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EVALUATION OF DAMAGE CAUSED BY *BRUCHUS PISORUM* L. ON SOME PARAMETERS RELATED TO SEED QUALITY OF PEA CULTIVARS

I. Nikolova [*] and N. Georgieva

Institute of Forage Crops, "General Vladimir Vazov" 89, 5800 Pleven, Bulgaria.

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Correspondence to Author:
I. Nikolova

Institute of Forage Crops,
"General Vladimir Vazov"
89, 5800 Pleven, Bulgaria.

E-mail: imnikolova@abv.bg

ABSTRACT: It was evaluated the damage caused by *Bruchus pisorum* on the germination ability of pea forage cultivars. Result of damage in seeds with parasitized larva was significant decrease of the germination by 16.4% percentage points, the length and weight of primary radicle by 16.8 and 24.5%, the length and weight of plumule by 12.3 and 14.1%, the vigor index of primary radicle and plumule by 32.5 and 32.8% as well as the germination index by 17.4%. The inhibitory effect was 17.8%. Essential significant changes regarding the studied parameters were found for damaged seeds with bruchid emergence hole. There the germination decrease by 58.3% percentage points, the length and weight of primary radicle by 34.1 and 36.2%, the vigor index of primary radicle and plumule by 81.1 and 82.1% as well as the germination index by 83.1%. The inhibitory effect was on average 58.3%. The damaged seeds with parasitoid emergence hole provided the better possibility for growth, development of plants and stable yields. As tolerant to damage by pest distinguished Glyans cultivar for which the values of parameters related to germination and vigor of seeds were influenced in the lowest degree from the damage unlike the sensitive Pleven 4.

INTRODUCTION: germination and emergence are important stages in crop cultivation. They have essential meaning on the following stages of plant growth and development [1] and for the realization of high productivity with good quality [2]. On the other hand, an important condition for implementation of this process is the use of qualitative seeds: with genetic purity, strong germination capacity, uniformity of seed size, freedom from seed-borne diseases and absence of weed or other crop seeds [1, 3]. According to Wang *et al.*, [4] seed quality is multiple concept comprising several components. The seed vigor is an important component that can influence crop plant density and yield [5].

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That vigor is related to the germination and seed ability to grow rapidly and jointly. It suggested that the speed and uniformity of emergence are important parameters of seed quality [6]. Although, many vigor tests are suggested only a few are accepted by seed analysts and seed testing organization [7]. Some of the applied tests are germination test and seed vigor test which are used to determine seed viability [8, 9, 10, 11].

Seed yield and viability can be reduced by different types of environmental stress, one of which is damage of seed weevils. The final effect of seeds with a beetle infestation on the germination of host legumes can be unpredictable [12]. In some cases, the larva feeding effectively kills the embryo or removes so much endosperm that the seed cannot germinate [12, 13]. Larval feeding may also create openings for pathogenic bacteria and fungi [13, 14, 15]. Even if germination occurs prior to seed infestation after that, the infestation may distort the development of cotyledons or prevent the formation of true leaves [13]. Depletion of cotyledon reserves may slow plant growth and hence reduce the probability for its establishment. Despite these detrimental effects of seed-beetle damage, some proportion of infested seeds may germinate successfully [16, 17]. The pea weevil is one of the most destructive pests in grain legumes [18,] and cultivar improvement for bruchid resistance is among the most important strategies for mitigating the action of biotic factors.

The subject of the present study was to the evaluation of the damage caused by *Bruchus pisorum* L. on seed germination, growth, and vigor in pea forage cultivars.

MATERIALS AND METHODS: In 2012 a field trial was carried out in the experimental field of the Institute of Forage Crops (Pleven) with 5 pea forage cultivars: Glyans (Ukraine), Cvit (Ukraine), Kamerton (Ukraine), Modus (Ukraine), Pleven 4 (Bulgaria). It was laid out by the design of a long plot method with three replications. Pesticides were not used during the vegetation period. The laboratory germination of seeds, as well as the length and weight of primary radicle and plumule, was determined four months after harvesting. The seeds of each cultivar were classified into three types: healthy seeds (type 1), damaged seeds with parasitoid emergence hole (type 2) and damaged seeds with bruchid emergence hole (type 3).

For every cultivar and type of seeds, the germination percentage was evaluated by taking 200 seeds (50 seeds in each replication). The seeds were placed in Petri dishes on double-layered Filtrak 383 filter paper with 150 mm diameter and kept in an incubator at a temperature of 20 ± 1°C for 8 days according to the ISTA[19] rules. The germinated seeds were counted daily (AOSA, 1983). The seedlings with stunted primary roots were considered as abnormally germinated[19]. A seed was considered to have germinated when the radicle reached a length of 10 mm [20].

The energy of emergence (EG) was recorded on the 4th day after sowing. It was the percentage of germinating seeds 4 days after planting relative to the total number of tested seeds [21]. The germination percentage was calculated 8 days after sowing using the formula below for each replication of the variant:

$$GP\ \% = (n / N) \times 100$$

Where, GP is the germination percentage, n is the number of germinated seeds, and N is the total number of seeds [22].

The following formula calculated the inhibitory effect (IE, %) from damage by *B. pisorum* on germination (Ahn and Chung, 2000):

$$IE = [(a-b)/a)] \times 100$$

Where, a = number of germinated seeds in the control variant (healthy seeds); b = the number of germinated seeds in the studied variant (damaged seeds).

After the final count in the standard germination test, seedling growth was assessed by measuring seedling length (plumule and radicle length) and seedling weight (fresh weight). The root length was measured from the tip of the tap root to the joining point of the cotyledon.

The vigor indexes (VI) of primary radicle and plumule were calculated, using formula from Baki and Anderson [23], as follows:

Vigor Index = Standard germination (%) × length of primary radicle (plumule) (cm)

The germination index (GI) was calculated as described in the Association of Official Seed Analysts [24] by the following formula:

GI = (Number of germinated seed / Days of the first count) +……+ (Number of germinated seed / Days of final count)

Mathematical, statistical processing of experimental data was conducted after the preliminary transformation of the percentage of damaged seeds relative to the control variant, by the formula: $Y = arcsin = \sqrt{(x_{\%} / 100)}$. All data analyses were conducted using the Statgraphics Plus software program for statistical analysis.

RESULTS: At comparing the emergency energy and germination of healthy seeds among studied pea cultivars was observed a high percentage of normally germinated seeds without significant difference among them **Table 1**. The germination was in limits 77.08 – 84.76% which means that seed was suitable for sowing. It provided the development of healthy plants with possibilities for maximum yield according to the requirements for minimum germination in pea sowing [25]. As a result of damage from *Bruchus pisorum* and related to that deterioration of seed quality was changed the germination of seeds. The germination was in limits from 50.28 to 70.78% in damaged seeds with parasitoid emergence hole (type 2). It significantly decreased from 9.45 to 26.80 percentage points to the germination of the relevant healthy seeds (type 1). Among cultivars with statistically significant lower germination was distinguished Pleven 4 (50.28%) with a decrease by 26.80 percentage points. This cultivar was distinguished with significantly the highest inhibitory effect (IE_1) - 37.32%. The damaged seeds with bruchid emergence hole (type 3) were characterized with the lowest energy of emergence and germination. Compared to the healthy seeds the germination significantly reduced from 54.34 to 64.16 percentage points as among the cultivars the lowest significant germination and high inhibitory effect (IE_2) was found in Pleven 4 (12.92 and 94.56 % respectively). At this type of seeds (type 3) Glyans cultivar was with significantly lower germination to Kamerton and with lowest inhibitory effect (IE_2) - 78.13%.

TABLE 1: EFFECT OF THE DAMAGE CAUSED BY *BRUCHUS PISORUM* ON SEED GERMINATION IN DIFFERENT CULTIVARS OF SPRING FORAGE PEA

Cultivars	1	1	2	2	3	3	LSD	IE_1,	IE_2,	LSD
	EG	GP	EG	GP	EG	GP	0.05%	%	%	0.05%
Glyans	54.23	84.76 c[1] /a[2]	50.77	70.78 b/b	19.97	27.74 a/c	8.797	10.11a/a	78.13 b/a	10.937
Cvit	48.35	80.90 c/a	45.30	65.91 b/b	23.23	26.57 a/bc	6.826	14.46 a/a	79.59 b/a	13.665
Kamerton	52.24	79.48 c/a	47.87	70.03 b/b	20.70	21.42 a/b	7.747	11.78 a/a	86.44 b/ab	7.720
Modus	53.23	80.90 c/a	40.69	64.04 b/b	19.22	22.79 a/bc	9.149	17.08 a/a	84.64 b/a	11.525
Pleven 4	47.39	77.08 c/a	40.69	50.28 b/a	10.51	12.92 a/a	8.096	37.32 a/б	94.56 b/b	12.879
Average	51.09	80.63	45.06	64.21	18.73	22.29		18.15	84.67	
$LSD_{5\%}$		5.980		9.103		7.674		10.383	9.692	

Legend: Type 1 – healthy seeds; Type 2 – damaged seeds with parasitoid emergence hole; Type 3 – damaged seeds with bruchid emergence hole; EG - Energy of emergence, %; GP - Germination percentage, %; IE_1, % - Inhibitory effect of damaged seeds with parasitoid emergence hole; IE_2, % - Inhibitory effect of damaged seeds with bruchid emergence hole, %; [1] - significance among the type of seeds for a cultivar; [2] - significance among the cultivars values without same letter are significantly different.

As an expression of the sowing characteristics of seeds was the growing strength of primary radicle and plumule within certain cultivars. Data from biometric measurements regarding the length of primary radicle and plumule (cm) and their weight (g) permitted objectively to evaluate the reaction of studied cultivars in the initial stages of their development as a result of damage by *B. pisorum* **Table 2**. It was observed some difference concerning the upgrowth length of primary radicle and plumule in the fresh seeds as significantly the highest values were found for Pleven 4 cultivar (9.015 and 3.773 cm respectively). Exception for the significant difference was observed only relative to Glyans cultivar regarding the radicle length. At the other cultivars the values were in close limits and varied from 7.169 to 7.945 cm and from 1.034 to 2.030 cm respectively for primary radicle and shoot.

Regarding the weight of primary radicle with significantly the highest weight was distinguished Glyans (0.117 g), and at the others, it varied from 0.078 to 0.098 g with significant differences between Cvit and Modus (0.098 and 0.078 g respectively). At Pleven 4 cultivar was observed statistically significant the greatest weight of plumule (0.083 g) followed by Cvit (0.055 g). Among the upgrowth length of primary radicle and plumule were established positive correlations as strongly expressed ones were between the length and weight of plumule (r = + 0.981) and between the length of primary radicle and plumule (r = + 0.928).

As a result of the larva feeding was suppressed in some degree the upgrowth of primary radicle at seeds type 2 as its length varied from 4.571 to 7.736 cm. Only in Pleven 4 cultivar was found significant reduction from 49.3% in the upgrowth of radicle compared to this of the healthy seeds till at other cultivars it was insignificant (from 2.6 to

11.1% reduction). In regard to the weight, a significant decrease from 21.3 to 39.3% was observed at Glyans, Cvit and Pleven 4. The damaged seeds with parasitoid emergence hole were characterized with lower values of the plumule length and weight (from 4.2 to 23.3% and from 3.3 to 25.8% respectively) to the healthy seeds but these values were statistically insignificant. Among the cultivars with significantly lower values of the radicle length was distinguished Pleven 4 (4.571 cm) as this cultivar had and the greatest length of plumule (3.152 cm).

TABLE 2: EFFECT OF THE DEGREE OF DAMAGE BY *BRUCHUS PISORUM* TO PEA SEEDS ON THE LENGTH AND WEIGHT OF PRIMARY RADICLE AND PLUMULE

Cultivars	1		2		3		$LSD_{5\%}$
			RL				
Glyans	7.945	B[1]/ab[2]	7.736	b/b	6.900	a/b	0.823
Cvit	7.653	b/a	7.032	a /b	4.923	a/ab	2.153
Kamerton	7.169	b/a	6.656	ab/b	4.473	a/ab	2.435
Modus	7.571	b/a	6.733	ab/b	5.850	a/ab	1.576
Pleven 4	9.015	b/b	4.571	a/a	3.775	a/a	1.969
Average	7.871		6.546		5.184		
$LSD_{5\%}$	1.157		1.198		2.570		
			RW				
Glyans	0.117	b/c	0.092	a/b	0.082	a/b	0.018
Cvit	0.098	b/b	0.067	a/a	0.061	a/ab	0.014
Kamerton	0.083	a/ab	0.069	a/a	0.061	a/ab	0.03
Modus	0.078	b/a	0.069	ab/a	0.055	a/a	0.016
Pleven 4	0.092	b/ab	0.056	a/a	0.040	a/a	0.03
Average	0.094		0.071		0.060		
$LSD_{5\%}$	0.018		0.017		0.028		
			PL				
Glyans	1.660	b/ab	1.514	b/ab	1.021	a/a	0.442
Cvit	2.030	a/b	1.945	a/b	1.755	a/b	0.826
Kamerton	1.231	b/ab	0.944	ab/a	0.780	a/a	0.332
Modus	1.034	a/a	0.974	a/a	0.785	a/a	0.324
Pleven 4	3.773	b/c	3.152	ab/c	2.292	a/c	1.294
Average	1.946		1.706		1.326		
$LSD_{5\%}$	0.879		0.667		0.507		
			PW				
Glyans	0.040	a/ab	0.038	a/a	0.029	a/ab	0.011
Cvit	0.055	a/b	0.051	a/a	0.040	a/ab	0.061
Kamerton	0.025	b/a	0.019	ab/a	0.015	a/a	0.009
Modus	0.027	a/a	0.026	a/a	0.019	a/a	0.009
Pleven 4	0.083	a/c	0.063	a/a	0.049	b/b	0.032
Average	0.046		0.039		0.030		
$LSD_{5\%}$	0.024		0.048		0.030		

Legend: 1 – healthy seeds; 2 – damaged seeds with parasitoid emergence hole; 3 – damaged seeds with bruchid emergence hole; RL - radicle length, cm; RW - radicle weight, g; PL - plumule length, cm; PW - plumule weight, g; [1] - significance among the type of seeds for a cultivar; [2] - significance among the cultivars values without the same letter are significantly different. The essential changes as regards the studied parameters were found in the damaged seeds with bruchid emergence hole (type 3). In all cultivars was observed significant suppression in the upgrowth of primary radicle and its weight (the only exception was the weight of Kamerton cultivar) to the relevant in the healthy seeds from 13.1 to 58.1% and from 27.0 to 56.7%. The suppression was most pronounced for Pleven 4 and the lowest - for Glyans. A significant decrease in plumule length was established for Pleven 4 (39.3%), Glyans (38.5%) and Kamerton (36.7%) and as regards its weight - for Pleven 4 (40.8%) and Kamerton (39.8%). The comparing of cultivars showed significant differences regarding the length and weight of primary radicle and plumule length between Pleven 4 and Glyans. Significant differences between seeds type 2 and type 3 were observed for Glyans in respect to the extent of primary radicle and plumule until for other cultivars such differences were not found. The obtained results at the determination of the vigor index of primary radicle (VIr) and plumule (VIp) in **Table 3** showed a significant difference among the three types of seeds for studied cultivars.

TABLE 3: EFFECT OF THE DEGREE OF DAMAGE BY *BRUCHUS PISORUM* TO PEA SEEDS ON VIGOR INDEX (VI) AND GERMINATION INDEX (GI)

Cultivars	1		2		3		$LSD_{5\%}$
			VIr				
Glyans	673.44	c[1]/ab[2]	547.59	b/c	191.43	a/c	71.36
Cvit	619.14	c/ab	463.45	b/b	130.78	a/b	71.766
Kamerton	569.81	c/a	466.08	b/b	95.80	a/ab	70.984
Modus	612.50	c/ab	431.19	b/b	133.30	a/b	92.101
Pleven 4	694.87	c/b	229.83	b/a	48.78	a/a	172.334
Average	633.95		427.63		120.02		
$LSD_{5\%}$	133.56		83.485		60.594		
			VIp				
Glyans	140.69	c/ab	107.19	b/b	28.33	a/ab	22.793
Cvit	164.25	b/b	128.22	b/bc	46.61	a/b	56.132
Kamerton	97.87	c/ab	66.14	b/a	16.70	a/a	27.932
Modus	83.62	c/a	62.39	b/a	17.89	a/a	17.802
Pleven 4	290.80	c/c	158.46	b/c	29.61	a/a	121.724
Average	155.44		104.48		27.83		
$LSD_{5\%}$	88.63		49.189		12.541		
			GI				
Glyans	15.42	b/a	15.28	b/c	3.13	a/b	3.523
Cvit	14.84	b/a	12.20	b/ab	3.44	a/b	3.719
Kamerton	15.68	b/a	14.01	b/bc	2.55	a/ab	2.201
Modus	15.97	c/a	12.18	b/ab	2.45	a/ab	2.953
Pleven 4	14.48	c/a	9.59	b/a	1.39	a/a	4.68
Average	15.28		12.65		2.59		
$LSD_{5\%}$	4.711		2.955		1.392		

Legend: 1 – healthy seeds, 2 – damaged seeds with parasitoid emergence hole, 3 – damaged seeds with bruchid emergence hole, VIr – vigor index of radicle, VIp- vigor index of plumule, GI - germination index; [1] - significance among the type of seeds for a cultivar; [2] - significance among the cultivars values without same letter are significantly different, With the lowest significant values were damaged seeds with bruchid emergence hole (type 3) followed by damaged seeds with parasitoid emergence hole (type 2). VIr and VIp varied from 48.78 to 191.43 and from 16.70 to 46.61 for type 3 and from 229.83 to 547.59 (VIr) and from 62.39 to 158.46 (SVIp) for type 2 respectively. At comparing among cultivars with the highest vigor index of healthy seeds (type 1) was distinguished Pleven 4 (694.87 and 290.80).

Respectively for radicle and plumule) followed by Glyans and Cvit. This trend at type 2 and 3 (seeds) was retained only at Glyans regarding VIr where the values of parameter were significantly higher to other studied cultivars (547.59 and 191.43 respectively). In this cultivar, the reduction relative to the healthy seeds was least pronounced – 18.7 and 71.6% respectively for seeds type 2 and 3.

The results were not so categorical for Cvit independently of higher vigor index of the primary radicle. Pleven 4 was distinguished with the lowest vigor index of primary radicle among the cultivars (229.83 and 48.78 respectively for type 2 and 3) and the greatest reduction to the healthy seeds (66.9 and 93.0%). The greater plumule length of healthy seeds for Pleven 4 did not a secure decrease in VIp values of the damaged seeds. It was important to note that for this cultivar the reduction in VIp to the healthy seeds was the most essential (45.5 and 89.8% for seeds type 2 and 3 respectively). The results regarding the germination index were analogical and indicative. Glyans was distinguished with high values in both types (2 and 3) of damaged seeds (15.277 and 3.129%) as well as with the lowest degree of reduction to the relevant seeds from type 1. This cultivar had significant differences to Pleven 4.

The last one had the lowest germination index for all types of seeds and the most pronounced reduction in the values of seeds for type 2 and typed 3-33.7 and 90.4% respectively to the healthy seeds. Independently of the cultivar factor significantly lowest index (variation in limits 1.388-3.438%) was observed in damaged seeds with bruchid emergence hole. The germination index for damaged seeds with parasitoid emergence hole (type 2) was significantly higher to type 3 and markedly lower to type 1 only for Pleven 4 and Modus cultivars. It was not observed significant difference in the values of parameter among the cultivars for seeds type 1 as they varied from 14.479 to 15.793%. The analysis of variance regarding the germination ability of healthy seeds and damaged seeds by *B. pisorum* in pea cultivars showed that dominant factor in all analyzed parameters was the type of seeds (factor B) - **Table 4.** It had the strongest influence on the sowing qualities and significant effect – from 5.6 to 94.8% of the total variation. It was observed an exception only regarding the plumule length and weight and where it was not found significant influence. The cultivars were also factor in more parameters with significant strength of influence, but their interaction was lower pronounced - from 2.4 to 70.3%. The interaction between two factors (AxB) as the strength of influence varied in many narrow limits – from 0.9 to 17.4% and was significant in RL, RW and VIp parameters.

TABLE 4: ANALYSIS OF VARIANCE FOR STUDIED FACTORS IN PEA FORAGE CULTIVARS

Source of variation	**df**	**GP MS**	**GP IF,%**	**RL MS**	**RL IF, %**	**RW MS**	**RW IF, %**	**PL MS**	**PL IF, %**
Total	59	1368.8	-	3.2	-	0.00053	-	0.9	-
Factor A-Cultivar	4	491.2	2.4	5.3	11.3*	0.00212	27.3*	9.3	70.3*
Factor B–Types of seeds	2	38281.3	94.8*	36.1	38.4*	0.00598	38.4*	1.9	7.3
A x B	8	90.3	0.9	4.1	17.4*	0.00019	5.0*	0.3	4.0
Pooled error	42	26.0	1.5	1.4	32.9*	0.00020	29.3*	0.2	18.3*
Source of variation	df	PW MS	PW IF, %	GI MS	GI IF, %	VIr MS	VIr IF, %	VIp MS	VIp IF, %
Total	59	0.00076	-	35.6	-	93897.1	-	9775.4	-
Factor A-Cultivar	4	0.00417	37.2*	13.2	2.5	38019.5	2.7	29230.5	20.3*
Factor B–Types of seeds	2	0.00125	5.6	897.0	85.4*	2434145.0	87.9*	151248.5	52.4*
A x B	8	0.00012	2.2	4.7	1.8	41439.1	6.0	11055.4	15.3*
Pooled error	42	0.00055	55.0*	4.8	10.3	4178.9	3.4	1530.8	11.9*

LSD $_{0.05\%}$; DF - Degrees of freedom; MS - Mean square; IF - Influence of factor; GP - germination percentage; RL - radicle length; RW - radicle weight; PL - plumule length; PW - plumule weight; GI - germination index; VIr - vigor index of radicle; VIp- vigor index of plumule; *significant.

DISCUSSION: Cultivars appurtenance of seeds was a factor influencing their germination and sowing characteristics [26]. On the other hand, the emergence of seeds is influenced by many abiotic and biotic factors including damages by different insects. The period for which the seeds emerge and germinate has serious consequences on the whole process of plant growth and development [1]. According to Fox *et al.*, [12] the effects of damage bruchid seeds on the germination could be unpredictable. The damaged seeds with parasitoid emergence hole (type 2) had significantly lower germination independently that the larva did not reach its full development and was died. This type was distinguished with significantly higher germination and considerably lowered inhibitory effect (IE_1) to damaged seeds with bruchid emergence hole (type 3). The early mortality of bruchid larvae due to parasitism had no negative influence in great degree on seed germination because the larvae were killed before consuming too large a quantity of the seed. Unlike that, the larval feeding (in damaged seeds with imago) effectively kills the embryo or removes so much endosperm that a large part of seeds cannot germinate [13]. The result of damage was the high inhibitory effect (IE_2). Despite these detrimental effects of seed-beetle damage, some proportions of infested seeds germinate successfully. Similar results reported Nakai *et al.*, [27] under which the seeds from which *Pteromalus* wasps is emerged germinated more successfully than the seeds from which *Bruchus loti* adults emerged. *B. loti* larvae parasitized by the two wasp species consumed with less intensively the seeds of *Lathyrus japonicus* than the non parasitized larvae of weevil. Mateus *et al.*, [28] are found that the proportion of pea germinated seeds is significantly higher for non-attacked seeds from *Bruchus pisorum* compared to the attacked seeds.

Similar results about reduced germination in the result of bruchid damages are reported and other [16, 17]. The cultivar factor influenced the germination only for damaged seeds with bruchid emergence hole (type 3). The established highest germination and low inhibitory effect for Glyans probably were due to the higher content of nutrients. It was found that depending on the sensitivity of different pea cultivars regarding the attack of *Bruchus pisorum* occurred biochemical changes related to increased content of crude protein, proteins, total phenols, water-soluble sugars, phosphorus and decreased the content of calcium and trypsin inhibitory activity. The sensitive cultivars had the most pronounced increase regarding crude protein, proteins, total phenols which due to the protective reaction of the plant to compensate the losses from damage [29].

The result of larva feeding of pea weevil was suppression in the growth of primary radicle and plumule as well as a decrease of their weight. The damaged seeds with parasitoid emergence hole were less affected than the damaged seeds with bruchid emergence hole where was observed significant suppression in the growth and weight of primary radicle for all cultivars. The depletion of cotyledon reserves in seeds type 3 probably slowed the growth and development of plant and hence reduced the probability of establishment. Glyans cultivar was distinguished as the most tolerant to damage by *B. pisorum* which likely was related to the different quantity of reserve nutrients accumulated in seeds and their potential. As the most sensitive was manifested Pleven 4 which independently of the greatest length and weight of plumule to other cultivars was the most affected by the damages and with reduced sowing characteristics of seeds. Mateus *et al*., [28] found that the mean weight and mean length of primary radicle and plumule were significantly greater than these of damaged seeds by *B. pisorum.* At the same time comparing the two types (2 and 3) of seeds did not show significant differences between them regarding seed germination and seedling vigor. A similar tendency was also observed in the present study (Glyans was an exception) as there was a significant decrease in the length of primary radicle and plumule between seeds from type 2 and type 3. According to Bonal *et al*., [30] in some plants, part of the cotyledon may serve to buffer the negative impact of bruchid damage whereas any loss of cotyledon tissue in other plants greatly reduces seedling mass. Probably this was the reason for the different reaction of studied cultivars to pea weevil attack.

In support of the above were the results regarding the vigor index and germination index. Pleven 4 had a high vigor index of healthy seeds, but at damage by pea weevil it could not overcome or compensate for the negative consequences. It was distinguished and with the lowest germination index regarding three types of seeds. As opposed to it Glyans (independently of lower vigor index of healthy seeds) overcame the detrimental effects from bruchid damage and had higher vigor index and germination index in damaged seeds to other cultivars.

Irrespective of cultivars the damage by pea weevil was related to the reduction of germination and vigor of seeds and the possibility for fast and simultaneously emergence and development. The damaged seeds with parasitoid emergence hole (type 2) had better potential for growth and development whereas the damaged seeds with bruchid emergence hole had significantly low germination, vigor and sowing characteristics. These seeds could not provide the establishment of the well-garnished stand and stable yields. As the most tolerant to damage by *B. pisorum* was distinguished Glyans which can be used as a germplasm source for selection.

CONCLUSION: Result of damage by *Bruchus pisorum* in seeds with parasitized larva was significant decrease of the germination by 16.4% percentage points, the length and weight of primary radicle by 16.8 and 24.5%, the length and weight of plumule by 12.3 and 14.1%, the vigor index of primary radicle and plumule by 32.5 and 32.8% as well as the germination index by 17.4%. The inhibitory effect was on average 17.8%. Essential significant changes regarding the studied parameters were found for damaged seeds with bruchid emergence hole. In these seeds the germination decrease by 58.3% percentage points, the length and weight of primary radicle by 34.1 and 36.2%, the length and weight of plumule by 31.8 and 34.3%, the vigor index of primary radicle and plumule by 81.1 and 82.1% as well as the germination index by 83.1%. The inhibitory effect was on average 58.3%.

The damaged seeds with parasitoid emergence hole (type 2) provided a better possibility for growth and development of plants. These seeds could provide the establishment of the well-garnished stand and stable yields. As the most tolerant to damage by *Bruchus pisorum* was distinguished Glyans cultivar for which the values of parameters related to germination and vigor of seeds were influenced in the lowest degree from damage unlike the sensitive Pleven 4. It was found that the dominant factor influencing germination ability of seeds for all analyzed parameters was the type of seeds compared to cultivars appurtenance.

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