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RESEARCH ARTICLE

Formation of yield and quality of chickpea seed products under climate change

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Abstract

The aim of the study is to determine the peculiarities of yield and quality of chickpea seeds depending on the varietal composition, pre-sowing seed treatment with a bacterial preparation and the use of different concentrations of retardant. The variant treatment of seeds with *Rizogumin Plus* and double treatment of crops with the retardant chlormequat chloride was distinguished by the manifestation of the studied traits: first in phase of the 3rd trifoliate leaf, second in budding phase. The maximum content of crude protein in seeds of chickpea variety Pegas 30.42% and 28.26% in variety Skarb was noted in variants where the bacterial preparation *Rizogumin Plus* was used for pre-sowing seed treatment and double spraying of plants with 0.75% solution of retardant during the vegetation.

Keywords: Chickpea, Variety, Pre-sowing seed treatment, Growth regulating substances, Yield, Quality

Introduction

In Ukraine, demand is growing and area under chickpeas is expanding: over the past 10 years, the area under chickpeas has increased more than 10 times, amounting to about 50 thousand hectares-70 thousand hectares (Vdovenko S.A. et al., 2018; Kaletnik G. et al., 2020). It is known that chickpea growing regions are characterized by unstable weather conditions due to climate change, especially in summer, including frequent droughts, which cause a decrease in yield of both legumes and other crops. That is why it is important to grow drought-resistant crops, which include valuable legume chickpea (Pantsyreva H.V. 2019; Honcharuk I. et al., 2023). At this stage development of domestic crop production, which is focused on principles of sustainable development, it is important to obtain high-quality seed products with minimal use of synthetic products, including organic compounds containing nitrogen. In view of this, in conditions of climate neutrality, it is important to increase productivity and sown areas under chickpea and the supply of biological nitrogen to the soil for subsequent crops (Bondarenko V. et al., 2022). Symbiotic nitrogen fixation plays a leading role in providing agrocenoses with biological nitrogen, which improves soil fertility, reduces energy costs in chickpea cultivation technology

and negative environmental impact (Kaletnik G. & Lutkovska S. 2020). Thus, the use of biological products and growth regulating substances in chickpea cultivation allows to obtain a stable yield of this crop with high seed quality.

Materials and Methods

The field research was conducted in 2018-2022 at the experimental field of Vinnytsia National Agrarian University. The soil of experimental field is gray forest medium loam. The predecessor was winter wheat. We studied varieties of common chickpea Skarb and Pegas, sowing the crop in a wide row method with a row spacing of 45 cm and a seeding rate of 500 thousand germinating seeds per 1 ha. Agricultural practices in experiment were generally accepted for the region. The field experiments were laid out in quadruplicate, randomized, with a plot size of 25 m^2. The scheme of field experiment was as follows: control (no treatment), seed inoculation (treatment of seed with the biological preparation *Rizogumin Plus*), concentration of retardant (no treatment, 0.5%, 0.75% and 1% solution). Field and laboratory studies were conducted on following indicators: chickpea yield, fat and crude protein content in seeds according to generally accepted methods (Tkachuk O. et al., 2024; Yanovich V. et al., 2018).

On day of sowing, chickpea seeds were treated with the bacterial preparation *Rizogumin Plus* (600 g per hectare of seeds). During vegetation period (3^{rd} trifoliate leaf and budding phases), the retardant chlormequat chloride (750 g/l), BASF CE, Germany, in different concentrations (working solution rate of 200 l/ha), which belongs to the group of quaternary ammonium compounds, was used in experimental variants according to scheme. It was proved that for formation of maximum yield of chickpea grain, it is necessary to apply two-time treatment of crops with the retardant chlormequat chloride: first in phase of the 3rd trifoliate leaf, second in budding phase (Hetman N. et al., 2024; Monarkh V.V. and Pantsyreva H.V. 2019).

Results and Discussion

The studies have shown that combination of seed bacterization and double treatment of chickpea plants during growing season with a retardant has a positive effect on increasing yield of all varieties subject to study. The seed yield was determined by genetic characteristics of the species and varied in different ranges depending on the variety (Tab. 1).

Table 1. Seed yield of common chickpea varieties depending on cultivation practices, t/ha (average for 2018-2022).

Variety	Concentration of retardant, %	Pre-sowing seed treatment	
		Untreated	*Rizogumin-Plus*
Skrab	untreated (control)	2.14	2.32
	0.5	2.19	2.4
	0.75	2.33	2.53
	1	2.26	2.46
Pegas	untreated (control)	2.28	2.54
	0.5	2.37	2.79
	0.75	2.56	3.02
	1	2.45	2.87

$HIP_{0.05}$ t/ha (chickpea): A-0.02; B-0.03; C-0.03; AB-0.02; AC-0.04; BC-0.14; ABC-0.05

2018 $HIP_{0.05}$ t/ha: A-0.01; B-0.01; C-0.03; AB-0.02; AC-0.02; BC-0.02; ABC-0.04

2019 $HIP_{0.05}$ t/ha: A-0.02; B-0.02; C-0.03; AB-0.02; AC-0.02; BC-0.02; ABC-0.04

2020 $HIP_{0.05}$ t/ha: A-0.02; B-0.03; C-0.03; AB-0.02; AC-0.02; BC-0.02; ABC-0.05

2021 $HIP_{0.05}$ t/ha: A-0.02; B-0.01; C-0.02; AB-0.03; AC-0.03; BC-0.03; ABC-0.06

2022 $HIP_{0.05}$ t/ha: A-0.03; B-0.02; C-0.03; AB-0.03; AC-0.02; BC-0.02; ABC-0.03.

It was established that treatment of vegetative crops of chickpea varieties Skarb and Pegas with retardant chlormequat chloride at a concentration of 0.75% in phases of the 3rd trifoliate leaf and budding provides the best conditions for growth, development and formation of high yields at level of 2.53 t/ha-3.02 t/ha.

According to data of analysis of variance, the share of influence of studied factors on formation of chickpea seed yield was determined. Thus, seed bacterization ensured formation of 19.6% of seed yield, variety 31.3%, chickpea treatment with chlormectate chloride in different concentrations 18.0% of yield, 8.1% interaction of factors, 23.0% hydrothermal conditions and other unaccounted factors.

An important criterion for value of chickpea seeds, which largely determines their overall quality and marketability, is chemical composition, especially content of crude protein and fat, which depends on a number of factors, but main ones are varietal characteristics and technological methods of cultivation (Mazur V. et al., 2021; Didur I. et al., 2020). According to results of determining content of crude protein and fat in chickpea seeds, it was found that maximum values of these indicators were formed under conditions of a combination seed bacterization with *Rizogumin Plus* and two-time treatment of plants with a 0.75% solution of retardant during growing season. The minimum content of crude protein and fat in chickpea seeds was obtained in control variant (Tab. 2).

Table 2. Crude protein and fat content in seeds of common chickpea varieties depending on cultivation practices, t/ha (average for 2018-2022).

Variety	Concentration of retardant, %	Pre-sowing seed treatment			
		Untreated		*Rizogumin-Plus*	
		Content in chickpea seeds, %.			
		crude protein	fat	crude protein	fat
Skrab	untreated (control)	21.11	3.23	23.84	3.29
	0.5	23.77	3.34	25.95	3.41
	0.75	26.53	3.49	27.66	3.61
	1	25.72	4.42	26.9	3.54
Pegas	untreated (control)	25.12	4.01	26.16	4.22
	0.5	26.31	4.23	27.54	4.49
	0.75	28.26	4.48	30.42	4.84
	1	27.05	4.35	28.35	4.57
$HIP_{0.05}$ t/ha (chickpea): A-0.03; B-0.05; C-0.03; AB-0.04; AC-0.09; BC-0.2 ABC-0.06					
2018 $HIP_{0.05}$ t/ha: A-0.01; B-0.01; C-0.03; AB-0.02; AC-0.02; BC-0.02; ABC-0.04					
2019 $HIP_{0.05}$ t/ha: A-0.02; B-0.02; C-0.03; AB-0.02; AC-0.02; BC-0.02; ABC-0.05					
2020 $HIP_{0.05}$ t/ha: A-0.05; B-0.04; C-0.03; AB-0.05; AC-0.04; BC-0.07; ABC-0.06					
2021 $HIP_{0.05}$ t/ha: A-0.06; B-0.05; C-0.05; AB-0.06; AC-0.08; BC-0.08; ABC-0.07					
2022 $HIP_{0.05}$ t/ha: A-0.05; B-0.02; C-0.02; AB-0.03; AC-0.02; BC-0.04; ABC-0.10.					

Thus, it was found that maximum content of crude protein in chickpea seeds of Pegas variety (30.42%) was obtained in variant where bacterial preparation *Rizogumin-Plus* was used for pre-sowing seed treatment and spraying of plants with 0.75% solution of retardant during the growing season. The lowest content of crude protein in chickpea seeds of Skarb variety (21.11%) was recorded in control variant.

Conclusions

It was found that treatment of vegetative crops of chickpea varieties Skarb and Pegas in phases of the 3rd trifoliate leaf and budding with retardant chlormequat chloride at a concentration of 0.75% provides the best conditions for their

growth, development and formation of high yields at level of 2.33 t/ha-3.02 t/ha. The maximum content of crude protein in grain of chickpea variety Pegas – 30.42% and 28.26% in variety Skarb was noted in variant where the bacterial preparation *Rizogumin Plus* was used for pre-sowing seed treatment and double spraying of plants with 0.75% solution of retardant during growing season. The highest content of crude protein and fat in seeds of chickpea variety Pegas 30.42% and 4.84%, 27.66% and 3.61% of variety Skarb, respectively, was noted in variants where bacterial preparation *Rizogumin Plus* was used for pre sowing seed treatment and double spraying of plants with 0.75% solution of retardant during growing season. This indicates that the studied technological methods of cultivation improve complex of economically valuable traits and seed yield of common chickpea varieties Skarb and Pegas.

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