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Influence of mineral fertilization of common bean (*Phaseolus vulgaris* L.) on yield and damage by Bean weevil (*Acanthoscelides obtectus* SAY) in a long-term stationary fertilizer experiment

Влияние на минералното торене на полски фасул (*Phaseolus vulgaris* L.) върху добива и повредите от фасулев зърнояд (*Acanthoscelides obtectus* Say, 1831) в траен торов опит

Evgeniya ZHEKOVA (✉), Galin GINCHEV, Svetlana STOYANOVA, Diana MARINOVA

IASS "Obraztsov chiflik" – Rousse, Agricultural Academy – Sofia, Prof. Ivan Ivanov str., Rousse – 7007, Bulgaria

✉ Corresponding author: e.d.zhekova@abv.bg

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ABSTRACT

The issue of storage and protection of yilded seeds from storage pests is fundamental to seed science, the nutrition of people and animals as well as the maintenance of state reserves. During 2019-2021, in the experimental field of IASS "Obraztsov chiflik" - Rousse, in a long-term stationary fertilizer experiment, seeds of common bean variety Obraztsov chiflik 12 were obtained utilizing the following fertilization options: 1 - individual nitrogen fertilization; 2 - individual phosphorus fertilization; 3 - individual potassium fertilization; 4 – combined NP application; 5 – combined NK application; 6 – combined PK application; 7 – triple combination of NPK. An unfertilized control variant was maintained for comparison purposes. The study aims to entomologically evaluate seeds regarding damage by bean weevils after crop harvesting. Measurements of yield, 1000-seed weight, damaged seeds percentage, Index of infestation, as well as weight loss were taken. The combined application of NP demonstrated the greatest positive effect on the yield qualities of beans, however it lead to an intermediate position of the yield in terms of damage by bean weevil. The variant treated with combined NK fertilization resulted in the lowest percentage of damaged seeds and Index of infestation; it was followed by the variant with full mineral fertilization and the control variant. The individual application of N resulted in highest damaged seeds percentage as well as highest Index of infestation; it also ensured the highest weight loss on average for the studied period.

Keywords: common bean, bean weevil, fertilization, damaged seeds, Index of infestation, weight loss

АБСТРАКТ

Въпросът за съхранението и опазването на получените семена от складови неприятели е основен за семезнанието, храненето на хората и животните и поддържането на държавните резерви. През периода 2019-2021 г. в опитното поле на ИЗС "Образцов чифлик" - Русе, в дългогодишен стационарен торов опит са получени семена от обикновен фасул сорт Образцов чифлик 12 при следните варианти на торене: 1 - индивидуално азотно торене; 2 - индивидуално фосфорно торене; 3 - индивидуално калиево торене; 4 - комбинирано приложение NP; 5 - комбинирано приложение NK; 6 - комбинирано приложение PK; 7 - тройна комбинация NPK. За сравнение се поддържа неторената контрола. Целта на изследването е да се направи ентомологична оценка на семената за повреди от фасулев зърнояд след прибиране от полето. Отчетени са добив, тегло на 1000 семена, процент повредени семена, индекс на нападение и загуба на тегло. Комбинираното прилагане на NP има най-голям положителен ефект върху добивните качества на фасула, но определя междинно положение по отношение на пораженията от фасулевия зърнояд. Комбинираното NK торене доведе до най-нисък процент повредени семена и Индекс на нападение, следван от варианта с пълно минерално торене и контролния вариант. Индивидуалното прилагане на N доведе до най-висок процент повредени семена и индекс на нападение и гарантира най-висока загуба на тегло средно за изследвания период.

Ключови думи: полски фасул, фасулев зърнояд, торене, добив, маса на 1000 семена, повредени семена, индекс на нападение, загуба на маса

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is a major agricultural crop - rich in valuable nutrients, and an important part of the human and animal diet (Apostolova et al., 2013, Gtozdenac et al., 2023). According to FAO, in 2021 the area occupied by beans worldwide is 35.920.593 ha, yielding 27.7 million tons (12.3 million tons in 1972). In Bulgaria, there is a trend of decreasing the production from 79912 to 7716 t for the period 1961-2021. Significant insect damage is among the major factors that lead to high losses in bean production (Celestino Filno and Almeida, 1980).

Common bean is attacked by a large number of harmful insects during all phenophases of field development and storage. However, the damage caused by *Acanthoscelides obtectus* Say on seeds is of significant economic importance to Bulgaria and to the whole world too (Yankova, 2010, Apostolova et al., 2013, Yankova and Sofkova, 2013; Soares et al., 2015). Bean weevil infestation begins in the field and then moves to storage and households, where it continues through the storage period (Soares et al., 2015). The life cycle of the insect is well adapted to reproduction in a confined environment and its populations are commonly found in storages (Nescimento et al., 2020) where they grow exponentially on untreated seeds and can destroy them within a few months (Golebiowski et al., 2008). Economic importance is based on yield losses caused by larvae, ranging from 7.4% after 45 days of storage in Colombian warehouses to 13% in Brazil and 35% in Mexico and Central America (Schmale et al., 2002). Earlier data by Celestino Filho and Almeida (1980) indicated losses from 20 to 30% of total bean production in Brazil caused by insect attacks during storage. Pemonge et al. (1997) reported that the larvae feed on the grains and often cause losses higher than 30% in the area of southern France and the Mediterranean. The vital activity of the larvae causes, in addition to quantitative damage (direct), decrease in weight and/or volume of seeds, as well as qualitative losses (indirect) - decrease in main nutrients, increase in temperature and moisture content, contamination with insect residues and excrement, etc. (Faroni et al., 2006; Nta et al., 2019).

Global warming imposes increased monitoring of the bean weevil because of its high potential for spread (Adler et al., 2022). Understanding the infection process may provide new ways to control it (Stathas et al., 2023). Certain alternatives for pest control, with potential future use are identified: use of resistant varieties, change in sowing dates, use of fertilizers and application of biological control (Tomlekova, 2012, Boiça Junior and Alonso, 2000). According to Lara (2017), the emergence of plant resistance to insects can be influenced by various environmental factors, incl. fertilization and irrigation. Jones (1976) reported that the use of nitrogen fertilizers often caused an increase in the number of insect species causing damage to the host plant, while the effect of phosphorus was less obvious and potassium fertilization led to the emergence of resistance in many cases.

In a world facing the critical challenge of food security, minimizing agricultural and food losses from insect infestations will be monumental (Stathas et al., 2023).

A deeper understanding of damage limitation mechanisms by regulating elements of crop production technologies is greatly needed. The present study aims to evaluate the effect of fertilization with nitrogen (N), phosphorus (P) and potassium (K) (individually and in combination with each other) on the manifestations of resistance of the common bean variety Obraztsov chiflik 12 to bean weevil by means of an entomological evaluation of the obtained seeds.

MATERIAL AND METHODS

Plant material and experimental design

The research was carried out during the period 2019-2021 (16^{th} rotation) of the long-term stationary fertilizer experiment in the experimental field of the Institute of Agriculture and Seed Science "Obraztsov chiflik" – Rousse, Bulgaria. The trial is witin an area of 1 ha which is occupied by several crops - wheat, common bean, malting barley and maize according to the method and scheme of Georges Ville – in three replications and eight variants arranged according to Rümker. The size of the experimental plots is 100 m^2. Wheat was the crop preceding beans.

Seven variants of fertilization were evaluated with individual and combined application of the three macro-elements nitrogen (N), phosphorus (P), potassium (K) for the bean as follows: N - 50 kg/ha active substance (a.s.), P_2O_5 – 120 kg/ha a.s. and K_2O – 70 kg/ha a.s. An unfertilized control variant (0) was maintained for comparison. Phosphorus and potassium fertilizers were applied before tillage and nitrogen fertilizers - after crop emerging, as an early spring dressing.

The experimental field is located at 43°48' north latitude, 26°02' east longitude and an altitude of 152 m. The soil type is highly leached chernozem with poor humus content - 1.75%. The mechanical composition is heavy-sandy clay with physical clay of about 45% (Nenova et al., 2011).

The common bean variety "Obraztsov chiflik 12", genotype *Phaseolus vulgaris* L., was selected at IASS "Obraztsov chiflik" – Ruse. The variety is high-yielding, ripens evenly and has good pod shatter resistance (Dobrev and Patenova, 2003).

The experiment was carried out in a natural infestation with *Acanthoscelides obtectus*, using a "free choice" host condition. The natural pest population density did not exceed the defined economic threshold numbers at any moment of the study (BFSA, 2017). No insecticides were applied.

Data collection and statistical analysis

Bean seeds were harvested manually at full maturity. Productivity is reported by weight - seed yield kg/ha - to standard moisture. The storage in paper bags and analyses were carried out in laboratory conditions at a temperature of 25 ± 1 °C and air humidity of 60 ± 5%. The 1000-seed weight, g is determined by Methodology for Sampling and Analysis for Purity, Germination and 1000-seed weight. Damaged seeds were counted as a number in samples of 100 seeds 45 days after harvesting and were grouped according to the degree of infestation in classes. The Index of infestation (II) in per cent was calculated by McKinney (1923):

$$II = \frac{Sum\ of\ all\ numerical\ ratings\ \times 100}{Total\ number\ of\ seeds\ \times\ The\ highest\ numerical\ rating}$$

Classes, degrees of infestation and numerical ratings used in rating damaged and undamaged seeds are listed in Table 1.

Table 1. Classes, degrees of infestation and numerical ratings used in rating damager and undamaged seeds

Classes	Degree of infestation	Numerical rating
1.	Undamaged seeds	0
2.	Damaged seeds with one hole	1
3.	Damaged seeds with two holes	2
4.	Damaged seeds with three holes	3
5.	Damaged seeds with more than three holes	4

The weight loss, as a result of the life activity of the larvae, in percentages was estimated according to Adams and Schulter (1978):

$$Weight\ loss = \frac{(U\ \times Nd) - (D\ \times Nu)}{U\ \times (Nd + Nu)} \times 100$$

where:

U – Weight of undamaged grains,

Nu – Number of undamaged grains,

D – Weight of damaged grains,

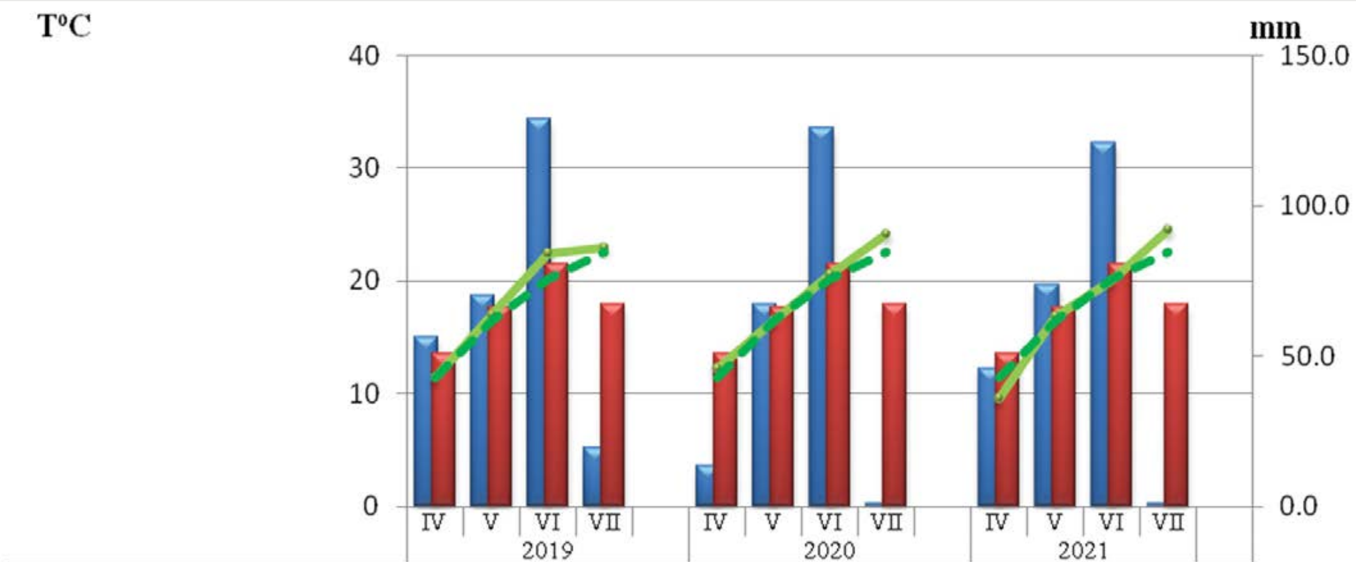
Nd – Number of damaged grains.

The differences between variants were verified using a one-way Analysis of Variance (ANOVA). The statistical evaluation of data was performed with the SPSS 17.0 programme ($P < 0.05$). Means were compared using the Tukey´s HSD test.

Meteorological conditions during study period

The meteorological conditions – mean monthly air temperature (°C) and total monthly rainfall (mm) – during the growing season of common bean for the three years of the study are presented in Figure 1.

Agrometeorological conditions in April and May 2019 were characterized by rainfall and temperatures around and above the long-term average (LTA). The temperature, with maximum values of 26-29.5 °C, accelerated the development of bean germination and leaf formation. Rainfall in April (56 mm) and May (70.4 mm) was slightly above the long-term average for those months and was unevenly distributed, resulting in uneven cropping. The extremely high temperatures during the first and second ten-day period of June, with maximum values of above 31 °C, caused plant damage expressed in flower and bud shedding. The maximum temperatures, measured in the first 10 days of July were above 34 °C. The amount of rainfall in June exceeded the long-term average with about 50%, and in July it was twice less than the climatic norm for the area. Premature start of ripening was observed in the first ten day period of July, which was brought about by the high temperarures and the lack of precipitation. Meteorologically, 2020 was favorable for the bean development. Despite the small amount of rainfall in April (13.6 mm), germination was not difficult. May and June were rainy, with a total rainfall of 193.1 mm which helped the crop to grow well. The last ten-day period of June and the whole of July were characterized as dry and hot, resulting in the first pods of beans being nourished, while the beans formed later were empty or with underdeveloped seeds.



	2019 IV	2019 V	2019 VI	2019 VII	2020 IV	2020 V	2020 VI	2020 VII	2021 IV	2021 V	2021 VI	2021 VII
Total monthly rainfall	56.0	70.4	129.1	19.5	13.6	67.1	126.0	1.1	45.6	73.5	121.0	1.0
LTA rainfall	50.7	66.1	80.5	67.4	50.7	66.1	80.5	67.4	50.7	66.1	80.5	67.4
Mean monthly air temperatures	11.4	17.0	22.4	23.0	12.2	16.5	20.6	24.1	9.6	16.8	20.0	24.6
LTA temperature	11.4	16.5	20.2	22.5	11.4	16.5	20.2	22.5	11.4	16.5	20.2	22.5

Figure 1. Meteorological data (total monthly rainfall, mean monthly air temperatures) 2019–2021 and long-term average (LTA) 1896–2005

In the third year of the trial, April was characterized by a sufficient amount of rainfall (45.6 mm), but with average temperatures below the norm, which led to a delay in the germination of the crop. May and June were rainy, with a total of 194.5 mm of rainfall, which helped the crop to grow well. The last ten-day period of June and the whole month of July were characterized as dry and hot, resulting in the first pods of beans being well-nourished, whereas the beans formed later were empty or with underdeveloped seeds like the previous year.

The average daily temperatures of the last ten-day period of July during the three years of the trial (respectively 24.4, 25.7 and 25.1 °C) approached and slightly exceeded the lower limit of the 25-30 °C range preferred by the bean weevil (Harizanov and Harizanova, 2018) and coincided with the short ovipositional period before crop harvesting.

RESULTS AND DISCUSSION

The tested fertilization variants influenced the bean seed yield (Table 2). In 2019, the yield varied between 313.4 and 1090.0 kg/ha. As expected, the lowest value was recorded in the control variant with no fertilizers applied. The highest yield was obtained from the variant with combined NP application. All tested variants exceeded the control in terms of yield, but the difference was not proven statistically for the variant with individual K fertilization - 532 kg/ha. The variant with application of the triple combination (NPK) - 936.4 kg/ha and individual application of N - 930 kg/ha showed similar results.

However, the differences between the variant with triple combination (NPK) and the variant with individual application of N in comparison to the highest-yielding variant (NP) were not proven. In 2020 the control variant presented the lowest yield - 809.2 kg/ha whereas the variant with application of the NP combination - the highest - 1361 kg/ha. Higher yields in all variants were proven statistically, except for variants with individual applications of P - 888.4 kg/ha and K - 911.8 kg/ha. Variants with individual N application – 1230 kg/ha, combined NK application – 1254.2 kg/ha and triple combination NPK – 1013.4 kg/ha showed lower yields compared to the highest-yielding variant but the differences were not proven statistically in one variant (NK). In 2021, the yield from the control variant (346.6 kg/ha) exceeded that in 2019 and the lowest yield was obtained from the variant with individual K fertilization – 335 kg/ha. The variant with combined application of NK presented itself with the highest yield – 896.8 kg/ha. The excess of 60 kg/ha in the average values compared to the yield of the NP variant – 836.8 kg/ha was not proven statistically. The differences between the variant with combined application of NK and the NP variant in comparison to the variant with individual N - 788.4 kg/ha were not proven either.

Table 2. Common bean seed yield (2019-2021)

Variant	Seed yield (kg/ha)			
	2019	2020	2021	2019-2021
N	930.0^{cd}	1230.0^{c}	788.4^{c}	982.8^{bc}
P	796.6^{bcd}	888.4^{ab}	526.8^{b}	737.3^{abc}
K	532.0^{ab}	911.8^{ab}	335.0^{a}	592.9^{ab}
NP	1090.0^{d}	1361.0^{d}	836.8^{cd}	1095.9^{c}
NK	643.4^{bc}	1254.2^{cd}	896.8^{cd}	931.1^{abc}
PK	675.6^{bc}	1151.8^{c}	455.0^{ab}	760.8^{abc}
NPK	936.4^{cd}	1013.4^{b}	975.0^{d}	974.9^{bc}
0	313.4^{a}	809.2^{a}	346.6^{a}	489.3^{a}

Means followed by the different letters in each column are significantly different; Tukey test at $P < 0.05$

The average data for the period indicated that the control variant with no fertilizer application presented the lowest yield - 489.3 kg/ha, followed by the variant with individual K fertilization - 592.9 kg/ha (no proven difference), the variants with application of P – individual (737.3 kg/ha) and the combination RK (760.8 kg/ha) (no proven difference), and the variant with combined application of NK – 931.1 kg/ha (no proven difference).

The differences in the average yields in the variant with individual N fertilization - 982.8 kg/ha and in that with application of the triple NPK combination - 974.9 kg/ha were statistically proven in comparison with the control variant, but were not proven in comparison to the highest-yielding variant - NP - 1095.9 kg/ha.

Despite the lack of consensus among individual researchers regarding the application of mineral fertilizers to field beans (Zhekova et al., 2017), the results obtained in this study are consistent with Milev (2000), according to whom the highest result accounts for the combined NP fertilization.

The 1000-seed weight is a major component of yield and is used as a measure of seed size, which can vary depending on many factors, including fertilization (AGRI-FACTS, 2018). In the case of common bean grown in the conditions of a long-term stationary fertilizer experiment, in 2019 the lowest 1000-seed weight was shown by the control variant - 210.0 g, followed by the variant with individual K fertilization - 212.7 g (Table 3).

Table 3. Thousand-seed weight mass (2019-2021)

Variant	Thousand-seed weight mass (g)			
	2019	2020	2021	2019-2021
N	233.7^{c}	209.6^{ab}	222.9^{c}	222.1^{ab}
P	227.4^{bc}	218.6^{c}	215.6^{bc}	220.5^{ab}
K	212.7^{a}	203.4^{a}	195.3^{a}	203.8^{a}
NP	249.1^{d}	212.5^{bc}	222.8^{c}	228.1^{b}
NK	238.1^{cd}	212.6^{bc}	213.7^{bc}	221.5^{ab}
PK	220.9^{ab}	206.6^{ab}	203.3^{ab}	210.3^{ab}
NPK	238.5^{cd}	207.8^{ab}	211.3^{bc}	219.2^{ab}
0	210.0^{a}	206.7^{ab}	204.3^{bc}	207.0^{ab}

Means followed by the different letters in each column are significantly different; Tukey test at $P < 0.05$

The highest result was recorded for the variant with a combined application of NP – 249.1 g, while the variant with complete NPK fertilization showed a slightly lower result (238.5 g) but the difference was not statistically proven. In 2020, the lowest 1000-seed weight was recorded in the variant with individual K fertilization - 203.4 g and the highest - in the variant with individual application of P - 218.6 g.

Four variants (PK, 0, NPK and N) slightly exceeded the lowest value, but not proven, and two variants (NP and NK) approached the highest value but differences in mean values were not statistically proven.

In 2021, the lowest value showed the variant with individual application of K – 195.3 g. The variants with individual applications of N and the NP combination showed approximately the same highest values. All other variants, except for those with combined application of PK, showed statistically proven higher values by comparison to the variant with the lowest indicator (K). From the average data for the experimental period, a statistically proven lowest 1000-seed weight was found in the variant with individual K fertilization – 203.8 g, and the highest – in the variant with combined application of NP. The obtained results correspond to the lowest and the highest yields of seeds respectively in the specified variants. They are consistent with the conclusions of other authors, claiming that an increase in 1000-seed weight leads to an increase in yield in sunflowers (Kaya and Atakifli, 2003; Hladni et al., 2016) and that mineral fertilization has a relatively weak effect on 1000-seed weight in common bean (Milev, 2000).

The damaged seeds, as a result of the vital activity of the larvae of the first bean weevil generation and after the appearance of the adults of the new generation, in the samples of the tested variants of independent and combined fertilization with the main macronutrients are separated and presented in Figure 2.

In 2019, the highest percentage of damaged seeds (3%) in the variants with individual K fertilization and the combined use of NP was recorded. The highest percentage of damaged seeds during the experiment was reported in the variant with individual nitrogen fertilization in 2020 – 7%, followed by the variant with combined application of NP – 5%. The variants with the combined application of PK and the triple NPK combination showed the same percentage of damaged seeds in 2019 and 2020. In 2021 the variant with the individual application of N showed the highest percentage of damaged seeds, exactly as did the variant with the individual application of P – 5%.

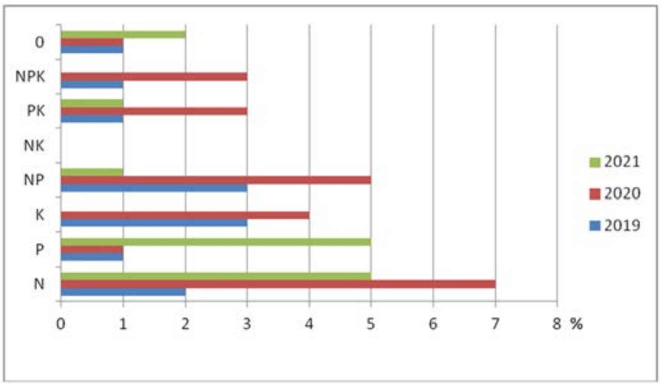


Figure 2. Damaged seeds (2019-2021), in %

On average for the three years, the highest percentage of damaged seeds showed the variant with individual N fertilization (4.7%), followed by the variant with combined application of NP (3.0%) and the variants with individual application of P and K (2.3%) (Table 4). In the variant with the combined use of NK, no damaged seeds were recorded during the trial period.

Table 4. Damaged seeds and Index of infestation average for the period 2019-2021

Variant	2019-2021	
	Damaged seeds %	Index of infestation %
N	4.7[c]	2.75[b]
P	2.3[abc]	1.08[ab]
K	2.3[abc]	1.25[ab]
NP	3.0[bc]	1.5[ab]
NK	0.0[a]	0.00[a]
PK	1.7[ab]	1.25[ab]
NPK	1.3[ab]	0.83[ab]
0	1.3[ab]	0.83[ab]

Means followed by the different letters in each column are significantly different; Tukey test at $P < 0.05$

The obtained results show that only the damage in the variant with individual application of N exceeds the economic threshold for stored-product insect infestation level – 4% (Baier and Webster, 1992; Hagstrum and Flinn, 2014). On the other hand, all tested variants (except the variant with individual N application in 2019) showed a lower percentage of damaged seeds compared to the data indicated for the same variety (6%) by Yankova and Sovkova-Bobcheva (2009). The same authors, when testing the reaction of Bulgarian common and snap bean varieties to the bean weevil, ranked Obraztsov chiflik 12 variety in second place in terms of damaged seeds percentage among the common bean varieties, after Abritus variety - with a result of 3.67%.

The calculated Index of infestation in 2019 is the highest in the variant with individual K fertilization, followed by the variant with individual N fertilization - 1.25% and the one with combined application of NP - 0.75%. The other treatments showed the same results. No Index of infestation was calculated in the variant with the combined use of NK, which resulted in the absence of damaged seeds in all three years of the trial. In 2020, the variants with individual N application and the NP combination showed the highest Index of infestation – 3.5% which was the highest value of the index during the three years of the trial. The lowest values of the index were reported in the control variant and the variant with individual P fertilization - 0.25%. In 2020, the variants with the application of K fertilization (individual, in combination PK and the complete combination NPK) showed a high index - over 2%, in contrast to 2021, when the index was calculated at 0.75% in the combination PK variant, and 0% in the others (Figure 3).

The average values of the Index of infestation for the three years of testing ranged from 2.75% for the variant with individual application of N to 0% for the variant with combined application of NK (Table 4). For the variants with individual applications of P and K, the combination between them - PK, as well as for the NP combination, the average values of the Index of infestation exceed 1%.

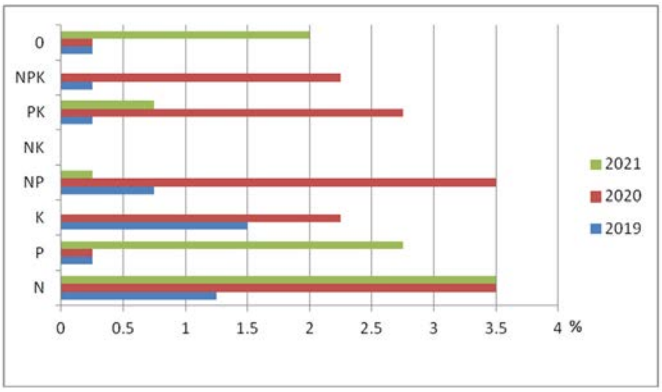


Figure 3. Index of infestation (2019-2021), in %

The obtained results correspond with previous studies by Yankova and Sovkova-Bobcheva (2009), who reported an Index of infestation of the variety Obraztsov chiflik 12 with standard cultivation technology of 2.58%. In this study, a higher rate of Index of infestation in the averaged data for the three-year period of the trial shows only the variant with individual N fertilization.

Various scientists have established the relationship between field bean seed size and the Index of infestation. In studies of genotypes of Bulgarian common bean varieties and lines for resistance to bean weevil, Yankova et al. (2010) found a higher Index of infestation for genotypes with larger seeds (respectively, the lowest Index of infestation for smaller seeds), which confirms the results obtained by Schoonhoven et al. (1983) and Ignatoviwicz and Lucka (1987). Contrariwise, Apostolova et al. (2013) found that seeds of large genotypes were less damaged than those with smaller seeds.

In this test of the response of only one common bean variety, with a proven difference in seed size (by the measure of 1000-seeds weight) between the variants with individual application of K and combined application of NP, no difference was demonstrated in both indicators - damaged seeds and Index of infestation (Table 4).

Common bean seed weight loss was recorded as a result of bean weevil larval feeding and development (Table 5). The lowest value was 0% (no damage) in the NK combination variant in all three years of the trial. The highest value is reported in the variant with individual N fertilization - 1.99% in the second and 1.93% in the third year. In 2019, the highest degree of weight loss was observed in the variant with the combined use of NP fertilizers. In the third year of the trial, variants with individual K and complete mineral fertilization (NPK) did not register any weight loss, because of the absence of damage. On average over the three-year trial period, a difference in weight loss was demonstrated between the variant with the combined use of NK, the NPK triple combination and the control variant on the one hand, and the variant with individual application of N on the other hand.

Table 5. Weight loss (2019-2021)

Variant	Weight loss (%)			
	2019	2020	2021	2019-2021
N	1.07	1.99	1.93	1.66[b]
P	0.59	0.41	1.34	0.78[ab]
K	1.10	1.44	0.00	0.85[ab]
NP	1.33	1.33	0.07	0.91[ab]
NK	0.00	0.00	0.00	0.00[a]
PK	0.62	0.82	0.13	0.52[ab]
NPK	0.45	0.40	0.00	0.28[a]
0	0.60	0.14	0.38	0.37[a]

Means followed by the different letters in each column are significantly different; Tukey test at $P < 0.05$

The weight loss in the tested varieties did not exceed 2% and was significantly lower than the 4.19% found by Yankova and Sovkova-Bobcheva (2009) in an earlier study of the variety.

The manifestation of resistance of the common bean variety Obraztsov chiflik 12 against bean weevil attack was evident when using the combination of NK, which corresponded with the results of the studies by Boiça Junior and Alonso (2000). Using only N as fertilizer increased the mass of damaged seed, but its presence in the double and triple combination did not give the same effect, while the same authors reported a decrease in the mass of damaged seed by applying N.

The results of this study support the existing positions (Jones, 1976; Altieri and Nicholls, 2003; Hsu et al., 2009; Altieri et al., 2012) that the application of mineral fertilizers generally leads to an increase in plant yield byfavouring plant growth and development. The individual application of N fertilizer also caused an increase in the damage caused by bean weevil, while the effects of P and K were less obvious.

CONCLUSIONS

The application of mineral fertilizers to the common bean variety "Obraztsov chiflik 12" affects the damage caused by the bean weevil. The combined application of NP has the greatest positive effect on the yield qualities of beans but determines an intermediate position in terms of damage by bean weevil. Combined NK fertilization resulted in the lowest damaged seeds percentage and Index of infestation, followed by the variant with full mineral fertilization and the control variant. Individual application of N resulted in the highest damaged seeds percentage and Index of infestation, followed by combined NP fertilization. The individual nitrogen fertilization variant ensured the highest mass loss on average for the study period, because of both the higher damaged seeds percentage and the high seed weight.

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