their root collar thickness in the autumn, before wintering, is 8-10 mm [Velička 2002]. Other researchers have reported that root collar thickness of 5-6 mm is sufficient before the onset of winter [Cramer 1990]. As shown in Figure 2, with a delay in sowing date, root collar thickness tended to decrease. Plants sown in August had thick root collars (6.4-12.3 mm). Plants sown on September 10-15th exhibited particularly thin root collars of 2.3-3.2 mm. Plants sown on September 5th also had insufficiently thick root collars of 4.5 mm (cultivar Sunday) and 5.2 mm (hybrid cultivar Kronos). The same tendency was investigated in the previous year of experiments [Velička *et al*. 2010].

When sown on September 15th, the root collar thickness of both cultivars did not differ, and due to insufficient thickness the plants sown on the latest date had doubtful chances of surviving winter. The plants of the hybrid cultivar Kronos sown on August 30th and September 5th produced thicker root collars than those of cultivar Sunday. As a result, a slightly delayed sowing date revealed the hybrid plants ability to prepare better for wintering.

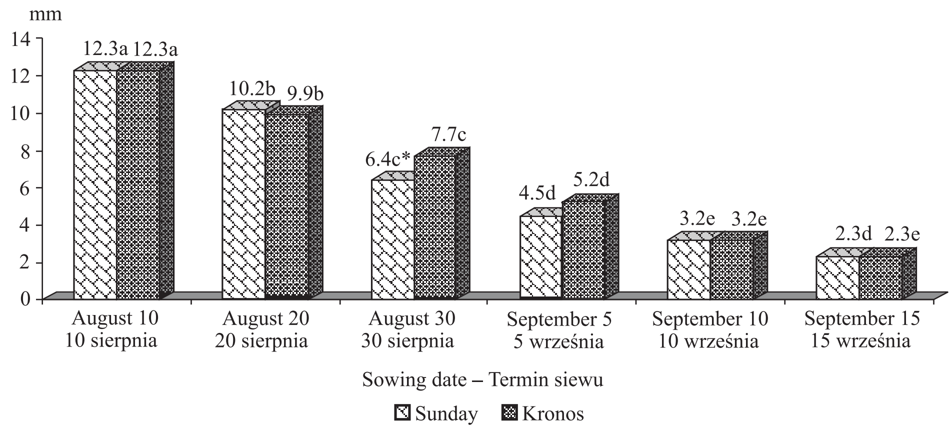

Fig. 2. Root collar diameter of winter rapeseed cultivars Sunday and Kronos at the end of growth in autumn 2009-2010
Rys. 2. Średnica szyjki korzeniowej rzepaku ozimego odmiany Sunday i Kronos jesienią, na koniec okresu wegetacji 2009-2010

Winter rapeseed plants exhibit better over-winter survival when in the autumn, before wintering, the height of the apical bud above the soil surface does not exceed 30 mm [Hauman and Wilke 1988]. Apical buds of rapeseed plants sown on August 10th were significantly higher above the soil surface compared with those of later sown plants, which indicated that the plants were overgrown (Fig. 3). Apical bud height of both cultivars sown on August 20th also exceeded 30 mm and was significantly higher than that of plants sown on August 30th. According to this indicator, the plants were not adequately prepared for wintering. Apical bud height of plants sown on August 30th did not reach 30 mm, which indicated their adequate preparation for wintering. Plants of both cultivars sown on September 10-15th produced particularly small apical buds.

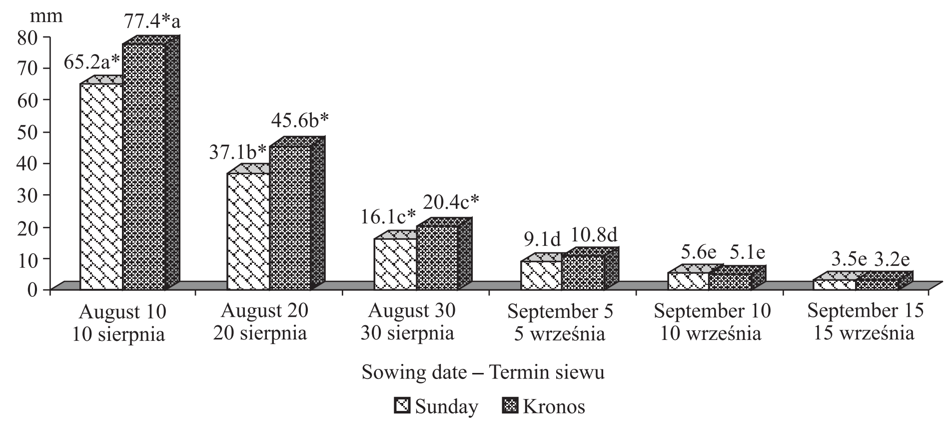

Fig. 3. Height of the apical bud of winter rapeseed cultivars Sunday and Kronos at the end of growth in autumn 2009-2010
Rys. 3. Wysokość pączka szczytowego rzepaku ozimego odmiany Sunday i Kronos jesienią, na koniec okresu wegetacji 2009-2010

Correlation-regression analysis of the obtained data revealed a strong and very strong relation between the sum of temperatures ≥+2.0°C accumulated by plants and the biometric parameters of winter rapeseed in autumn at the beginning of wintering: cultivar Sunday – leaf number $y = 2.693 + 0.007x$; $r = 0.85$, $P < 0.01$; root collar diameter $y = -2.916 + 0.0191x$; $r = 0.96$, $P < 0.01$; height of apical bud $y = -34.571 + 0.114x$; $r = 0.95$, $P < 0.01$; cultivar Kronos – leaf number $y = 1.956 + 0.010x$; $r = 0.87$, $P < 0.01$; root collar diameter $y = -2.323 + 0.018x$; $r = 0.94$, $P < 0.01$; height of apical bud $y = -4.021 + 0.013x$; $r = 0.95$, $P < 0.01$. Biometric parameters of winter rapeseed rosette of both cultivars increased depending on the sowing date with the increase in the sum of temperatures ≥+2.0°C. The sum of temperatures ≥+2.0°C correlated more strongly with root collar diameter and height of the apical bud ($r = 0.94$-0.96) than with leaf number per plant ($r = 0.85$-0.87), showing that in the first case 88-92% and in the second one 72-76% of variability was accounted for by the sum of temperatures ≥+2.0°C.

According to the previous studies by the Authors, plants that accumulated more dry matter and total sugar contents with lower N to K ratio exhibited better over-winter survival. Strong correlations were established among those indicators [Velicka *et al*. 2006]. The findings by the Authors indicate that sowing date has a significant effect on dry matter accumulation in the apical bud (Figs 4 and 5). The plants of both cultivars sown on September 10th and 15th accumulated significantly less dry matter in the apical bud compared with those sown on August 10th and 20th.

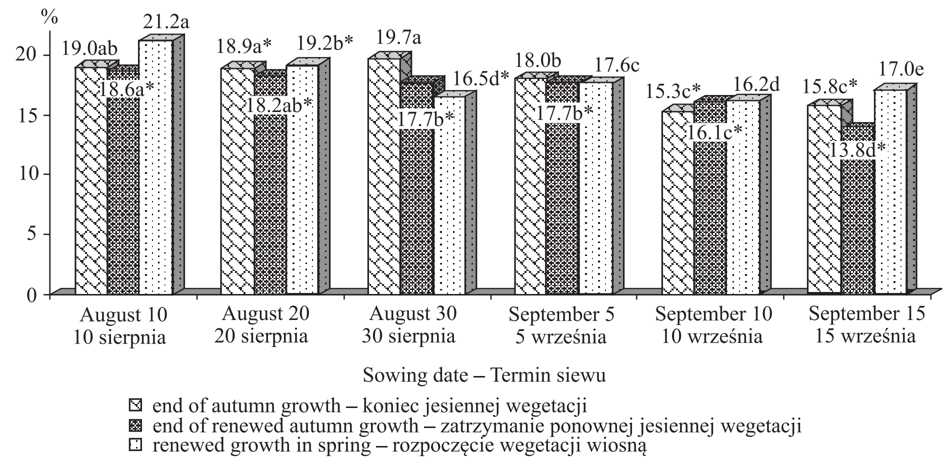

Fig. 4. The amount of dry matter in the apical bud of winter rapeseed cultivar Sunday (2009-2010)

Rys. 4. Ilość suchej masy pączka szczytowego w rzepaku ozimym odmiany Sunday (2009-2010)

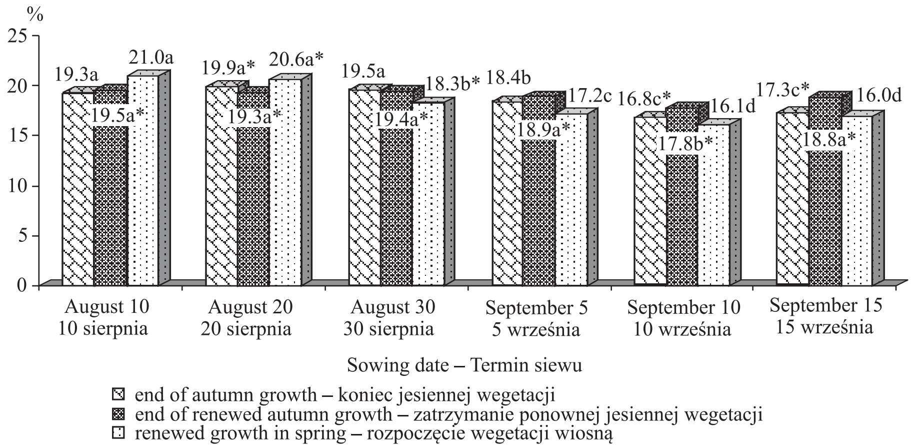

Fig. 5. Amount of dry matter in the apical bud of winter rapeseed cultivar Kronos (2009-2010)
Rys. 5. Ilość suchej masy pączka szczytowego w rzepaku ozimym odmiany Kronos (2009-2010)

Plants of the hybrid cultivar Kronos, especially those sown on later dates, accumulated more dry matter in the apical buds compared with the plants of cultivar Sunday. The lowest content of total sugar was accumulated by plants sown on September 15th; however, the sugar content in the apical bud of hybrid Kronos plants was higher than in the plants of cultivar Sunday (Figs 6 and 7). Even at an extremely delayed sowing date (September 15th), the plants of the hybrid cultivar were better prepared to survive winter, which was likely to have resulted from the heterosis effect. The plants of both cultivars accumulated significantly less total sugar in the apical bud when sown in September. Having sown winter rapeseed on August 30th, the plants of the hybrid cultivar performed better in terms of total sugar accumulation in the apical bud. When sown on later dates, the plants of this cultivar exhibited more intensive preparation for wintering by protecting the apical bud from frost-killing.

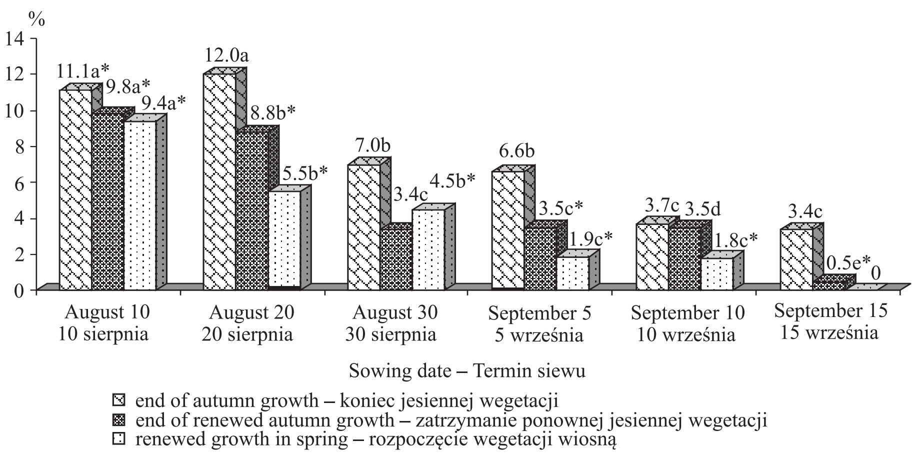

Fig. 6. Amount of total sugar in the apical bud of winter rapeseed cultivar Sunday (2009-2010)
Rys. 6. Zawartość cukru ogółem w pączku szczytowym w rzepaku ozimym odmiany Sunday (2009-2010)

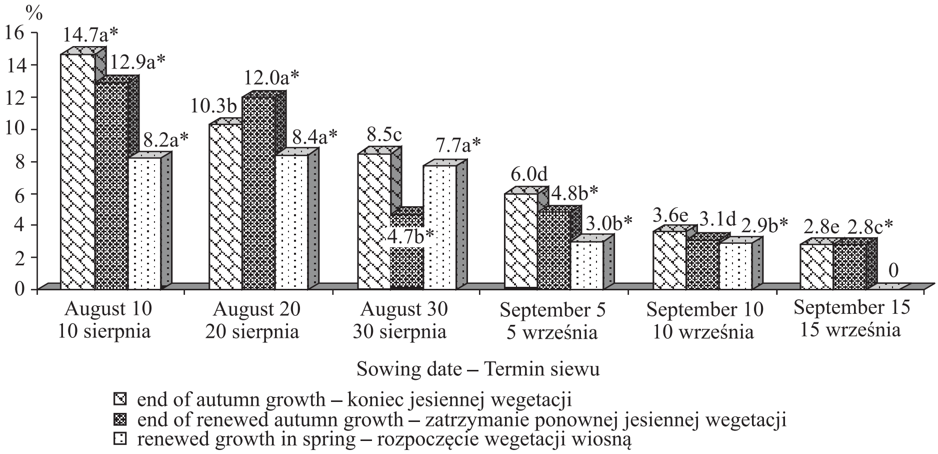

Fig. 7. Amount of total sugar in the apical bud of winter rapeseed cultivar Kronos (2009-2010)
Rys. 7. Zawartość cukru ogółem w pączku szczytowym w rzepaku ozimym odmiany Kronos (2009-2010)

Sowing time had a significant impact on the nitrogen to potassium ratio (N:K), both in winter rapeseed leaves and in the apical bud (Table 1). According to the N:K ratio, sowing time had a lower effect on hybrid rapeseed preparation for wintering compared with that of cultivar Sunday. Nitrogen to potassium ratio in the leaves of hybrid plants even when sown on September 10th was not significantly higher compared with that of plants sown in August. In the leaves of the hybrid plants sown on all sowing dates, the N:K ratio was lower compared with that of cultivar Sunday. In terms of the N:K ratio, in the apical bud, the sowing time exerted a greater effect on the plants of cultivar Sunday than on hybrid plants. Significant differences in the N:K ratio were established among all the sowing dates. The N:K ratio in the apical bud of hybrid plants sown on September 10^{th} and 15^{th} did not significantly differ from that of plants sown on August 30^{th}.

Table 1. N:K ratio in winter rapeseed rosette in autumn at the beginning of overwintering (2009--2010)
Tabela 1. Stosunek N:K w rozecie rzepaku ozimego jesienią, w początkowym okresie przezimowania (2009-2010)

Sowing date – Termin siewu	N:K			
	leaves – liście		apical bud – pączek szczytowy	
	Sunday	Kronos	Sunday	Kronos
August 10 – 10 sierpnia	1.54d	1.51d	1.27d	1.27d
August 20 – 20 sierpnia	1.57cd	1.55cd	1.32d	1.33d
August 30 – 30 sierpnia	1.66bc	1.64b	1.61bc*	1.69a*
September 5 – 5 września	1.76b	1.72b	1.49c*	1.58c*
September 10 – 10 września	1.71b	1.63b	1.54c*	1.66b*
September 15 – 15 września	1.89a	1.88a	1.71a	1.73a

mean values marked with different letters (a, b, c…; sowing date) and asterisk (*, cultivar) are significantly different ($P < 0.05$) – średnie z różnymi literami (a, b, c…; termin siewu) i asteriskem (*, odmiana) różnią się statystycznie ($P < 0,05$)

Renewed vegetative growth at the beginning of wintering (26 days with the average daily temperature of +2ºC) had an adverse effect on the dry matter content in the apical bud of the plants of cultivar Sunday. During that period, dry matter content in the apical bud decreased, except for the plants sown on September 10th (Fig. 4).

Upon growth resumption in the spring, increase in the dry matter content in the apical bud was recorded for the plants of cultivar Sunday sown on August 10th and 20th and September 15th. Early-sown winter rapeseed plants were better prepared for the growth resumption in the spring. The plants sown very late contained significantly less dry matter in the apical buds compared with the plants sown on the earliest dates.

The tested cultivars of winter rapeseed differed in the dry matter content in the apical bud after growth resumption during wintering. The dry matter content in the apical bud of the Kronos plants sown on later dates (September) was found to be higher at the end of the period compared with the one at the beginning of wintering (Fig. 5). The plants of the hybrid cultivar sown on later dates, up to the end of growth, accumulated nutrients more effectively than plants of cultivar Sunday. Differences in the dry matter content in the apical bud upon the completion of growth resumption of the hybrid plants of cultivar Kronos sown on different dates were not significant (except the sowing on September 10th), in contrast with the ones of the plants of cultivar Sunday. This indicated that sowing time had a lower effect on hybrid plants preparation for wintering.

Plants of cultivar Kronos, of all the sowing dates, had a significantly higher dry matter content in the apical bud upon the completion of growth resumption compared with the plants of cultivar Sunday. After growth resumption during wintering, dry matter content in the apical bud of Kronos plants sown on August 20th and 30th decreased.

Upon growth resumption in the spring, the plants of cultivar Kronos sown on August 10th and 20th contained the highest content of dry matter (20.6-21.0%) in the apical bud, which was significantly more than did plants of the later sowing dates. The earliest-sown hybrid plants of cultivar Kronos showed the most intensive accumulation of dry matter in the spring. Dry matter content in the apical bud of the latest-sown (September 15th) Kronos plants did not significantly differ from the content in the plants sown on September 5th (Fig. 5).

Upon growth completion during wintering, total sugar content in the apical bud of the Sunday plants sown on all dates tended to decrease. During the three experimental periods, sugar content in the apical bud of plants sown on the first date varied the least, while that for the plants of the other sowing dates decreased. Upon growth resumption in the spring, total sugar content in the apical bud was even lower, except for the plants sown on September 10th (Fig. 6).

Upon the completion of growth resumption during wintering, the plants of the hybrid cultivar Kronos sown in September had a higher total sugar content in the apical bud compared with cultivar Sunday (Figs 6 and 7). With dry matter changes, total sugar content variation shows a better ability of the hybrid cultivar to prepare for wintering when sown on later dates. In the spring, upon growth resumption, the Kronos plants sown on August 30th had the most rapid increase in the sugar content in the apical bud (Fig. 7). During this period, no significant differences in sugar content were noted between the hybrid plants sown in August. At the end of growth resumption during wintering, total sugar content in the apical bud of the hybrid plants sown on September 10 was similar to the one after growth resumption in the spring. It amounted to 3.1% and 2.9%, respectively. Winter rapeseed of both cultivars sown on September 15th did not overwinter.

Sowing date had a significant effect on the overwinter survival of both cultivars. Plants of the hybrid cultivar Kronos showed better over-winter survival with plants ranging from 39.2 to 77.0%, while the over-winter survival of cultivar Sunday amounted to 12.8-53.9% (Table 2). The plants of cultivar Sunday showed the best over--winter survival (53.9%) when sown on August 30th. Plants sown earlier (August 20th) and later (September 5th) demonstrated poorer over-winter survival, but no significant differences were noted between those sowing dates (43.4-44.5%). The plants of the hybrid cultivar Kronos demonstrated the best over-winter survival when sown on August 30th and September 5th – 77.0% and 74.8%, respectively, and no significant differences between those sowing dates were found. The earlier (August 20th) and later (September 10th) sowing dates significantly reduced over-winter survival of plants, which was 56.2% and 55.5%, respectively. No significant differences in terms of over-winter survival were noted between those sowing dates either. For both cultivars, the plants of the sixth sowing date (September 15th) did not survive winter. This might have been influenced by their chemical composition, namely the lowest dry matter and total sugar content and the highest nitrogen to potassium ratio at the end of the renewed growth in autumn.

Table 2. Percentage amount of overwintering plants of winter rapeseed cultivars Sunday and Kronos (2009-2010)
Tabela 2. Procentowa ilość roślin rzepaku ozimego odmiany Sunday i Kronos po przezimowaniu (2009-2010)

Sowing date – Termin siewu	Overwintering – Przezimowanie, %	
	Sunday	Kronos
August 10 – 10 sierpnia	12.8d*	39.2c*
August 20 – 20 sierpnia	43.4b*	56.2b*
August 30 – 30 sierpnia	53.9a*	77.0a*
September 5 – 5 września	44.5b*	74.8a*
September 10 – 10 września	22.2c*	55.5b*
September 15 – 15 września	0e	0d

mean values marked with different letters (a, b, c…; sowing date) and asterisk (*, cultivar) are significantly different (P < 0.05) – średnie z różnymi literami (a, b, c…; termin siewu) i asteriskem (*, odmiana) różnią się statystycznie (P < 0,05)

After correlation-regression analysis, very strong and strong non-liner correlations (quadratic) occurred between the sum of temperatures ≥+2.0°C accumulated by plants and over-wintering as follows: cultivar Sunday – $y = -142.335 + 0.683x - 0.001x^2$; $r = 0.95$; $P < 0.01$; hybrid cultivar Kronos – $y = -156.598 + 0.812x^2$; $r = 0.79$; $P < 0.01$. This confirms the proposition that the winter rapeseed of the hybrid cultivar is less sensitive to the sowing date compared with the winter rapeseed of cultivar Sunday. The sum of temperatures ≥+2.0°C accumulated by the hybrid plants strongly correlated with successful overwintering (r = 0.79), and the sum of temperatures ≥+2.0°C accumulated by plants of Sunday cultivar correlated with successful overwintering very strongly (r = 0.95). Strong and very strong non-linear correlations (quadratic) between the number of leaves, root collar diameter, and the height of the apical bud of the winter rapeseed of cultivar Sunday and overwintering were noted (accordingly: r = 0.81; r = 0.95; r = 0.78. P < 0.01). Strong non-linear (quadratic and cubic) correlations between the number of leaves, root collar diameter, and the height of the apical bud of the winter rapeseed of cultivar Kronos and overwintering were established: (accordingly: $r = 0.86$; $r = 0.82$; $r = 0.76$, $P < 0.01$). It results from the obtained data that stronger correlations between the biometric parameters (except the number of leaves) of winter rapeseed rosette prepared for wintering and overwintering were of cultivar Sunday compared with cultivar Kronos.

Correlation-regression analysis showed a significant strong correlation (quadratic) between the amount of dry matter in the leaves and rapeseed overwintering of cultivar Sunday: $y = -1515.78 + 176.69x - 4.991x^2$; $r = 0.87$, $P < 0.01$; between the amount of dry matter in the apical bud and rapeseed overwintering of cultivar Sunday, a significant moderate strong linear correlation was established: $y = -82.46 + 6,29x$; $r = 0.57$, $P < 0.01$. Moderate strong significant correlation was shown between the N:K ratio in the leaves and overwintering of rapeseed cultivar Sunday: $y = -1430.53 + 1764.44x - 529.85x^2$; $r = 0.58$, $P < 0.05$; between the N:K ratio in the apical bud and over-wintering of rape cultivar Sunday – moderate strong significant cubic relationship: $y = -1155.53 + 1648.59x - 573.26x^2 + 4.25x^3$; $r = 0.65$, $P < 0.01$. Relation between the amount of total sugar in the leaves and overwintering of rapeseed cultivar Sunday was moderate strong linear: $y = -8.08 + 7.95x$; $r = 0.59$, $P < 0.01$, and between the amount of total sugar in the apical bud and overwintering of rapeseed cultivar Sunday was moderate strong quadratic: $y = -37.65 + 18.83x - 1.08x^2$; $r = 0.63$, $P < 0.01$.

Significant weak linear correlation was shown between the N:K ratio in the leaves and overwintering of rapeseed cultivar Kronos: $y = 187.01 - 82.62x$; $r = 0.42$, $P < 0.05$, significant moderate strong quadratic correlation – between the N:K ratio in the apical bud and overwintering of rapeseed cultivar Kronos: $y = -1419.43 + 2034.59x - 691.3x^2$; $r = 0.57$, $P < 0.01$. Between the amount of total sugar in the leaves and overwintering of rapeseed cultivar Kronos, significant moderate strong linear correlation was established: $y = -22.65 + 15.34x$; $r = 0.54$, $P < 0.01$, in the apical bud – significant moderate strong quadratic correlation: $y = -15.43 + 18.79x - 1.016x^2$; $r = 0.67$, $P < 0.01$. There was no relation between the amount of dry matter in the leaves and the apical bud and overwintering of both winter rapeseed cultivars.

CONCLUSIONS

1. Plants of the hybrid cultivar Kronos grew and developed more rapidly than the plants of cultivar Sunday. They produced on average 15.3% more leaves and 4.3% thicker root collars compared with cultivar Sunday of winter rapeseed plants. According to the biometrical indicators and chemical composition of the rosette, hybrid and cultivar Sunday of winter rapeseed plants sown between August 20th and September 5th were best prepared for wintering.
2. The best over-winter survival was demonstrated by the plants of both cultivars sown on August 30th and September 5th. The plants of the hybrid cultivar Kronos were noted for better over-winter survival, namely 39.2-77.0%, compared with that of cultivar Sunday – 12.8-53.9%.
3. The plants of the hybrid cultivar showed more intensive preparation for wintering and responded less sensitively to the sowing date and survived winter better than cultivar Sunday plants when sown both earlier (August 10-20th) and later (September 10th). When sown very late (September 15th), the plants of both cultivars did not survive winter due to insufficient development. The earliest-sown (August 10th) plants were overgrown and wintered more poorly (especially cultivar Sunday) than those sown later.

4. Dry matter content in the apical bud of the rapeseed of the hybrid cultivar Kronos sown on September 5-15th tended to increase when the growth resumption occurred during wintering. Total sugar content in it decreased more slowly than that of rapeseed cultivar Sunday sown on the same dates. This shows that the rapeseed of Sunday cultivar utilised the accumulated nutrients more intensively than that of the hybrid cultivar Kronos, which reduced their chances of surviving winter.

5. Upon winter rapeseed growth resumption in the spring, the plants of both cultivars exhibited the most rapid accumulation of dry matter in the apical bud when sown early – on August 10th and 20th. In the spring, at the beginning of growth, the hybrid plants sown on August 30th accumulated 7.9% more dry matter than cultivar Sunday plants.

6. The correlation-regression analysis of the experimental data showed that winter oilseed rape over-winter survival depended on the biometrical indicators of the rosette (number of leaves, root collar thickness, and apical bud height) and its chemical composition (dry matter and total sugar contents), as well as on the sum of temperatures ≥+2°C.

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WPŁYW JESIENNEGO TERMINU SIEWU NA PRZEZIMOWANIE MIESZAŃCOWEJ I KONWENCJONALNEJ ODMIANY RZEPAKU OZIMEGO

Streszczenie. Doświadczenie polowe przeprowadzono w latach 2009-2010 w Stacji Doświadczalnej Litewskiego Uniwersytetu Rolniczego (54°53’ N; 23°50’ E). Zastosowano różne terminy siewu dla dwóch odmian rzepaku ozimego (*Brassica napus* L. spp. *oleifera biennis* Metzg.). Celem badań była ocena wpływu terminu siewu dwóch odmian rzepaku ozimego na wartość parametrów biometrycznych w stadium rozety, skład chemiczny jesienią przed przezimowaniem, zmiany składu chemicznego w okresie jesienno-zimowym i przezimowanie. Termin siewu znacząco wpłynął na wszystkie badane cechy. Według parametrów biometrycznych, składu chemicznego liści i pąków wierzchoł-kowych, rzepak ozimy zasiany w terminie od 30 sierpnia do 5 września był lepiej przygotowany do przezimowania i w konsekwencji przezimował najlepiej. Wzrost w okresie przygotowania do przezimowania był bardziej intensywny, zmiany składu chemicznego w ciągu zimowania były korzystniejsze oraz przezimowanie mieszańcowej odmiany rzepaku ozimego Kronos było lepsze niż tradycyjnej odmiany rzepaku ozimego Sunday.

Słowa kluczowe: cechy biometryczne roślin, przezimowanie, rzepak ozimy, skład chemiczny, termin siewu

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