DISTRIBUTION OF CLICK BEETLES AND THE DEVELOPMENT OF CONTROL MEASURES IN POTATO FIELDS OF THE REPUBLIC OF ARMENIA

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ABSTRACT

The studies were conducted at the Aragatsotn region of the Republic of Armenia during the years 2021-2024. Four species of click beetles (family Elateridae) belonging to the order Coleoptera of the class Insecta were recorded. The most widespread species was the sowing click beetle (*Agriotes sputator* L.), making up 56%. The steppe click beetles (*Agriotes gurgistanus* Fald.) accounted for 25% of the total population. The striped (*Agriotes lineatus* L.) and dark (*Agriotes obscurus* L.) click beetles were relatively less common, constituting 14% and 5%, respectively. Based on the analysis of the damage caused by wireworms to the tubers of different potato varieties it can be concluded that the Impala and Arizona varieties are more resistant to the phytophagous pest. These varieties are recommended for cultivation in potato farms. Nuprid (0.2 L/t), Kruiser (0.2 L/t), and Force (15 kg/ha) demonstrate high biological efficacy against wireworms, showing effectiveness comparable to the standard variant, Prestige (1.0 L/t).

Keywords: Wireworms, Resistant potato varieties, Biological efficacy, Systemic insecticides, Beetle community

مجلة العلوم الزراعية العراقية- 2025 :56 (5):1779-1786 تيرليميزيان وآخرون

توزيع الخنافس الطقطاقة وتطوير إجراءات المكافحة في حقول البطاطا في جمهورية أرمينيا

تيرليميزيان سارغسيان هاروتيونيان مكرتشيان سارغسيان غازاريان

المستخلص

أجريت الدراسات في إقليم أراغاتسوتن بجمهورية أرمينيا اثناء السنوات 2021–2024. تم تسجيل أربع أنواع من الخنافس الطقطاقة (فصيلة Elateridae) التابعة لرتبة Coleoptera من طائفة الحشرات Insecta. وكان النوع الأكثر انتشارًا هو الخنفساء الطقطاقة الزراعية (*Agriotes sputator* L.) بنسبة 56%. أما الخنافس الطقطاقة السهبية (*Agriotes gurgistanus* Fald.) فشكّلت 25% من إجمالي المجتمع الحشري. في حين كانت الخنافس الطقطاقة المخططة (*Agriotes lineatus* L.) والداكنة (*Agriotes obscurus* L.) أقل شيوعًا، حيث بلغت نسبتها 14% و5% على التتابع استنادًا إلى تحليل الأضرار التي سببتها يرقات هذه الخنافس (الدودة السلكية) على درنات أصناف البطاطا المختلفة، يمكن الاستنتاج أن صنفي إمبالا (Impala) وأريزونا (Arizona) أكثر مقاومة لهذا الآفة النباتية، ويوصى بزراعتهما في حقول البطاطا. كما أظهرت المستحضرات نوبرِد 0.2 لتر/طن) وكرويزر 0.2 لتر/طن) وفورس 15 كغم/هكتار) فعالية بيولوجية عالية ضد الدودة السلكية، إذ كانت فعاليتها مماثلة لمعاملة المقارنة بريستيج 1.0 لتر/طن.

الكلمات المفتاحية: الدودة السلكية، أصناف البطاطا المقاومة، الكفاءة البيولوجية، المبيدات الحشرية الجهازية، مجتمع الخنافس.

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INTRODUCTION

Potato (*Solanum tuberosum* L.), a member of the Solanaceae family, is considered one of the world's most valuable food crops, cultivated extensively for human consumption, animal feed, and industrial applications (2, 3, 4, 5, 6). Despite its economic and nutritional importance, potato production is severely constrained by a wide range of biotic stresses, particularly insect pests and plant diseases (37, 38, 39, 40, 43). Among these, the larvae of click beetles (commonly known as wireworms) are recognized as some of the most destructive soil-dwelling pests affecting potato cultivation (7, 8, 22, 27, 28, 30). Wireworms attack underground plant parts, primarily tubers, causing direct feeding damage that reduces market quality and storage potential, and indirectly predisposing tubers to secondary infections by pathogens. The extent of yield losses caused by wireworms is often underestimated, largely because these pests remain concealed beneath the soil surface, making early detection and monitoring particularly challenging.The larvae of click beetles are polyphagous pests that live under plant residues, in the soil, and in decaying trees (18, 33, 34). They feed on plant shoots, roots, sown seeds, root vegetables, and tubers. These pests damage both annual and perennial crops, as well as fore, st trees, shrubs, and flowers (9, 11, 13, 19, 42) Potato is one of the crops that suffers significant damage from wireworms everywhere (17).

According to literature data (1), wireworms are also vectors of potato blackleg and rhizoctonia diseases. In potato fields, wireworms create characteristic holes in the tubers, allowing pathogens to penetrate and develop. As a result, yield decreases, storage time shortens, and the commercial appearance and market value of the potatoes decline.The first species of click beetles was described by Carl Linnaeus between 1758 and 1767 (25). According to the same literary source, there are 9,000 species of click beetles worldwide, 140 species in the Transcaucasus, and 103 species in Armenia. Wireworms got their name due to their elongated body shape and hard cuticular covering (24). To date, the most effective method for controlling this phytophagous pest is considered to be chemical control (15, 20, 36, 44, 45, 46).

MATERIAL AND METHODS

The research was conducted in the conditions of the Aragatsotn region of the Republic of Armenia from 2021 to 2024. The research material consisted of click beetles and their larvae found in the potato agrocenosis. The studies on the species identification, distribution, and harmfulness of click beetles and their larvae (hereafter referred to as wireworms) were conducted through route-based and permanent observations during the vegetation period. Soil excavations and visual inspections of the tubers were carried out in accordance with methodological guidelines (10, 35). The species identification of the phytophagous pest was clarified using appropriate identification keys (21, 32, 32) and with the assistance of entomologists from the scientific center. To determine the infestation of wireworms in the experimental fields, soil samples were collected in the spring, before soil cultivation, according to the methodological guidelines (32, 41). Areas were considered to have weak, moderate, or strong infestation based on the number of wireworms per square meter: up to 5, 6-20, and more than 20, respectively (16). The damage to the tubers of different potato varieties was recorded using a scale based on the number of holes created by wireworms, as follows:

0 - Healthy tubers;

1 - Slightly damaged tubers (1 hole);

2 - Moderately damaged tubers (2-5 holes);

3 - Severely damaged tubers (more than 5 holes).

The degree of tuber damage was determined using the following formula:

$$X = \sum abc \ \frac{100}{n \cdot 3} (\%),$$

Where:

X - is the degree of tuber damage, %

Σ abc - is the sum of the tuber damage scores

n - is the total number of tubers recorded

3 - is the highest score.

The biological effectiveness of the tested insecticides was calculated using the following formula (14):

$$E = 100 - \frac{\text{B}}{\text{a}} \cdot 100 \ (\%),$$

Where:

E - is the biological effectiveness (reduction in tuber damage) (%)

B - is the degree of tuber damage on the observation day in the experimental variant

a - is the degree of tuber damage on the observation day in the control variant. In order to select highly effective preparations, during the research years, field trials were conducted in the potato fields of the Hartavan community. Various chemical preparations from different groups were tested against the phytophagous pest, including:

Prestige (control sample), 29% WP, Deligent, 25% SC , Force, 1.5% G, Cruiser, 35% FS, Razore Plus, 29% WP, Sancho, 35% WP, Nuprid, 60% WP.

Each variant of the field trials had 3 replications, each covering an area of 100 m². In each variant, 300 tubers were recorded (100 tubers per replication).

The preparations that demonstrated the highest biological effectiveness in the field trials were tested under production conditions in 2024 in fields planted with the Arizona variety. Each variant covered 0.9 ha (with three replications, each 0.3 ha). In the production trials, the economic effectiveness of the applied preparations against wireworms was calculated according to the accepted methodology (12). The experimental results were subjected to mathematical analysis (23, 26, 29).

RESULTS AND DISCUSSION

The result shows four species of click beetles (family Elateridae) belonging to the order Coleoptera of the class Insecta were recorded in the potato plantations of the Aragatsotn region of the Republic of Armenia (Figure 1). Among them, the most widespread species was the sowing click beetle (*Agriotes sputator* L.), making up 56%. The steppe click beetles (*Agriotes gurgistanus* Fald.) accounted for 25% of the total population. The striped (*Agriotes lineatus* L.) and dark (*Agriotes obscurus* L.) click beetles were relatively less common, constituting 14% and 5%, respectively.

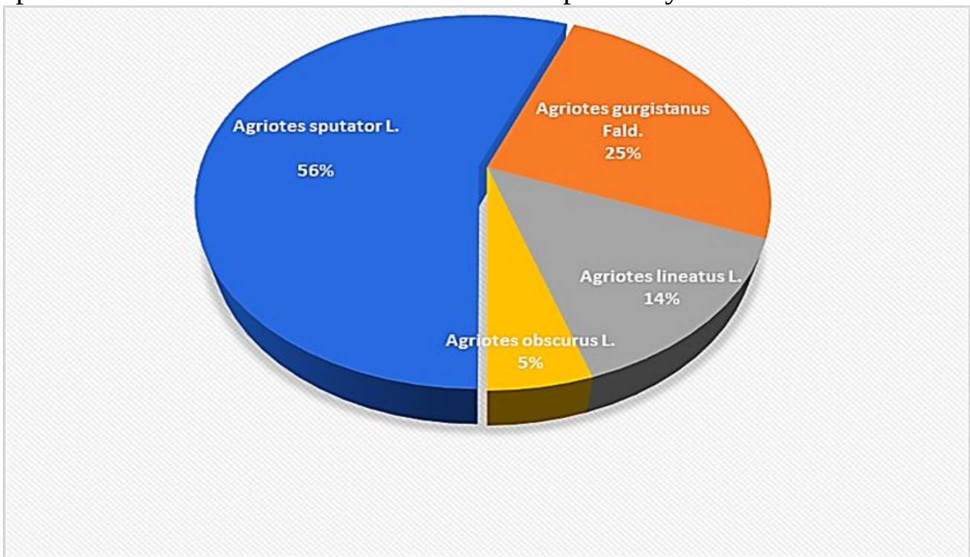

Figure 1. Percentage distribution of click beetle species (average for 2021-2022)

To obtain food, wireworm larvae gather in the underground parts of potato plants. However, visible damage becomes evident only from the middle of the vegetation period, when tubers begin to form. The holes created by the pest in the tubers (Figure 2) significantly reduce their marketable appearance and quality. These openings serve as entry points for various fungal and bacterial pathogens, leading to tuber rot and rendering them unfit for consumption. The larvae of this phytophagous pest caused the most significant damage starting from their second year of feeding until harvest.

Figure 2. Potato tuber damaged by wireworms

The studies were carried out in the Hartavan during the harvest, it was found that all the tested potato varieties were damaged by the phytophagous pest, but the degree of damage varied. Specifically, for the Marfona, Nevsky, Impala, Pamir, and Arizona varieties, the degree of tuber damage in 2021-2022 ranged from 22.4-24.2%, 27.7-29.9%, 18.4-20.1%, 24.7-26.4%, and 15.8-18.2% respectively (Figure 3).

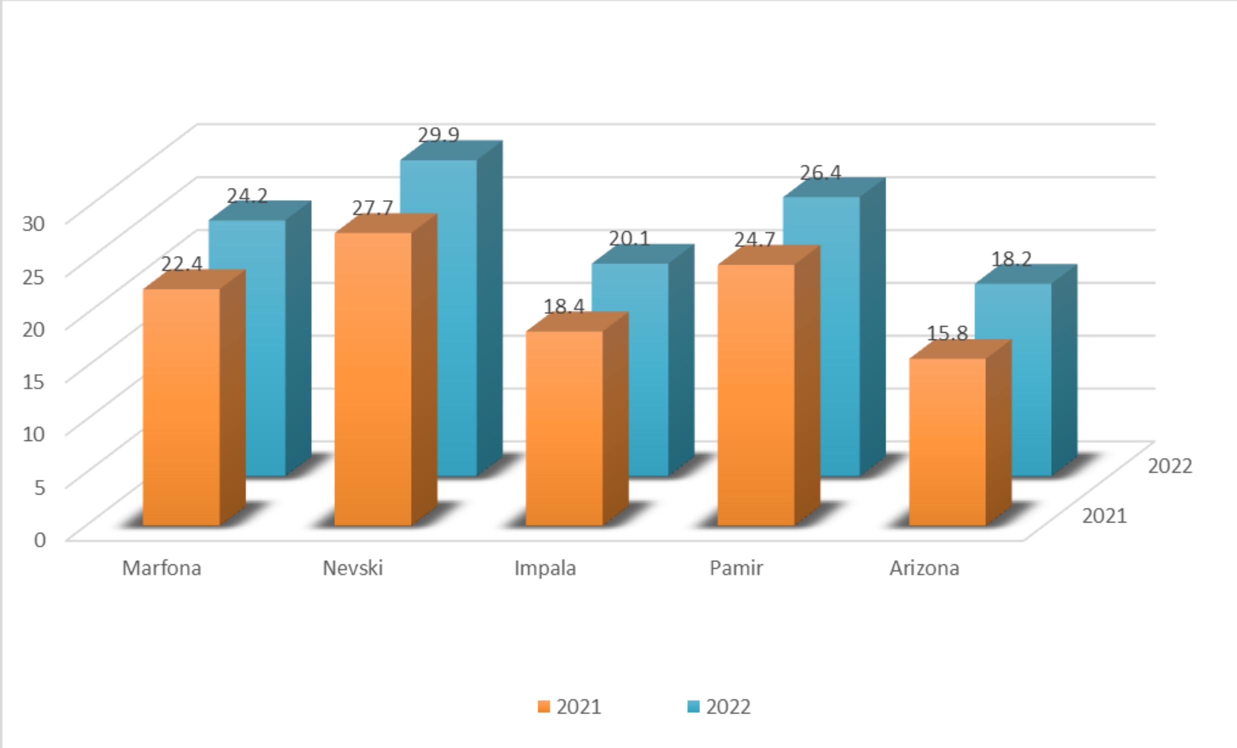

Figure 3. Degree of damage caused by wireworms to different potato varieties in 2021-2022

The Fig. 3. clearly shows that the Marfona, Nevsky and Pamir varieties are the most affected by wireworms.

In summary, based on the analysis of the damage caused by wireworms to the tubers of different potato varieties in 2021-2022, it can be concluded that the **Impala** and **Arizona** varieties are more resistant to the phytophagous pest. These varieties are recommended for cultivation in potato farms that are more severely affected by the pest. In the spring of 2022-2023 (May 16-19), the following chemical preparations from different groups were tested against wireworms in the experimental plots, at various concentrations: Deligent, 25% SC, Force, 1.5% G, Cruiser, 35% FS, Razore Plus, 29% WP, Sancho, 35% WP, Nuprid, 60% WP, and Prestige (control sample), 29% WP. Prior to planting seed potatoes, based on the calculations, it was established that the average number of wireworms per square meter of soil ranged from 5.0 to 6.7, which corresponded to the economic threshold of pest damage (41). Before planting the Arizona variety potatoes, the seed material was disinfected with aqueous suspensions of the above-mentioned preparations at various concentrations, except for Force, which was applied to the soil at the time of tuber planting. The results of these trials are presented in Table (1). The results of the quality assessment of the harvest (conducted on October 13-15, 2022, and October 3-4, 2023) revealed that not all of the tested preparations and their varying concentrations demonstrated high effectiveness against wireworms. Thus, the highest biological effectiveness was demonstrated by the following treatments: Prestige (1.0 L/ton) and Force (15 kg/ha), with effectiveness values ranging from 92.2% to 93.4% in 2022-2023. In the Cruiser treatments (0.2-0.22 l/ha), there was no significant difference in biological effectiveness, and over the course of the study years, the effectiveness ranged from 93.0% to 95.5%. Among the Nuprid treatments, the most effective concentrations were 0.2 and 0.3 L/ha, with biological effectiveness ranging from 94.4% to 97.6% over the two years of trials.

Table 1. Biological Effectiveness of Preparations Against Wireworms (Plot Trials, Hartavan, 2022-2023)

Variant	Consumption rate, l/t, kg/t, kg/ha	Degree of tuber damage at harvest, %	Biological efficiency, %
		2022 /2023	
Checker (pesticide-free)	-	21,5/18,0	-
Prestige (sample)	0,7	11,0/9,4	48,8/47,8
	0,85	6,2/5,1	71,2/71,7
	1,0	1,5/1,4	93,0/92,2
Diligent	0,2	6,7/7,0	68,8/61,1
	0,21	6,0/5,1	72,1/71,7
	0,22	5,4/4,4	74,9/75,5
Force	10	7,0/6,0	67,4/66,7
	12,5	5,3/3,3	75,3/81,7
	15	1,4/1,4	93,4/92,2
Cruisers	0,2	1,5/1,0	93,0/94,4
	0,21	1,5/1,0	93,0/94,4
	0,22	1,4/0,9	93,4/95,5
Razoo Plus	0,7	10,3/8,8	52,1/51,1
	0,85	6,6/5,7	69,3/68,3
	1,0	3,5/3,0	83,7/83,3
Sancho	0,2	6,2/7,4	71,2/58,9
	0,21	6,2/7,3	71,2/59,4
	0,22	5,5/6,4	74,4/64,4
Nuprid	0,1	4,4/3,5	79,5/80,5
	0,2	0,7/1,0	96,7/94,4
	0,3	0,5/0,9	97,6/95,0

Based on the data from Table (1), it can be observe that the reduction in tuber damage varied when applying insecticides with different dosages. The highest quality tubers were obtained in the following treatments: Force (15 kg/ha), Nuprid (0.2-0.3 L/ton), Cruiser (0.2-0.22 L/ton), and the control Prestige (1.0 L/ton). In these variants, tuber damage at harvest during 2022-2023 ranged from 0.5% to 1.5%. This shows that these treatments led to the least damage to tubers, making them the most effective options for controlling wireworm damage. Based on the two-year scientific experiment results, it has been determined that out of the 21 chemical insecticide variants tested against wireworms, the following exhibited high biological efficacy: Force (15 kg/ha), Prestige (1.0 L/ton), Nuprid (0.2-0.3 L/ton), and Cruiser (0.2-0.22 L/ton). Since there is no significant differences in the efficacy between the high-performance variants of Nuprid and Cruiser, it has been concluded that, from both environmental and economic perspectives, it is more appropriate to use the relatively lower application rates (0.2 L/ton) of Nuprid and Cruiser in production trials. Thus, the data obtained from the plot trials have provided the basis for testing the recommended pesticides under production conditions in agriculture. This step will help validate their effectiveness in real-world farming environments, ensuring that the best options are implemented for pest control while considering both economic and environmental factors. In 2024 (May 14-16), the most acceptable dosages of formulations that demonstrated high biological efficacy against wireworms in the 2022-2023 plot trials were tested under production conditions. Data in Table (2) shows that all tested formulations exhibited high biological efficacy. The highest efficacy was recorded in the Kruiser and Nuprid variants (95.5% and 96.5%, respectively). In the Force and Prestige variants, the efficacy was 92.3% and 94.0%, respectively.

Table 2. Biological Efficacy of Preparations Against Wireworms

Variant	Consumption rate, l/t, kg/t, kg/ha	Degree of tuber damage at harvest, %	Biological efficiency, %
Force	15	1,55	92,3
Kruiser	0,2	0,9	95,5
Nuptid	0,2	0,7	96,5
Prestige (sample)	1,0	1,22	94,0
Checker (pesticide-free)	-	20,2	-

Table (3) presents the economic efficiency indicators of the insecticides used against wireworms. According to the data, compared to the control (untreated), the pesticide-treated variants resulted in an additional yield of 46-51 quintals per hectare. Table (3) shows the potato yield and its mathematical analysis in pesticide-treated and untreated variants. According to the data, compared to the control, pesticide-treated variants resulted in an additional yield of 46-51 quintals per hectare. The data also indicates that the coefficient of variation and the experimental error ranged from 3.89% to 7.81% and 2.2% to 4.5%, respectively, confirming the reliability of the production trial results.

Table 3. Mathematical Indicators of Potato Yield in Pesticide-Treated and Untreated Variants

Variant	Average Yield, q/ha (quintals per hectare)	Quadratic Deviation (Variance)	Coefficient of Variation, %	Mean Error	Experimental Error, %
Force	368	14,306	3,89	8,260	2,2
Kruiser	371	28,994	7,81	16,740	4,5
Nuptid	373	18,547	5,00	10,708	2,9
Prestige (sample)	368	25,729	6,99	14,855	4,0
Checker (pesticide-free)	322	16,753	5,20	9,673	3,0

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

DECLARATION OF FUND

The authors declare that they have not received a fund.

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