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GRAIN QUALITY OF WINTER PEA DEPENDING ON FERTILISATION SYSTEMS AND WEATHER CONDITIONS IN SOUTHERN UKRAINE

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Topicality. *The quality of agricultural products is determined by the weather and climate conditions of the growing area and technology, the active component of which is the plant fertilisation system. Regional climatic fluctuations require the search for new crops or varieties and the study of their response to changes in growing conditions and technologies. Therefore, the characteristics of the formation of the main grain quality indicators of winter pea under the weather and climatic conditions of the Southern Steppe of Ukraine are expedient to study.* ***Purpose.*** *To determine the effect of mineral fertilisers on the grain quality of winter pea under climate changes in the Southern Steppe of Ukraine.* ***Methods****. Field method was used to study the effect of basal fertilisation: $N_{30-45-60}$, $P_{40}K_{40}$, $N_{30-60}P_{40}$, $N_{30-60}K_{40}$, $N_{30-45-60}P_{40}K_{40}$; and of mineral feeding with $N_{30-45-60}$ by growth stages on the grain quality of winter pea of the Enduro variety; laboratory method – to determine protein content, 1,000 seed weight and volume weight; statistical method – to perform correlation analysis, analysis of variance and statistical evaluation of research results.* ***Results****. The results of research on the effect of fertilisers on the formation of grain quality indicators of winter pea are presented. The characteristics of the influence of weather conditions of the Southern Steppe on the protein content in grain, grain fraction and volume weight were determined.* ***Conclusions.*** *A significant dependence of grain quality on specific weather conditions was observed: The protein content was dependent on the temperature regime of the spring-summer growing season by 84.6 % and on precipitation of the same period by 60.8 %, and in the first case it was a direct relationship, in the second – an inverse one; while precipitation during the growing season and in the spring development period had a positive effect on the 1,000 seed weight (r=0.95–0.99), it had a negative effect on the volume weight of the grain (r= /-0.73/ – /- 0.99/). Improvement of nutritional conditions resulted in an increase in the protein content of winter pea grain, but the rate of growth depended on the nitrogen rate in the mineral fertiliser, the application method (basal fertilisation or feeding) and the plant development stage. The maximum increase in protein content was 14.2 % at basal application of $N_{30}P_{40}$ and 15.2 % at the distribution of N_{60} into three feeding by stages: spring growth resumption, flower bud formation and grain filling. The 1,000 seed weight decreased with increasing rates of mineral fertiliser.*

Key words: *pea, winter sowing, fertilisers, basal application, feeding, quality*

Introduction. The assessment criteria for the effectiveness of any nutrition system are both the level of yield and the obtained product quality. The main quality indicators of legumes include protein content and grain size, which is characterised by the 1000 seed weight. The most important factor in the grain quality of peas, in particular their protein content, is nitrogen, which can be consumed by plants from the air and soil. The effectiveness of fertiliser depends on the formulation, rate, application method and dates [1–6].

According to research by Canadian scientists, increasing the nitrogen rate from 20 to 80 kg/ha did not significantly increase the protein content of pea grain [7].

This conclusion was confirmed by D. Janusauskaite, who studied the effectiveness of nitrogen application at a rate of 0 to 60 kg/ha on a background of $P_{40}K_{80}$ on three pea varieties

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and revealed that the protein content in grain was more influenced by the precipitation of the growing season (48.6–52.6 %), and the combined effect of weather conditions and nitrogen fertilisers ranged from 1.1 to 2.2 % of the total variation in protein content, while an increase in the nitrogen rate caused a decrease in the 1000 seed weight by 2.7–3.5 % [2]. However, according to A. Buket and colleagues, the effect of fertilisation on the 1000 seed weight was not significant [8]. Other researchers have also noted the significant effect of precipitation on pea grain quality [9].

Earlier studies have shown that [10] the application of monoammonium phosphate in six different rates to legumes such as peas, lentils, and beans did not affect the protein content in the grain. According to other test results, nitrogen rates led to a significant increase in the protein content of pea grain [11, 12]. Application of $N_{30}P_{60}K_{60}$ in the weather conditions of Vinnytsia region led to an increase in protein content in pea grain by 9.0–14.4 % compared to the control [13], and the application of nitrogen fertilisers in the rate of 30 to 90 kg/ha on sod-podzolic soils against the phosphorus-potassium background in the cultivation of such grain legumes increased the protein content in the grain by 0.8–0.9 absolute percent, but further increase of the rate of mineral nitrogen to 120 kg/ha led to deterioration of the grain quality [14].

The research data show different effects of mineral fertilisers on the grain quality of common peas, while similar data are not available for winter peas, which find their place in the crop rotations of agricultural producers.

The study was aimed at determining the effect of mineral fertilisers on the grain quality of winter peas under conditions of climate change in the Southern Steppe of Ukraine.

Materials and Methods. In the experiment, the material was winter peas of the Enduro variety, which were sown during 2021–2023 on southern low-humus heavy loamy black soil with a low content of available nitrogen and medium content of phosphorus and potassium. In the first experiment, mineral fertilisers were applied under the main cultivation in the following rates: N_{30}, N_{45}, N_{60}, $P_{40}K_{40}$, $N_{30}P_{40}$, $N_{60}P_{40}$, $N_{30}K_{40}$, $N_{60}K_{40}$, $N_{30}P_{40}K_{40}$, $N_{45}P_{40}K_{40}$, and $N_{60}P_{40}K_{40}$. In the second experiment, fertilisation with the indicated rates of mineral nitrogen was carried out on frozen thawed soil (*FTS*), during spring growth resumption (*SGR*), at the beginning of flower bud formation (*FB*), during grain filling (*GF*) and by the split method – *SGR+GF*, *SGR+FB+GF*.

Peas were sown in the middle of October, harvesting and recording were carried out at the beginning of the middle of June. The protein content of the pea grain was determined with infrared spectroscopy using a Spectran-119 M device according to DSTU 4117:2007, the 1000 seed weight – according to DSTU 4138-2002, and the bulk weight – according to DSTU 10840:2019.

The experimental data were processed using Excel 2007 and Statistica 6 mathematical statistics software.

The experimental plots are located in the Southern Steppe of Ukraine, the precipitation and average monthly air temperature for the years of research are presented in Table 1.

The amount of precipitation during the active vegetation period of winter peas was 336 mm in 2021, 208.6 mm in 2022 and 356 mm in 2023. Precipitation in 2021 and 2023 was 18.7 % and 25.8 % higher than the long-term average for the same period, respectively, and 26.3 % lower in 2022. In 2022, pea plants

Table 1. Weather conditions during the years of research

Growing season	Month									
	IX	X	XI	XII	I	II	III	IV	V	VI
	Precipitation, mm									
2020/2021	31.5	7.5	32.0	36.5	45.0	51.0	36.0	42.0	55.0	92.5
2021/2022	18.0	26.0	28.5	65.0	20.0	5.0	12.0	8.1	26.0	55.0
2022/2023	50.0	18.5	37.0	50.0	19.0	6.0	18.0	100.0	58.0	32.0
Average monthly air temperature, °C										
2020/2021	20.7	16.2	6.4	3.9	0.1	0.8	4.1	8.4	14.6	21.4
2021/2022	16.1	10.7	7.5	2.7	0	3.8	3.8	10.4	16.5	22.4
2022/2023	19.6	10.8	9.8	6.3	2.5	3.2	7.6	11.2	18.4	24.0

were most affected by soil drought in spring: only 46.1 mm precipitation fell over three months, or 22.1 % of the total. And the air temperature was the highest in 2023, when the average air temperature during the growing season of winter peas exceeded the long-term average by 4.4 °C, while in 2021 and 2022 it was 2.4 °C and 2.6 °C, respectively.

Results and Discussion. Over the years of research, the protein content in pea grain under all fertilisation systems (except for $P_{40}K_{40}$ in 2023) significantly exceeded the control variant (Table 2). Thus, on average, over three years of research, the increase in protein content ranged from 6.8 % ($P_{40}K_{40}$) to 14.2 % ($N_{30}P_{40}$) (Fig. 1) with $LSD_{0.95}$ = 4.4 % and during 2021 and 2022, the maximum increase in protein content in pea grain (20.5 % and 14.8 %, respectively) was also observed with the introduction of $N_{30}P_{40}$.

Protein yield per unit area was determined

Table 2. Protein content in dry substance of winter pea grain by the basal fertilisation systems and the years of research

Variant	% per dry substance			
	2021	2022	2023	average
control	17.74	21.18	20.89	19.94
N_{30}	19.04	22.83	22.40	21.42
N_{45}	20.59	23.50	22.73	22.27
N_{60}	20.69	23.79	22.41	22.30
$P_{40}K_{40}$	18.89	23.20	21.82	21.30
$N_{30}P_{40}$	21.38	24.33	22.59	22.77
$N_{30}K_{40}$	19.97	23.47	22.42	21.95
$N_{60}P_{40}$	19.59	23.91	23.61	22.37
$N_{60}K_{40}$	19.92	23.45	23.82	22.40
$N_{30}P_{40}K_{40}$	18.73	23.13	23.21	21.69
$N_{45}P_{40}K_{40}$	20.62	22.89	23.18	22.23
$N_{60}P_{40}K_{40}$	19.73	23.34	23.65	22.24
$LSD_{0.95}$	0.83	0.69	1.18	2.72

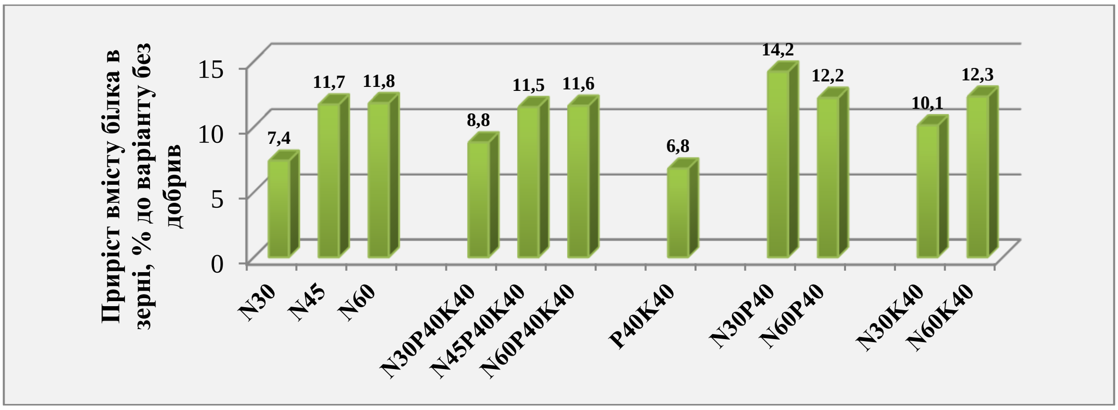


Fig. 1. The increase in protein content of winter pea grain by variants of basal application of mineral fertilisers, 2021–2023.

by the winter pea grain yield and protein content; the increase in yield compared to the control was from 34.3 % (N_{30}) to 80.8 % ($N_{30}P_{40}K_{40}$). The 1000 seed weight in the variants with the basal application of fertilisers was mostly lower than in the control by 5.0–8.9 % with $LSD_{0.95}$=3.8 %. With the exception of the variant with N_{30}, where the plants formed grain 2.5 % larger than in the control, but this increase was significant only in 2022, in the other two years the value varied within the limits of reliability.

The analysis of the grain quality of winter peas by variants of feeding showed that the mineral nitrogen rates and the dates of crop treatment significantly affected the protein content in the grain, compared to the control, all experimental variants were significantly effective each year and on average for two years, and the increase relative to the control was from 6.1 %

(N_{15} + N_{15}) to 15.2 % (N_{20} + N_{20} + N_{20}) at $LSD_{0.95}$ = 5.9 % (Table 3).

Table 3. Protein content (%) in winter pea grain and protein yield per area unit (kg/ha) by variants of nitrogen feeding

Nitrogen rate	Protein content, %		yield per area unit, kg/ha		Average				
					%	± % to control	kg/ha	± to control	
	2022	2023	2022	2023				kg/ha	%
control	20.27	20.94	213.6	519.3	20.61	-	366.5	-	-
*1 N_{30}	22.79	22.64	267.0	645.2	22.72	10.2	456.1	89.7	24.5
1 N_{45}	23.48	22.91	291.2	728.5	23.2	12.6	509.9	143.4	39.1
1 N_{60}	23.81	22.62	330.7	782.7	23.22	12.7	556.7	190.2	51.9
2 N_{30}	22.24	21.95	248.1	599.2	22.10	7.2	423.7	57.2	15.6
2 N_{45}	22.04	22.87	279.6	704.4	22.46	9.0	492.0	125.5	34.3
2 N_{60}	22.27	23.27	294.5	730.7	22.77	10.5	512.6	146.1	39.9
3 N_{30}	22.14	22.70	286.6	851.3	22.42	8.8	568.9	202.5	55.3
3 N_{45}	22.38	23.54	290.2	790.9	22.96	11.4	540.6	174.1	47.5
3 N_{60}	22.57	23.70	275.6	684.9	23.14	12.3	480.3	113.8	31.1
4 N_{30}	21.78	23.17	248.2	611.7	22.48	9.1	429.9	63.5	17.3
4 N_{45}	21.93	23.53	242.8	654.1	22.73	10.3	448.5	82.0	22.4
4 N_{60}	22.34	23.71	245.0	668.6	23.03	11.7	456.8	90.4	24.7
5 N_{15}+ N_{15}	21.39	22.34	231.4	661.3	21.87	6.1	446.3	79.9	21.8
5 $N_{22.5}$+ $N_{22.5}$	22.15	23.75	245.8	771.9	22.95	11.4	508.8	142.4	38.9
5 N_{30} + N_{30}	22.84	23.94	261.7	730.2	23.39	13.5	495.8	129.5	35.3
6 N_{10}+N_{10}+ N_{10}	22.21	23.67	256.0	899.5	22.94	11.3	577.7	211.3	57.7
6 N_{15}+N_{15}+ N_{15}	22.57	24.03	288.7	838.6	23.30	13.1	563.7	197.2	53.8
6 N_{20}+N_{20}+ N_{20}	23.39	24.09	311.8	686.6	23.74	15.2	499.2	132.7	36.2
$LSD_{0.95}$	0.86	0.62	-	-	-	5.9	-	-	12.5

** Notes. Dates of nitrogen feeding: 1 – on frozen thawed soil (FTS); 2 – spring growth resumption (SGR); 3 – flower bud formation (FB); 4 – grain filling (GF); 5 – SGR+FB; 6 – SGR+FB+GF*

In relation to the minimum dose of nitrogen (N_{30}), a significant increase in protein content of pea grain in 2022 with a single application of the full norm was observed only in the variant N_{60} over frozen thawed soil (+1.02 %). Increasing the nitrogen rate to 60 kg/ha in the variants with split application led to a significant increase in the protein content in the grain compared to the split application of N_{30}: a double treatment gave (+1.45 %) and when this rate was applied into three dates – (+1.18 %) at $LSD_{0.95}$=0.86.

A significant growth in protein content in pea grain was caused by an increase in the nitrogen rate under weather conditions in 2023, as follows: introduction during the spring growth resumption of N_{45} – by 0.92 % and N_{60} – by 1.32 % compared to N_{30}; in flower bud formation – 0.84 % and 1.0 %; in the spring growth resumption (SGR) and in the grain filling stage – 1.41 % and 1.60 %, respectively. In the variants of fertilisation over frozen thawed soil (FTS), in the grain filling stage and triple feeding, no significant difference between nitrogen rates was found, while the average protein content of the crops fertilised in the last two periods was significantly (by 0.72 % and 1.21 %) higher than the protein content of the pea grain in the crops fertilised over frozen thawed soil. The smallest significant difference at 95 % probability was 0.62 in 2023.

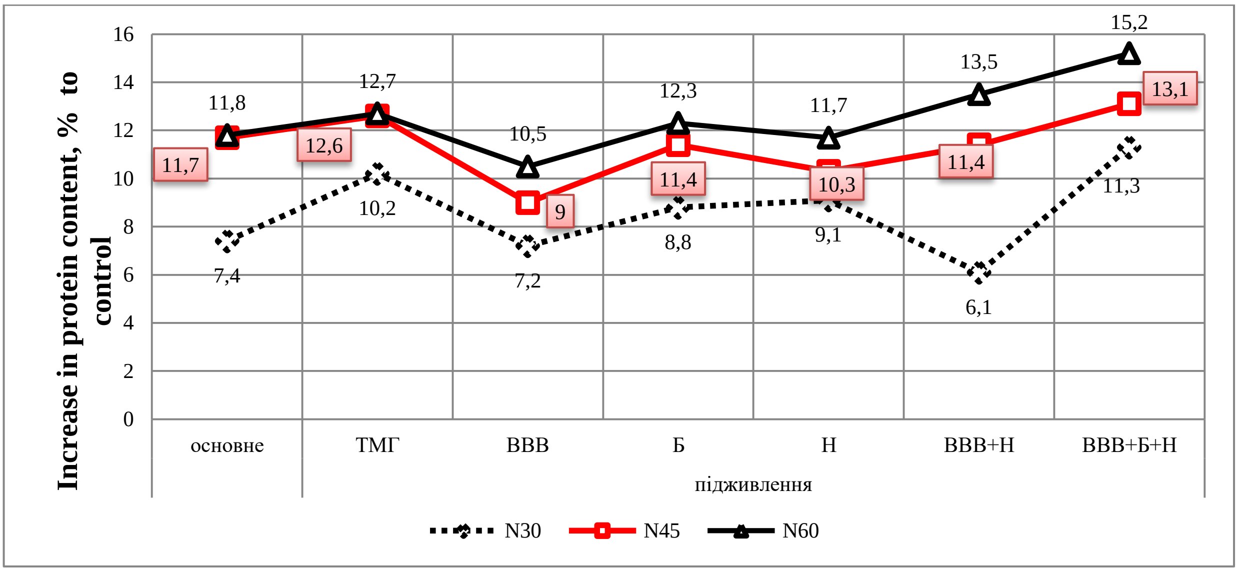
On average for two years, the maximum protein yield per hectare of winter pea crops was obtained in the following variants: N_{60} (FTS); N_{30} (FB); N_{10}+ N_{10}+ N_{10} and $N_1$5+ N_{15}+ N_{15}, the control was exceeded by 51.9 %, 55.3, 57.7 and 53.8 %, respectively.

The rates and dates of nitrogen feeding did not significantly affect the parameters of pea grain quality indicators. In 2022, the 1000 seed weight significantly increased (+9.2 g at $NIR_{0.95}$=4.2 g) only in the variant with N_{30} over FTS, the same rate (N_{30}) applied during spring growth resumption slightly (+2.1 g) affected the grain size, while all other combinations of rates and dates had a negative effect on this indicator.

Under the weather conditions of 2023, a slight significant increase in grain size was obtained in almost all variants of single nitrogen application, and in split application – only in the variant $N_{20}+N_{20}+N_{20}$. On average, over two years of research, an excess of the 1000 seed weight in the control variant was noted only when N_{30} was applied over FTS (+8.1 g).

The bulk weight of winter sown pea grain in almost all variants of nitrogen feeding significantly exceeded the control during both years of research. In 2022, the variants with N_{60} application over frozen thawed soil and during the spring growth resumption and N_{30} application during the flower bud formation stage became exceptions, as well as variants with N_{60} application during the SGR and flower bud formation stage in 2023. Over an average of two years, the introduction of N60 in the flower bud formation stage increased the bulk weight from 9.9 g and in case of application of N_{60} over frozen thawed soil to 23.9 g compared to the control variant.

Comparison of the effect of rates and nitrogen introduction methods on protein accumulation in winter pea grain shows a tendency to increase protein content with increasing nitrogen rate regardless of the method and date of application compared to the control (variant without nitrogen fertilisation). The graph lines fluctuate almost synchronously in terms of rates and dates of application (Fig. 2). The second tendency is also noted: split application of N_{45} and N_{60} in SGR+FB+GF increases the protein content in pea grain by 13.1 % and 15.2 %, respectively, compared to their single application at any period of plant development (the increase varied from 9.0 to 12.6 % for N45 and from 10.5 to 12.7 % for N_{60}). The above rates of mineral nitrogen applied over frozen thawed soil did not affect the protein content of grain (the increase in protein content was 12.6 % and 12.7 %, respectively).



** Notes. Dates of nitrogen feeding: 1 - on frozen thawed soil (FTS); 2 - spring growth resumption (SGR); 3 - flower bud formation (FB); 4 - grain filling (GF); 5 - SGR+FB; 6 - SGR+FB+GF*

Fig. 2. The increase in the protein content of winter pea grains.

The statistical analysis showed a correlation of different density and direction between weather conditions and pea grain quality indicators. The matrix of paired correlation coefficients between grain quality and weather conditions (Table 4) shows that the protein content in pea grain increased with rising temperatures of spring and summer growing season (r=0.92–0.99) and decreased with increasing precipitation during the same period (r= -0.78).

Grain size had a high positive correlation with the precipitation sum during the growing season (r=0.95–0.99), precipitation in June had a weak but negative effect on the 1000 seed weight (r= -0.49) and the increase in average monthly air temperatures in April and June also had no positive response (r= /-0.45/ – /- 0.84/).

The bulk weight of winter pea had a negative dependence on the precipitation sum and precipitation in spring (r= /-0.73/ – /- 0.99/) and

Table 4. Pairwise correlation coefficients between grain quality indicators of winter peas and weather conditions of the years of research

Quality indicators	Precipitation, mm					Air temperature, °C		
	∑	III	IV	V	VI	IV	V	VI
Protein content, %	-0.51	-0.99	-	-0.78	-0.20	0.99	0.92	0.99
1000 seed weight, g	0.95	0.82	0.64	0.99	-0.49	-0.73	-0.45	-0.84
Bulk weight, g	-0.98	-0.75	-0.73	-0.99	0.59	0.64	0.34	0.77

a positive dependence on the average level of precipitation at the end of ripening (r=0.59) and the increase in temperatures in April – June (r=0.44–0.77).

When calculating the regression models of dependence, weather indicators were selected as variables during the periods of their greatest impact on the harvest quality. These were mainly precipitation during the growing season and May, air temperature in April and June. The accuracy of regression models was estimated by Pearson's coefficient, the value of which should exceed 0.7, the coefficient of determination (R^2), which indicates the proportion of variation that is due to the variation of the variable. Among the obtained regression models for grain protein content, the most accurate (Table 5) were the models related to the precipitation in March and the temperature regime in April and May, as evidenced by the values of Pearson's and determination coefficients (0.993–0.999 and 0.986–0.998, respectively), the standard error (0.016–0.230) and the deviation of the forecasted protein content from the actual one, which varied within the interval of 2.1–16.6 %, not exceeding the permissible forecast error.

The regression model of protein content, where precipitation in May was an impact factor

Table 5. Regression models of winter pea grain quality dependence on precipitation and air temperature

Weather parameters	Regression equation	Coefficient of		Standard error of equation
		Pearson	determination	
Protein content, %				
Precipitation in March, mm –X_1	У = 25.23-0.15 X_1	0.994	0.989	0.016
Precipitation in May, mm – X_2	У =26.11-0.098 X_2	0.780	0.608	0.168
Average monthly air temperature in April, °C – X_3	У = 5.30 + 1.72 X_3	0.999	0.998	0.130
Average monthly air temperature in May – X_4	У = 1.91X_4 -8.08	0.993	0.986	0.230
1000 seed weight, g				
Precipitation during growing season, mm – X_1	159.12+0.088 X_1	0.946	0.900	0.030
Precipitation in May, mm – X_2	164.50+0.491 X_2	0.999	0.999	0.015
Average monthly air temperature in May, °C – X_3	311.23-5.57 X_3	0.990	0.979	0.15
Bulk weight, g				
Precipitation during growing season –X_1	835.62-0.39 X_1	0.968	0.937	0.10
Precipitation in May, mm – X_2	809.30-2.11 X_2	0.995	0.989	0.22
Average monthly air temperature in June, °C – X_3	183.63+23.71 X_3	0.976	0.953	0.05

with good values of Pearson's coefficient and R^2 (0.780 and 0.608, respectively), which met the requirements for model accuracy, had the highest standard error (0.168) and forecast error, which in two cases out of three years of observations exceeded 25 %, with the maximum (61.2 %) for the driest year of 2022.

Thus, our studies on the influence of weather conditions on the grain quality parameters of winter pea are in line with the conclusions obtained for other grain legumes [2, 9]. In the future, with the accumulation of a larger data set, factor analysis will be carried out to obtain more accurate models involving several factors simultaneously and to determine the share of each factor's contribution to the formation of grain quality of this crop.

Conclusions. The results clearly showed that chemical fertilisers improve the protein content of winter pea grain. The basal application of mineral fertilizers and mineral feeding with nitrogen led to an increase in the protein content of winter pea grain, but the level of increase depended on the nitrogen rate and the stage of its application: the maximum protein increase was obtained with the basal application of $N_{30}P_{40}$ (14.2 %) and with the distribution of N60 into three feedings: spring growth resumption, flower bud formation and the beginning of grain filling (15.2 %). The 1000 seed weight tended to decrease with increasing of the mineral fertiliser rates.

A correlation between weather parameters and grain quality components was established, so that protein content has a close positive relationship with air temperatures in the spring-summer growing season (April – June, r=0.92–0.99) and a negative above average (r=-0.78) with precipitation during this period. The increase in both total precipitation and rainfall during the spring growth season of peas has a direct correlation with the 1000 seed weight (r=0.95–0.99) and a negative effect on bulk weight (r= /-0.73/ – /-0.99/).

References

1. Faligowska, A., Kalembasa, S., Kalembasa, D., Panasiewicz, K., Szymańska, G., Ratajczak, K., Skrzypczak, G. (2022). The Nitrogen Fixation and Yielding of Pea in Different Soil Tillage Systems. *Agronomy*, *12 (2)*. 352. https://doi.org/10.3390/agronomy12020352.
2. Janusauskaite, D. (2023). Productivity of Three Pea (*Pisum sativum* L.) Varieties as Influenced by Nutrient Supply and Meteorological Conditions in Boreal Environmental Zone. *Plants (Basel)*, *9; 12 (10). 1938*. doi: 10.3390/plants12101938. PMID: 37653855; PMCID: PMC10221898.
3. Lithourgidis, A. S., Vlachostergios, D. N., Dordas, C. A., Damalas, C. A. (2011). Dry matter yield, nitrogen content, and competition in pea-cereal intercropping systems. *European Journal of Agronomy*, *34*. 287–294.
4. Ngeno, J., Chemining'wa, G. N., Muthomi, J. W., Shibairo, S. I. (2012). Effect of Rhizobium inoculation and nitrogen fertilizer application on growth, nodulation and yield of two garden pea genotypes. *Journal of Animal and Plant Sciences*, *15 (2)*. 2147– 2156.
5. Sayed, E. G., Ouis, M. A. (2022). Improvement of pea plants growth, yield, and seed quality using glass fertilizers and biofertilizers. *Environmental Technology & Innovation*, *26*. 102356 https: //doi.org/10.1016/j.eti.2022.102356
6. Stevovic, V., Djukic, D., Djurovic, D., Mandic, L., Bokan, N. (2006). The effect of nitrogen fertilization on the yield and quality of field pea. *Grassland Sci. 722 in Europe*, *11*. 721–723
7. Clayton, G. W., Rice, W. A., Lupwayi, N. Z., Johnston, A. M., Lafond, G. P., Grant, C. A., Walley, F. (2004) Inoculant formulation and fertilizer nitrogen effects on field pea: Crop yield and seed quality. *Can J. Plant Sci*., *84*. 89–96.
8. Buket, A., Bicer, B. T., Piring, V. (2015). The effect of different fertilizer forms in pea *Pisum Sativum* L. on yield and yield components. Presented at the *2ND International Symposium for agriculture and food ISAF* 2015. Ohrid. 2015.
9. Prusiński, J., Borowska, M. (2022). Effect of planting density and row spacing on the yielding and morphological features of pea (*Pisum sativum* L.) *Agronomy*, *12*. 715. doi: 10.3390/agronomy12030715.
10. Henry, J. L., Slinkard, A. E. and Hogg, T. J. (1995). The effect of phosphorus fertilizer on establishment, yield and quallty of pea, lentil and faba bean. *Can. J. Plant Sci*., *75*. 395-398
11. Eata, A. E. M., El-Sherbini, M. A. A., Asmaa, R. Mahmoud, Aisha H. Ali (2020). Effect of fertilizer management on growth, yield and quality of pea (*Pisum sativum* L.). *Singapore Journal of Scientific Research*, *10*. 327-335. DOI: 10.3923/sjsres.2020.327.335
12. Khan, S., Aman, F., Ismaeel, M., Ali, Z., Alam, M., Iqbal, S., Khan, T. (2021). Growth and yield response of pea (*Pisum sativum* L.) cultivars to phosphorus fertilization. *Sarhad J. Agric.*, *37*. 369–376.
13. Hnatiuk O. S. Influence of fertilizer system on the formation of pea productivity in the conditions of the experimental field of VNAU. URL: http://socrates.vsau.org/b04213/html/cards/getfile.php/21398.pdf [in Ukrainian].
14. Doctor N. M., Novytska N. V. (2020). Effect of fertilizing and inoculation on beans quality. *Tavriiskyi naukovyi visnyk* [Tavrian Scientific Bulletin], *111*. 55–59. DOI: https://10.32851/2226-0099.2020.111.7 [in Ukrainian].
15. DSTU 4117:2007. Grain and products of its processing. Determination of quality indicators by infrared spectroscopy. Kyiv: State Standart of Ukraine. 2007. 7 p. [in Ukrainian].
16. DSTU 4138-2002. Seeds of agricultural crops. Methods of determining quality. (2002). Kyiv: State Standart of Ukraine. P. 17–18. [in Ukrainian].
17. DSTU 10840:2019. Grain. The method of determining nature. (2019) Kyiv: State Standart of Ukraine. 12 p. [in Ukrainian].

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Бурикіна С. І. [1]***, Сергєєв Л. А.*** [1]***, Куліджанов Г. В.*** [2]***, Чепурних В. М.*** [3] ***Якість зерна гороху підзимової сівби за системами удобрення та погодними умовами півдня України.***
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Актуальність. Якість сільськогосподарської продукції визначається погодно-кліматичними умовами зони вирощування та технологією, активним компонентом якої є система удобрення рослин. Регіональні кліматичні флуктуації вимагають пошуку нових культур чи різновидів та вивчення їх реакції на зміну умов і технологій вирощування. Тому є доцільним вивчення особливостей формування основних показників якості зерна гороху за підзимової сівби в погодно-кліматичних умовах Південного Степу. **Мета.** Встановити вплив мінеральних добрив на якість зерна гороху за підзимової сівби в умовах кліматичних змін Південного Степу України. **Методи.** Польовий – вивчали дію основного внесення мінеральних добрив: $N_{30\text{-}45\text{-}60}$, $P_{40}K_{40}$, $N_{30\text{-}60}P_{40}$, $N_{30\text{-}60}K_{40}$, $N_{30\text{-}45\text{-}60}P_{40}K_{40}$,; підживлення мінеральним азотом $N_{30\text{-}45\text{-}60}$ за фазами росту на якість зерна гороху за підзимової сівби сорту Ендуро; лабораторний – визначення білка, маси 1000 насінин та натури; статистичний – виконання кореляційного, дисперсійного аналізу та статистичної оцінки результатів досліджень. **Результати.** Наведено результати досліджень з впливу мінеральних добрив на формування показників якості зерна гороху за підзимової сівби. Встановлено особливості впливу погодних умов Південного Степу на концентрацію білка в зерні, його калібр та об'ємну масу. **Висновки.** Відмічено наявність математично достовірної залежності якості зерна від конкретних погодних умов: рівень білковості на 84,6 % визначався температурним режимом весняно-літньої вегетації та на 60,8 % – опадами цього ж періоду, причому в першому випадку, це був прямий зв'язок, у другому – обернений; якщо на масу 1000 насінин опади за вегетацію та у весняний період розвитку позитивно впливали (r=0,95–0,99), то на натуру зерна – негативно (r= /-0,73/ – /- 0,99/). Поліпшення умов живлення приводило до підвищення концентрації білка в зерні гороху зимуючого, але рівень зростання залежав від дози азоту, способу застосування (основне чи підживлення) та фази його внесення: максимальний приріст білка отримали за основного внесення $N_{30}P_{40}$ – 14,2 % і при розподілі N_{60} на три підживлення: весняне відновлення вегетації, бутонізація та початок наливу –15,2 %. Маса 1000 насінин здебільшого мала тенденцію до зменшення при підвищенні дози мінерального добрива.
Ключові слова: *горох, підзимова сівба, добрива, основне внесення, підживлення, якість*