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EFFECT OF OVERWINTERING ON THE GROWTH AND DEVELOPMENT OF WINTER PEA (*PISUM SATIVUM* L.)

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Winter pea (*Pisum sativum* L.) cultivation in Lithuania is still at an early stage compared to other European countries, yet climate change and increasing spring droughts highlight the need for alternatives to spring-sown crops. Winter peas are considered a promising option as they fix atmospheric nitrogen, reduce the need for synthetic fertilizers, and may improve crop rotation sustainability. The aim of this study was to evaluate the influence of sowing date and seed rate on the overwintering and growth of winter peas under Lithuanian agroclimatic conditions.
A two-factor field experiment was established at the Vytautas Magnus University Agriculture Academy Experimental Station during 2024–2025. Three seed rates (90, 120, and 150 kg ha^{-1}) and four sowing dates (September 7, 14, 21, and 28) were tested in randomized blocks with four replications. Overwintering, plant height, branching, flowering, and pod formation were assessed, and data were statistically evaluated using ANOVA and correlation analysis.
Results showed that the highest seed rate (150 kg ha^{-1}) generally reduced overwintering success, especially in later sowings, while the lowest seed rate (90 kg ha^{-1}) ensured better survival. Plants sown on September 21 with 120 kg ha^{-1} achieved favorable height and branching, while late sowings (September 28) resulted in the lowest plant height. Seed rate had limited influence on pod formation, but sowing date significantly affected flowering and branching intensity.
It was concluded that moderate seed rates combined with optimal sowing dates are crucial for winter pea adaptation in Lithuania, offering potential to improve crop rotation resilience and reduce fertilizer dependency.

Keywords: *winter peas; Pisum sativum L.; seed rate; sowing date; overwintering; crop rotation; nitrogen fixation; climate change.*

INTRODUCTION

In Lithuania, the cultivation of winter peas (*Pisum sativum* L.) is not yet widespread, while intensive wheat and rapeseed crops dominate the agricultural landscape. These plants require large amounts of fertilizers, contributing to significant N_2O emissions. Climate change and increasing droughts during spring sowing push farmers to seek alternatives to summer crops. Attention is turning to the autumn sowing of those agricultural plants that have traditionally been sown in spring. Compared to other European Union countries, such as France and Germany, Lithuania is just beginning to develop sustainable practices for cultivating winter pulses like winter peas. In France and Germany, the cultivation of these plants is more integrated into crop rotation, allowing for better management of fertilizer use and reduction of N_2O emissions (Voisin et al., 2014; Gollner et al., 2019; Fateh, M'hand, 2020; Neugschwandtner et al., 2021). Research has shown that including winter peas in crop rotation is beneficial, as they consume significantly less soil water than winter wheat, and the residual nitrogen in the soil for subsequent crops is greater, leading to higher yields of summer wheat after winter peas compared to wheat following wheat (Schillinger, 2017; Neugschwandtner et al., 2015). Leguminous plants are particularly important in agriculture as they can fix atmospheric nitrogen and thereby help reduce the need for nitrogen fertilizers (Jensen et al., 2020). However, until now, only summer varieties have been cultivated in our country. It is expected that the productivity of summer cereals will decline in the coming decades due to anticipated changes in agro-climatic conditions. Average annual temperatures will rise, while total annual precipitation amounts and their distribution will decrease. Although precipitation will increase in autumn and winter, it will be less during spring and summer. This indicates that winter crops could gain greater significance in Lithuania's crop structure. Winter peas, like other legumes, can fix atmospheric nitrogen, thereby reducing the need for nitrogen fertilizers in the soil (Jensen et al., 2020;

Neugschwandtner et al., 2020). This is beneficial for the soil and decreases greenhouse gas emissions associated with fertilizer production and use. They serve as a good preceding crop for winter rapeseed or barley, which typically begins sowing quite early in the fall. In southern European regions, peas are often grown as winter crops. Sown in the fall for the winter growing season, peas mature well and cover the soil surface quickly, thus preventing soil degradation while saving moisture reserves. Increasing the cultivation of leguminous grains is essential in addressing a significant protein source shortage in Europe (Henseler et al., 2013). Several strategies are possible here, including the cultivation of legumes in intercropping systems with cereals (Neugschwandtner, Kaul, 2014) and shifting grain legume sowing from spring to autumn.

However, it is not enough to rely solely on the experiences of other countries; it is crucial to determine the best sowing time for our country's conditions to avoid frost damage. To successfully grow this variety in Lithuanian conditions, it is particularly important to prepare properly for sowing.

RESEARCH METHODS

A field experiment has been set up and will be conducted from 2024 to 2025 at the Vytautas Magnus University Agricultural Academy Experiment Station, focusing on the winter pea plot. A two-factor field experiment is established in the winter pea plot '*Arkta'*. Three different seed rates and four sowing times (delayed sowing every 7 days) are selected for winter pea sowing. The initial plot size is 80 m², and the accounting area is 48 m². The plot is divided into four repetitions.

Factor A – seed rate:
- 90 kg ha^{-1};
- 120 kg ha^{-1};
- 150 kg ha^{-1}.

Factor B – sowing time:
- September 7
- September 14;
- September 21;
- September 28.

The soil at the experiment station is categorized as IDg8-k (LVg-p-w-cc) – calcareous, shallow, clayey, leached soil (Calc(ar)i-Epihypogleyic Luvisol). The soil texture is light loam, mixed with medium and heavy loam. This area belongs to the sandy and dusty loams of the Nemunas River mid-region plateau, characterized by ordinary and calcareous leached soils. The arable layer of the soil is 20-25 cm thick. The agrochemical properties of the experimental soil were evaluated in 2020 at the LAMMC, Agricultural Institute's Chemical Research Laboratory. The soil pH is close to neutral at 6.0–6.7, with high to very high phosphorus content averaging 285.8 mg kg^{-1}, and high potassium content at 240.0 mg kg^{-1}. In the fields of our experiment, the organic carbon (Corg) content ranged from 1.28 to 1.11%, and total nitrogen (Ntotal) ranged from 0.110 to 0.009%.

In the selected location for the experiment, winter barley was the preceding crop for winter peas in 2023. After harvesting, the field was rolled to break down any germinated weeds and volunteer plants. Once the volunteers and weeds emerged, the field was rolled again, and it was tilled to a depth of 14–16 cm two weeks before pea sowing. Prior to sowing, the field was cultivated, and peas were sown at three different rates (90, 120, 150 kg ha^{-1}) for winter peas. After 7, 14, and 21 days, with shallow cultivation performed before each sowing.

Plant overwintering will be evaluated at the beginning of spring vegetation. In permanent plots, plants will be excavated, washed, and surviving individuals counted, recalculated per square meter, and the percentage of overwintering determined.

Root development and nodule formation will be assessed at full flowering of peas (BBCH 64–65). Ten plants will be randomly excavated without damaging the roots, which will then be washed, weighed, and their length measured. The number of nitrogen-fixing nodules will be counted, and the dry mass of the root system determined.

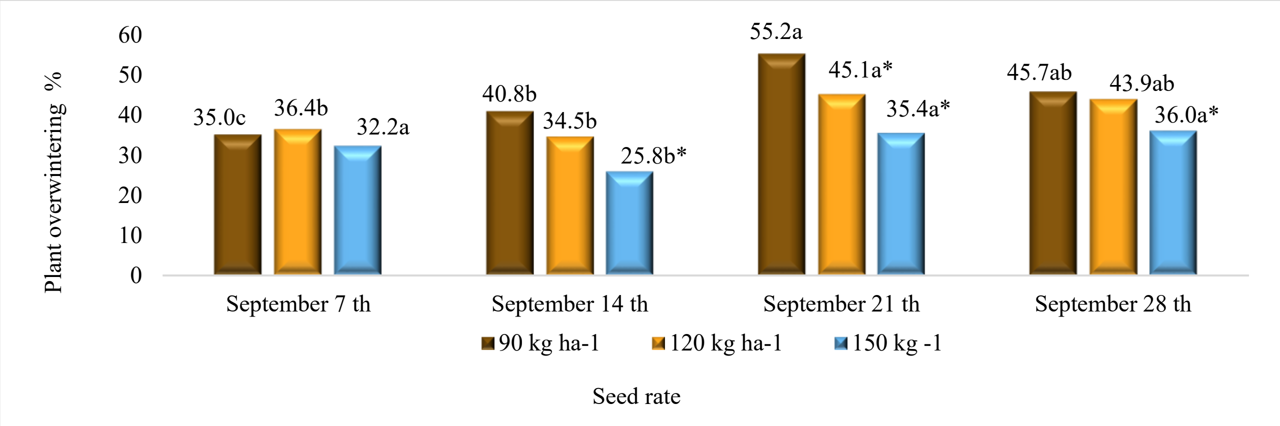
Biometric traits of plants will also be measured at full flowering (BBCH 64–65). Ten randomly selected plants will be measured and weighed, their dry mass determined, and the number of inflorescences and pods recorded.

The research results will be evaluated using two-factor analysis of variance (ANOVA), applying Fisher's criterion and the least significant difference at R0.05, 95% probability level. Statistical evaluation will be performed using the software package "SELEKCIJA" (Raudonius, 2017). Correlation and regression analyses will be used to assess trait interrelationships with the statistical software STATISTIKA.

RESEARCH RESULTS AND DISCUSSION

During the autumn and winter period of 2024–2025, meteorological conditions were favorable for the overwintering of cereals and oilseed rape; however, winter peas overwintered less successfully, and their survival strongly depended on both seed rate and sowing date (Fig. 1). Previous studies have noted that prolonged development of winter peas under unfavorable weather conditions may negatively affect plant morphology and growth (Klimek-Kopyra et al., 2023). The overwintering performance of peas in this trial may have been influenced by extended mild spells in January and February 2025, when positive air temperatures persisted for nearly two decades. During this time, the peas resumed vegetation and depleted their stored reserves, and as a result, when frosts returned at the end of February without a protective snow cover, part of the crop was lost.

Plants sown at the highest seed rate of 150 kg ha⁻¹ generally overwintered worse than those sown at lower rates of 90 and 120 kg ha⁻¹. The only exception was the earliest sowing (September 7), where seed rate had no significant effect. When sown on September 14, the 150 kg ha⁻¹ rate resulted in 39.2% poorer survival compared with the two lower rates. With a one-week delay (September 21), survival at the highest seed rate was significantly lower, by 35.8% and 21.5%, respectively. For the latest sowing (September 28), reductions reached 21.2% and 18%. The best overwintering was observed in plots sown with the lowest rate (90 kg ha⁻¹) on September 21, compared with the same rate on September 7 and 14. When peas were sown one week earlier (September 14) or later (September 28) at the same low rate, survival was still better than with 120 or 150 kg ha⁻¹. At later sowing dates (September 21 and 28), peas sown at 120 kg ha⁻¹ overwintered on average 25.7% better than those from earlier sowings (September 7 and 14).



Note. Treatment means marked with an asterisk (*) indicate a significant effect of seed rate, while means followed by different letters (a, b, …) indicate a significant effect of sowing date.

Fig. 1. Percentage of overwintered pea plants in the field

Evaluation of winter pea development at full flowering (BBCH 63–65) showed that the tallest plants were obtained from the September 21 sowing at a seed rate of 120 kg ha⁻¹ (Fig. 2). When sown at 90 kg ha⁻¹ on September 14, plant height during peak flowering did not differ significantly compared with peas sown one week earlier (September 7) or one week later (September 21), but it was 14.0% lower compared with the September 28 sowing. According to Šarūnaitė et al. (2013), winter peas were taller than spring peas by the end of May. In the present study, delaying sowing to September 28 at the highest seed rate (150 kg ha⁻¹) significantly reduced plant height, on average by 18.8%, compared with sowings one week earlier (September 21) and two weeks earlier (September 14).

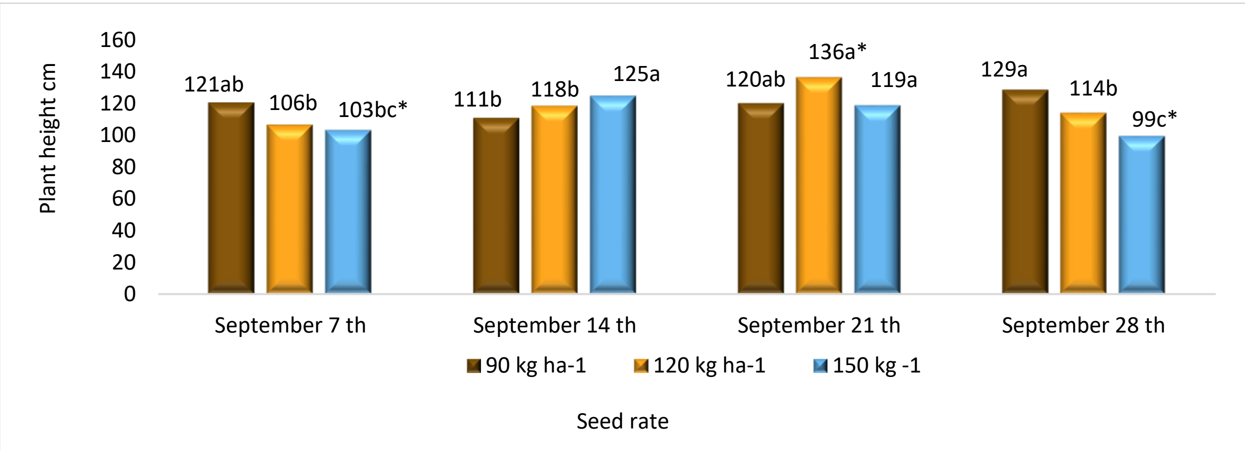


Fig. 2. Average height of a single winter pea plant (BBCH 63–65)

Researchers have indicated that as the winter hardiness of legumes increases, biomass production generally rises, and a strong correlation is often observed between overwintering success and the development of aboveground biomass (Dumont et al., 2009; McGee et al., 2013). However, in our experiment, no correlation was found between the density of overwintered plants and their aboveground biomass or height.

Assessment of winter pea development at full flowering (BBCH 63–65) showed that seed rate had no significant effect on the number of pods per plant (Fig. 3). A general tendency was observed that increasing the seed rate reduced the pod number per plant. The highest pod numbers were recorded in peas sown at 90 and 120 kg ha⁻¹ on September 7, whereas with higher seed rates the number of pods decreased, though not significantly. The smallest differences were noted when sowing was delayed by one week (September 14). Sowing date had a more pronounced effect on pod formation: delaying sowing by two or three weeks (September 21 and 28) resulted in significant differences compared with earlier sowings. Between the earliest sowings (September 7 and 14), no significant differences in pod number per plant were identified.

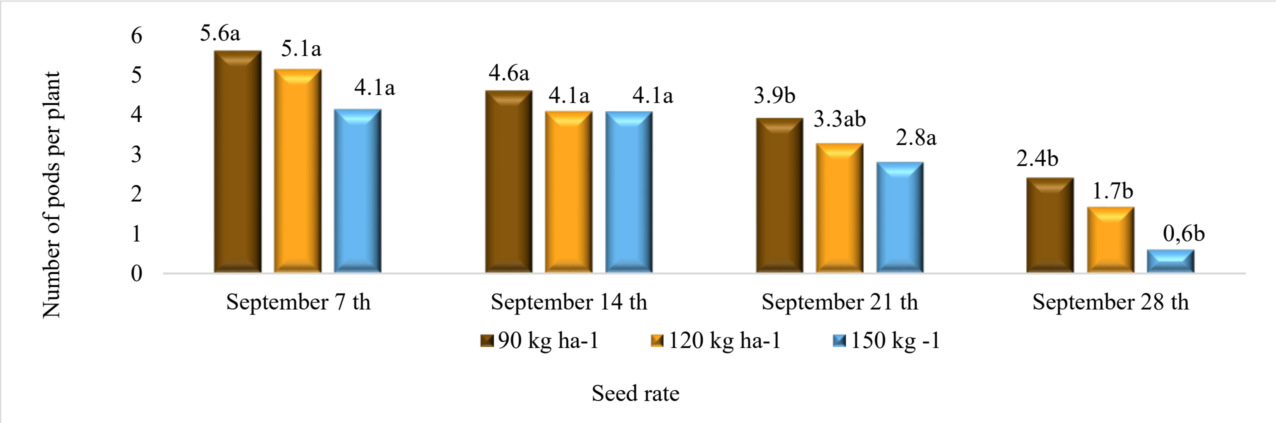


Fig. 3. Average number of pods per winter pea plant (BBCH 63–65)

Winter peas sown at the lowest seed rate (90 kg ha⁻¹) on September 7 flowered more intensively compared with those sown at the same date with a higher seed rate of 120 kg ha⁻¹, the difference being significant at 39.1% (Fig. 4). When sowing was delayed by one or two weeks (September 14 and 21), seed rate had no significant effect on the number of flowers per plant. However, at the latest sowing date (September 28), increasing the seed rate to 150 kg ha⁻¹ significantly reduced the number of flowers by 34.7%.

Sowing date itself had a marked influence on flowering intensity. Plants sown early (September 7) at 90 kg ha⁻¹ and those sown at the latest date (September 28) produced more flowers. Winter peas sown on September 21 at 120 and 150 kg ha⁻¹ formed a greater number of flowers per plant compared with earlier and later sowings. The fewest flowers were recorded in plants sown at the highest rate (150 kg ha⁻¹) at the latest sowing date (September 28), but a significant reduction of 33.6% was observed only in comparison with the sowing one week earlier (September 21).

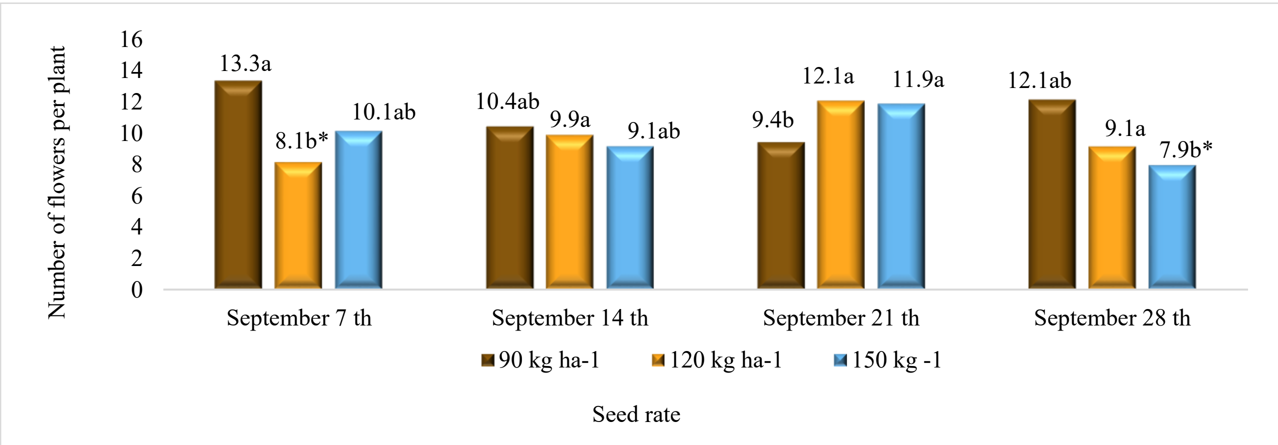


Fig. 4. Average number of flowers per winter pea plant (BBCH 63–65)

An increase in seed rate at the earliest sowing date (September 7) had no significant effect on the number of branches in winter pea plants. However, when sowing was delayed by one week (September 14), plants sown at the highest seed rate (150 kg ha⁻¹) produced 37.5% fewer branches compared with those sown at 90 kg ha⁻¹ (Fig. 5). At the sowing date of September 21, peas sown at 120 kg ha⁻¹ formed significantly more branches—on average 71.4% more—compared with those sown at 90 and 150 kg ha⁻¹. Plants sown at the latest date (September 28) branched the least, and increasing the seed rate to 150 kg ha⁻¹ significantly reduced the number of branches per plant by 28.6%. Although winter peas sown at 120 kg ha⁻¹ on September 21 were less dense compared with those sown at 90 kg ha⁻¹, no correlation between plant density and branching was observed.

A positive correlation was established between the number of branches, pods, and flowers per plant and the aboveground biomass (Fig. 6). With increasing seed rate, plant biomass as well as the number of branches, pods, and flowers per plant increased. However, the average plant biomass showed a negative correlation with higher seed rates, as aboveground mass decreased when seed rate increased. It can be assumed that stand density and delayed sowing date influenced winter pea development, although the correlations obtained were weak to moderate in strength.

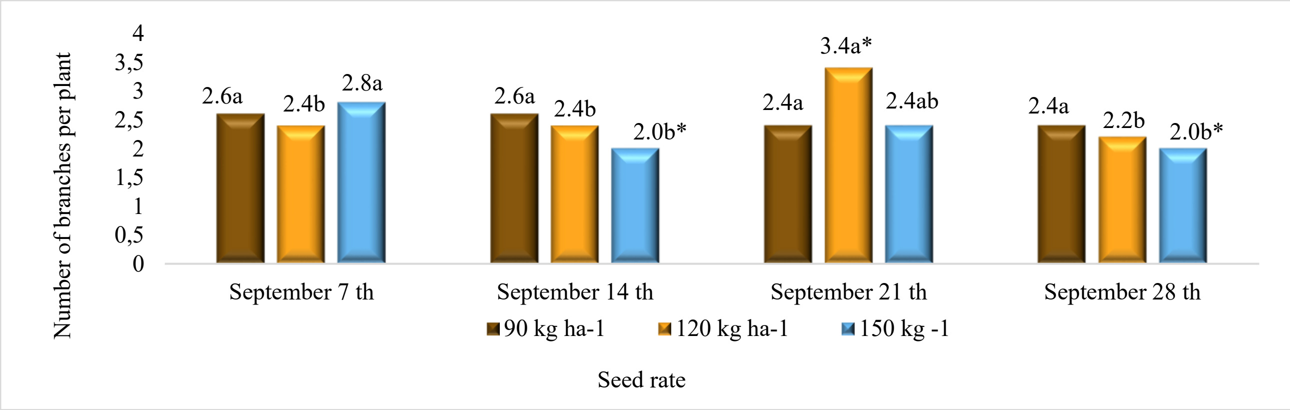


Fig. 5. Average number of branches per winter pea plant (BBCH 63–65)

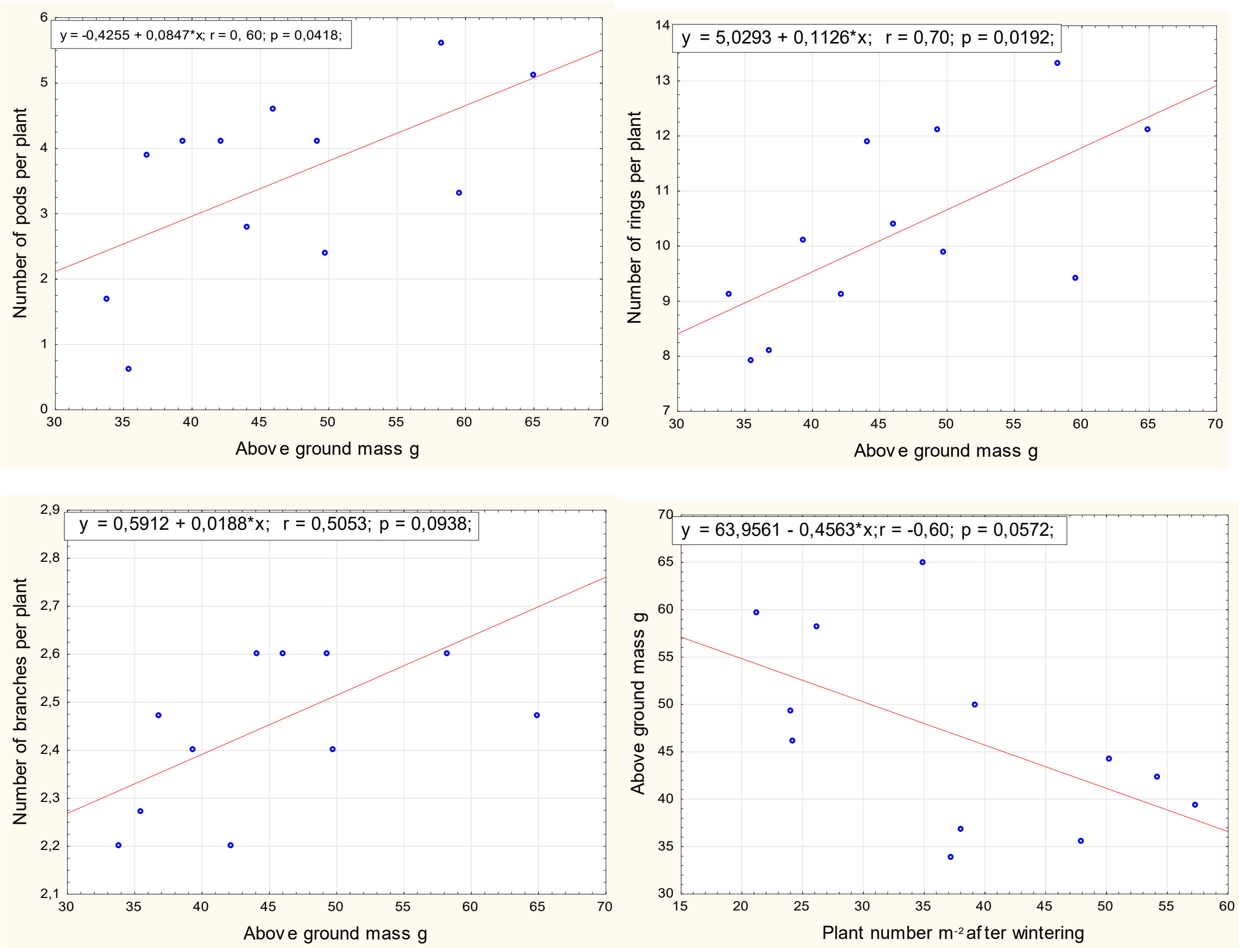


Fig. 6. Correlation dependencies of winter pea development traits on aboveground plant biomass with increasing seed rate Correlational dependence of winter pea biomass indices on aboveground plant mass with increasing seeding rate

CONCLUSIONS

Winter peas sown at the highest seed rate (150 kg ha^{-1}) overwintered worse compared with those sown at lower rates (90 and 120 kg ha^{-1}). Only in the earliest sowing (September 7) did seed rate have no significant effect.

Peas sown earlier (September 7) at the lowest rate (90 kg ha^{-1}) were taller, while in later sowings (September 14 and 21) taller plants were obtained at 120 and 150 kg ha^{-1}. The latest sowing (September 28) resulted in the shortest plants.

Increasing seed rate raised the biomass of winter peas as well as the number of branches, pods, and flowers per plant. However, the average plant biomass showed a negative correlation with seed rate, as aboveground mass decreased when the seed rate was increased.

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