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ВПЛИВ ЩІЛЬНОСТІ АГРОЦЕНОЗУ ГОРОХУ ПОСІВНОГО НА ЙОГО ЗЕРНОВУ ПРОДУКТИВНІСТЬ

Анотація. *Наведено аналітичний огляд вітчизняних і зарубіжних літературних джерел щодо встановлення оптимальної щільності агроценозу гороху посівного (Pisum sativum L.) залежно від ґрунтово-кліматичних умов зони вирощування, сортових особливостей та інших чинників. В результаті проведеного аналізу встановлено, що науковці та виробничники й до нині не мають єдиної думки щодо встановлення оптимальної норми висіву для польового ценозу гороху посівного. Велика кількість повідомлень має значну давнину, виконана за різних регіональних умов, а комплексні дослідження з вивчення впливу норм висіву, способу сівби та погодних умов на формування врожаю зерна гороху в умовах нестійкого зволоження Правобережного Лісостепу України не проводилися зовсім.*
Ключові слова: *горох, норма висіву, спосіб сівби, щільність агроценозу, врожайність.*

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ВЛИЯНИЕ ПЛОТНОСТИ АГРОЦЕНОЗА ГОРОХА ПОСЕВНОГО НА ЕГО ЗЕРНОВУЮ ПРОДУКТИВНОСТЬ

Аннотация. *Приведен аналитический обзор отечественных и зарубежных литературных источников по установлению оптимальной плотности агроценоза гороха посевного (Pisum sativum L.) в зависимости от почвенно-климатических условий зоны выращивания, сортовых особенностей и других факторов. В результате проведенного анализа установлено, что ученые и производственники и в настоящее время не имеют единого мнения относительно установления оптимальной нормы высева для полевого ценоза гороха посевного. Большое количество сообщений имеет значительную древность, выполненны при различных региональных условиях, а комплексные исследования по изучению влияния норм высева, способов сева и погодных условий на формирование урожая зерна гороха в условиях неустойчивого увлажнения Правобережной Лесостепи Украины не проводились вовсе.*
Ключевые слова: *горох, норма высева, способ сева, плотность агроценоза, урожайность.*

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EFFECT OF DENSITY OF PEA AGROCENOSIS ON ITS SEED PRODUCTIVITY

Abstract. *The analytical review of domestic and foreign literary sources regarding the determination of the optimal density of pea agrocenosis (Pisum sativum L.) depending on the soil-climatic conditions of the growing zone, varietal characteristics and other factors is given. As a result of the analysis, it is established that scientists and producers still do not have a common opinion on the determining the optimum seed rate for sowing peas. A large number of messages have a long history performed in different regional conditions and comprehensive studies on the influence of seed rates, sowing methods and weather conditions on the pea productivity under the conditions of unstable moisture of Right Bank Forest-Steppe of Ukraine were not conducted at all.*
Key words: *peas, seeding rate, sowing method, density of agrocenosis, productivity.*

Problem statement. Plant density is one of the most important elements of technology which significantly influences the crop yield. The future harvest of peas, as well as field infestation and productivity of subsequent crops depend on its correct choice [1].

The largest assimilation surface of agrocenosis from the beginning of the growing season can be achieved only due to the even placement of plants per unit area [2]. Under such conditions, both diffused radiation and direct solar rays are better and in larger quantities come into plants, the intra-type competition of such cenosis is minimizing and it develops better [3].

The feeding area of plants is an important factor in obtaining high and stable pea crops [4].

In XVIII century, I. M. Komov (1785) recommended in relation to the establishment of the sowing rate that "... bread should not be sown densely and excessively rarely... In the good soil, in warm and humid weather, fewer seeds can be sown and in worse weather more seeds should be..." [5].

One of the first significant scientific works devoted to the theoretical substantiation of sowing methods and norms of sowing of agricultural crops, most scientists consider the work of the famous German scientist E. Volni "Sowing and care for agricultural crops" (1885), in which the author pointed out [6] that with the increase in the feeding area, the productivity of plants first grows rapidly and then it does not matter how much it increases, it grows slowly. The yield increases with a decrease in the feeding area and an increase in the density of stems but to a certain extent, until one of the increase factors does not begin to limit the growth and development of plants.

It is known that the level of productivity of grain crops depends on the density of productive plant stand by 50%, on the individual productivity of plants by 25% and on the weight of formed grain by 25%. It has been found that the biggest density of productive plant stand is optimum which excess reduces the sowing productivity. It depends both on agrotechnological conditions, characteristics of each crop and variety.

Today, pea sowing rates in main areas of its cultivation vary widely – from 135 to 300 kg/ha or from 0.6 to 2.1

million similar seeds per hectare of sowing [7, 8]. As you can see, the interval is quite wide. Therefore, it is ***important*** to determine the optimum seeding rate for a particular growing zone, since practice shows that both thickened and thinned crops are unproductive.

Material and methods. During the research, general scientific methods were used, in particular, such as: hypothesis, observation, analysis, synthesis, induction and deduction, abstraction and generalization. The material was own observations and references on the chosen direction of studies.

Research results. Peas require an optimal feeding area which affects lighting, supply of nutrients and water for normal growth and development [9].

The feeding area is determined by the method of sowing and the seeding rate. With regard to seeding rates, there is a lot of data that shows that in some cases seeding rates affect yield and in others it almost does not depend on this element of technology.

It is found [10] that under the conditions of Western and Right Bank Forest-Steppe for large-seeded varieties the recommended seed rates are 1.0–1.2 million similar seeds/ha and in Left Bank Forest-Steppe they are 0.9–1.1 million seeds. At the same time, one of the main reasons for obtaining low yields of this crop is insufficient seeding rate. This is especially true for individual varieties.

I. V. Yakushkin also proves [11] that the best seeding rate for Forest-Steppe and Polissia should be 1.0–1.2 million similar seeds/ha and for the conditions of insufficient moisture the level of this indicator can be reduced by 25%.

Seeds of individual varieties of peas vary in size. So, depending on the growing conditions, the thousand-kernel weight of the same variety varies in a significant range, therefore, the seed rates must be adjusted annually. In particular, it is necessary to observe certain seed rates for large-seeded varieties.

Under the conditions of the Ukrainian Forest-Steppe determining the seed rate Y. F. Oleksenko [13] recommends to take into account the seed size, as well as the provision of plants with moisture and the optimum level of seeding is considered at the level of 1.1–1.5 million seeds/ha.

It is found that seeding with low seeding rates causes crop infestation and significantly reduces crop yields [14]. In turn, thickening of crops in the humid zone leads to the formation and damage of plants with fungal diseases. According to the authors [15], the optimum seeding rate is 1.2 million similar seeds per 1 hectare sown by the usual row or narrow row method for varieties in non-chernozem regions.

However, according to the research carried out under the conditions of Oriol region [16] it is found that pea sowing with a quantitative seed rate of 1.4 million similar seeds per 1 hectare provides the optimal density of its agrocenosis and, accordingly, the longest productive period of photosynthetic activity of its maximum leaf surface is 48–51 thousand m2/ha. In addition, peas are the best suppressors of weed plants at such density of sowing.

According to the results of many years of research [17], the largest yield of medium grain pea varieties is in crops planted by a standard rotational sowing method with a seed rate of 1.2 million similar seeds per hectare. This rate provides the plant density for the period of harvesting (106–109 seeds/m^2) and the assimilation surface has the best use of solar energy. However, under arid conditions, the seed rate of 1.4 million seeds/hectare provides an additional increase in grain yield at the level of 0.04–0.14 t/ha.

Long-term experiments of Uladovo-Lulinetska Selection Research Station have shown [18] that both overweight and underweight of seeding rate negatively affects the crop productivity. Thus, under the conditions of excessive thickening, conditions are created that cause mutual shading of plants and excessive growth of the stem. In addition, it is found that under the thickening conditions, the assimilation capacity of plants, number of fetal nodes, beans and seeds in them decreases. As a technological characteristic of crops (the thousand-kernel weight and the yield level are reduced), as a qualitative characteristic (protein content in the seed and its seed quality) are also significantly deteriorating. At the same time, thickening of crops less significantly affects the yield reduction compared with their thinning. The seed rate can be reduced on fertile weed-free soils and it should be increased on soils with weeds [19].

For medium-seed varieties the optimum seeding rate is 1.2 million similar seeds per hectare [20]. A deviation from this indicator in the direction of a decrease of 0.2 million is accompanied by a significant shortage of crops and the excess for the same amount does not pay off the received gain on the incurred costs of seed material. At the same time, the author notes that under the conditions of Forest-Steppe, the optimum seeding rate of peas is 1.2–1.3 million similar seeds per hectare, both in the narrow-row and the ordinary row sowing. Under the conditions of Steppe (Zaporizhzhia, Donetsk region and Crimea), the optimum seed rate is 1.0 million similar seeds per hectare and its increase to 1.2 million seeds does not increase the crop yield. In Odesa region, in the zone of Balta and Kilichivsk variety plots, the largest crop was obtained with 1.2 million seeds per hectare.

R. Sandstead and others [21] also argue that the highest yield of peas is obtained in sowing with the seed rate at the level of 1.2–1.4 million similar seeds/ha. They do not recommend higher seed rates because as a result of seed costs in market conditions, this greatly increases the harvest cost.

Two-year studies in the Republic of Moldova [22] show that the optimum seeding rate for pea seeds is in the range from 1.2 to 1.4 million similar seeds per hectare. However, according to the results of many years of research carried out in the non-chernozem zone, [23] it has been determined that the optimum plant density of legumes depends on their level of moisture and nutrient content. Thus, the most favorable rate for peas in the fertilized soil is 1.4 million similar seeds per 1 hectare and in the case of seeding in unfertilized areas it is 1.2 million. However, for fast-growing and low-growing varieties in poor soils, the seed rate should be increased by 10–15%.

A correct seeding rate contributes to the optimum rates of increase in the area of the assimilating surface. It is also found [24] that there is the certain dependence between the leaf surface formation and the harvest. According to these data, the use of ordinary row sowing with a seed rate of 1.2 million similar seeds per hectare is the most appropriate. Deviations from this rate both in the direction of increase and decrease are accompanied by a corresponding decrease in the assimilation area of leaves and grain yield. The seed rate of 1.4 million seeds is most effective in narrow row and cross sowing methods. Under such parameters of seed placement per unit area, grain yield increases by 1.0–1.5 c/ha.

According to the observations of German scientists [25], when choosing the optimum seeding rate, it is the most appropriate to choose upper recommended limit compared with the lower one. Also, under optimal conditions, the authors recommend to sow 1.0 million similar seeds/ha and under unfavorable conditions there should be 1.1 million similar seeds/ha. In addition, it is noted that in dense pea sowing, plant flowering is more friendly, in formed seeds there is greater mass and maturation is 1–2 days earlier.

Agroecological studies carried out in non-chernozem zone in soddy-podzolic soils [7] show that in the cultivation of small and mid seeded pea varieties the optimum quantitative seed rate is 1.2–1.4 million similar seeds per 1 hectare sowed by the usual row method. Under the conditions of insufficient moisture and in sandy soils, the sowing rate decreases to 1 million similar seeds/ha. As a result of the analysis, more than two thousand experiments on the study of pea sowing rates in state selection stations, the following rates were the best for all groups of varieties: Polissia and Forest-Steppe – 1.2–1.4 million similar seeds/ha; Steppe – 0.9–1.1 million similar seeds/ha; dry Steppe – 0.8–0.9 million similar seeds/ha. At the same time, upper limits of rates refer to small and

medium-seeded varieties (with the thousand-kernel weight up to 200–250 g) and lower ones refer to large-seeded varieties (with the thousand-kernel weight more than 250 g).

In areas with sufficient moisture, seed rates are significantly higher than in dry areas. Such conditions ensure the formation of significantly greater yield. In this case, higher seed rates are most grounded where spring soaking of soil with moisture reaches the depth of more than 100cm [7]. As a rule, under the conditions of Steppe the soil soaking less than 70 cm, so seeding rates should be reduced to decrease the intra-species competition of pea cenosis. The lowest seeding rates are under the conditions of Dry Steppe in brown soils where the soil soaking is often less than 40 cm.

There are other recommendations. Thus, according to the results of research carried out under the conditions of Uladovo-Lulinetska Selection Research Station [26] in low-humus chernozem and the main application of $P_{60}K_{60}$, the optimum seed rate for varieties of Aronis type is 1.8 million seeds/ha, Coral is 1.2 million seeds/ha and Uladivsky Kharchovyk is 1.5 million similar seeds/ha.

The research results carried out under the conditions of Northern Forest-Steppe [27] indicate that thickened sowings (1.5 million similar seeds/ha), due to the increased competition of plants for soil moisture consumption, reached 5 days earlier compared with thinned sowings (1.0 million similar seeds/ha). At the same time, an increase in the seed rate to 1.5 million seeds/ha caused a significant increase in grain yield at the level of 0.41–0.60 tons/ha.

American scientists believe [28] that in order to ensure optimal conditions for the growth and development of plants of medium ripe pea varieties, the density should be at the level of 1.6 million plants/ha (25 seeds/meter of a row); for late ripe varieties, the optimal density is 1.1 million plants per hectare (16 seeds/meter of a row). With such density sprouts successfully compete with weeds.

According to others [29], raising seeding rates to 1.5–1.8 million seeds/ha contributes to the optimal distribution of seeds in a row, and hence the creation of the optimal plant nutrition regime. At the same time, increasing seeding rates in arid years leads to a decrease in plant height and in wet years it leads to increasing.

In the United States, seeding rates for early ripe pea varieties almost did not affect the plant flowering time, number of seeds in the beans and yield. Thus, the highest seed yield was in variants with seeding rates of 1.8 to 2.2 million similar seeds/hectare [30].

In order to accelerate the reproduction of new and promising varieties, especially in clean soils without weeds, it is recommended to double the recommended seed rate for the zone. This method is widely used in selection and seed work [20].

Researchers in Ukraine and Latvia have established [31, 32] that the multiplication factor for pea seeds at doubled seeding rates is 2–4 times higher, compared to the recommended ones. However, due to insufficient control of weed infestation in crop sowings, there is a significant inhibition of cultivated plants by weeds.

There are also opposite data. So, other Ukrainian researchers argue [33] that the number of beans on plants, grain mass and their number in beans increases with a decrease in seeding rates. However, thickening of crops is of particular importance in selection work because it allows obtaining high quality seed material.

In the scientific literature there is evidence that seeds from thickened crops are even and have higher similarity [34].

Conclusion. From the above review of references, it is evident that views of both scientists and producers on plant density even under similar conditions of cultivation are quite controversial. However, most of them agree that sowing with the low seeding rate some factors remain unused that determine the level of seed productivity and we do not get the full economic effect of sowing. In thickened crop sowing there is a general inhibition of all plants and a competitive struggle for nutrients, moisture, light and other factors of life is increasing which leads to a sharp decline in yield and increase in its heterogeneousness. Therefore, it is clear that under all conditions, the development of zonal technology for growing peas must be carried out taking into account the specific soil-climatic conditions, nature of the use of basic products (food, feed and seed purposes) and specifically for each new type introduced into production.

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