

## Evaluation resistance to detach the pod's pedicels of chickpea (*Cicer arietinum* L.) accessions, part of the Bulgarian chickpea collection

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### Abstract

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The threshing loss in chickpea (*Cicer arietinum* L.) is influenced by environmental conditions, the genotypes and their status during the harvesting, the threshing technology and machines, as well as the parameters of their operating mode. The aim of the study is the evaluation of number of chickpea genotypes, part of the National Gene Bank collection, in terms of their resistance to pedicel detachment, combined with other valuable traits. In the course of two years (2020–2021), chickpea accessions were assessed in field experiments by economically important traits according to the International Chickpea Descriptor (UPOV, 2019). By laboratory tests, through an experimental setup, the energy to detach the pedicel of the pod from the chickpea stalk was determined. The phenotypic and genotypic coefficients were also determined.

The highest average energy value to detach the pod pedicel was established in B9E0014 accession, followed by BGR23151, A8E0412 and B9E0149. The B9E0014 accession was characterized by tall plants, high setting of the first pod and big mass of 100 grains, while BGR23151 distinguished by big numbers of branches, pods and grains per plant. Phenotypic and genotypic coefficients of variation were distinguished by high values. It was found that resistance to the pod pedicel detachment was mostly influenced by the interaction between the genotype and the moisture of the grains, followed by genotype with  $p = 0.04 < \alpha = 0.05$ . The genotype BGR23151 is recommended for direct implementation in practice.

*Keywords:* *Cicer arietinum*; resistance to detach the pod's pedicels; yield potential; plant breeding

### Introduction

The chickpea (*Cicer arietinum* L.) is the second most important legume crop after bean (Varshney et al., 2013). The world chickpea production is estimated at 11.30 million tonnes from an area of 12.14 million ha, with an average yield of 931 kg/ha (FAOSTAT 2012). It occupies a strategic place as a protein crop in the structure of world agricultural production in regions with warm, temperate, semi-arid and arid climates (Anbessa et al., 2006). This crop is grown in 54 countries, with nearly 90% of the area in developing countries. Almost 80% of the world's chickpea are produced

in South and Southeast Asia. India ranks first in the world, followed by Australia, Turkey, Myanmar and Ethiopia (FAOSTAT, 2012; Gaur et al., 2012).

Traditionally, chickpea has been harvested by pulling the entire plants to avoid any kind of losses. But this type of harvesting has many disadvantages: quality of feed is reduced, the nodules of nitrogen-fixing bacteria do not stay in the ground and the working costs are increased compared to other harvesting systems (Bansal & Sakr, 1992; Konak et al., 2002). The main long term objective of farmers in developing countries was the mechanization of *Cicer arietinum* L. harvesting. This was difficult task because of the low

structure and uneven ripening of the chickpea plants, low yield of the crop and high losses from the detachment of pod pedicels. Many researchers applied conventional combine harvesters for chickpea, but losses were significant (Haffar et al., 1991; Siemens, 2006). Chakraverty et al. (2003) reported that the losses from the mechanized harvesting of chickpea were 5.5%. The main reason for this is that combines have wide header that does not adapt to unevenness in the ground, which causes pod shattering losses. The use of chickpea harvesters with Shelbourne Reynolds' stripper header also caused high losses (Behroozi-Lar & Huang, 2002).

The main disadvantage of stripper headers is that they have excessive losses in low yield, and/or immature crops (Tado et al., 1998). Golpira et al. (2013) create prototype harvester, which has potential to improve chickpea harvesting systems with saving cost and time and provide an alternative to manual harvesting. Farmer experience has shown yield losses of up to 30% if harvest is delayed 2-4 weeks. According to Patil et al., 2014, the results of machine harvest indicated lower harvest losses for tall genotypes (ranging 2.64 to 4.96%) and higher loss (20%) for semi-erect genotype as compared to manual harvest (3.12 to 5.40%). The mechanized harvesting of chickpea grains, at humidity above 12-15%, is not accompanied by significant losses from their scattering, approximately they are around 5% (Vishwakarma et al., 2019). At technological maturity, the humidity of the pods drops significantly in a few hours and their pedicels become tender. This leads to their detachment from the stalks and scattering of the detached pods on the soil, as a consequence of the mechanical impact of the harvesting machine. In order to reduce the losses under the Bulgarian growing conditions, it is recommended the mechanized single-phase harvesting to be carried out before noon, while the pedicels are not dried out and are still tough. This practically extends the period for harvesting the crop and there is a need to select varieties with a stiff pedicels at full maturity.

The losses from the mechanized harvesting of chickpea are determined by the following groups of factors:

- The environmental conditions;
- The harvesting technology – single-phase, or two-phase;
- The harvesting machines and the parameters of their working mode;

- Indicators of the genotype and its status during harvest.

Different types of mobile and stationary threshers or combines are used for mechanized harvesting of chickpea. Harvester operating mode has been determined to have the most significant effect on mechanized harvesting without significant losses from pods scattering and mechanical seed handling (Olaoye, 2004; Olaoye et al., 2010).

According to many researchers, the main factors that cause loss in mechanized harvesting of chickpea are the environmental factors, such as grain moisture content (Olaoye, 2004), resistance of pod pedicels to detachment and grain hardness (Paulsen et al., 1981; Zeren et al., 1991), and the degree of genetic determination of this resistance is essential for any breeding program.

The aim of the present study was to assess the pedicels resistance to detachment in number of IRGR-Sadovo chickpea accessions parallel to some other valuable traits.

## Material and Methods

### *Plant material*

The two years experiment was conducted at the IRGR – Sadovo experimental field (2020-2021). The study included nine chickpea genotypes of different ecological-geographic origins, maintained at the National gene bank. Most of the investigated genotypes were of Bulgarian (B9E001, 86E0265, A8E0412, A8BM0071, B9E0149, B9E0014 and A9E0121) and two (5953 and B7000117) of foreign origin (Table 1).

The evaluation of the agronomical traits was done in accordance with the International Descriptor for *Cicer arietinum* L. (UPOV, 2019). Randomly selected ten plants from each chickpea genotype were manually harvested at full maturity and stored in a well-ventilated storage room. The following morphological traits were assessed: plant height

**Table 1. Passport data of the studied *Cicer arietinum* L. Accessions**

N	BGR/ Cat. №/Cultivar	Year	Accename	Origin	Status	Collecting source
1	B9E001	2008	Local	BGR	Traditional cultivar	Farm/Cultivated habitat
2	BGR23151	1986	Local	BGR	Traditional cultivar	Farm/Cultivated habitat
3	A8E0412	2008	Local	BGR	Traditional cultivar	Farm/Cultivated habitat
4	Balkan	2008	Local	BGR	Traditional cultivar	Farm/Cultivated habitat
5	B9E0149	2009	Local	BGR	Traditional cultivar	Farm/Cultivated habitat
6	BGR001	2017	Foreign	ROM	–	–
7	B9E0014	2009	Local	BGR	Traditional cultivar	Farm/Cultivated habitat
8	A9E0121	2009	Local	BGR	Traditional cultivar	Farm/Cultivated habitat
9	BGR21208	1959	Foreign	AZB	–	–

(cm), plant height to the first pod (cm), number of productive branches, number of pods per plant, number of grains per plant, number of grains per pod, mass of grains per plant (g), mass of 100 grains (g) and mass of the whole plant (g).

### Experiment setup

According to Ishpekov et al. (2021), the energy required to detach the pod pedicels from the stem determined the resistance of a single accession. For the purpose, a special device was used, composed of a pendulum apparatus, fixtures for the stem and an electronic data collection system that registers and records the angle of rotation of the pendulum –  $\phi$  (Figure 1). The required consumption energy for dynamic pedicels detachment was determined by the dependence:

$$\Delta T = \Delta T_1 - \Delta T_2,$$

where:

$\Delta T_1$  – the energy to detachment and move the pod, J;

$\Delta T_2$  – the energy just to move the same pod, J.



**Fig. 1. Pendulum apparatus for determining the energy to detach the pod pedicels from chickpea stem**

### Statistical analysis

The obtained experimental data were subjected to the following statistical procedures:

– The method of significant differences with visualization of the results through a Box and Whisker plot for mean, mean  $\pm$ SD and mean  $\pm$ 1.96SD (SD – standard deviation).

– A two-factor analysis of variance to determine the influence of energy for to detach the pod pedicels on the genotype-environment system. The dependent variable was the energy to detach the single pod pedicels and the independent variables were the genotype type and moisture content of the grain.

– Phenotypic and genotypic variances were estimated according to the method proposed by Burton & Devane, (1953):

*Environmental variance* ( $\sigma^2e$ ) = *Mse*

*Phenotypic variance* ( $\sigma^2p$ ) = ( $\sigma^2g + \sigma^2e$ )

*Genotypic variance* ( $\sigma^2g$ ) = *Mse* – *Mst*

Phenotypic and genotypic coefficients of variation:

$$\text{Phenotypic coefficient of variation (PCV)} = 100 \frac{\sqrt{\sigma^2 px}}{x}$$

$$\text{Genotypic coefficient of variation (GCV)} = 100 \frac{\sqrt{\sigma^2 gx}}{x},$$

where:

$\sigma$  is the variance;

p – phenotypic coefficient;

g – genotypic coefficient;

e – environmental coefficient;

x – average value of the sample;

Mse – mean square error;

Mst – mean square treatment.

According to Johnson et al. (1955) genetic advance (GA) and genetic advance as a percentage of mean (GAM) were determined.

$$\text{Genetic advance } GA = \frac{K \times \sqrt{\sigma^2 p} \times \sigma^2 g}{\sigma^2 p},$$

where:

k – standardized selection differential at 5% selection intensity (K = 2.063);

$\sigma^2g$  – the genotypic variance;

$\sigma^2p$  – the phenotypic variance.

Genetic advance as percentage of mean  $GAM(\%) = \frac{GA}{x} \times 100$ ,

where:

x – the average value of the sample;

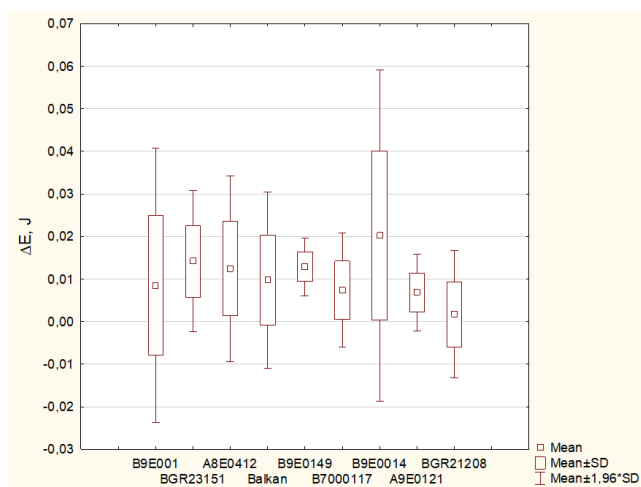
GA – Genetic advance.

The statistical program SPSS 19 for Windows was used for the two-factor analysis of variance and for the determination of phenotypic and genotypic variances, as well as genetic progress. The method of significant differences with visualization of the results by Box and Whisker plot was conducted using the STATISTICA 12 statistical processing program.

According to Deshmukh et al. (1986), if PCV and GCV values bigger than 20% were considered high, while values below 10% were considered low and values between 10 and 20% were considered medium.

## Results and Discussion

Experimentally obtained energy, required to detach the pod's pedicels, varied from 0.005 to 0.0252 J (Figure 2). The genotype B9E0014 had the highest average value, followed by BGR23151, A8E0412 and B9E0149. The lowest average energy was observed for BGR21208. The highest energy dispersion was reported for accession B9E0014, indicating that



**Fig. 2. Box and Whisker plot for mean, mean  $\pm$  SD and mean  $\pm$  1.96 SD of energy required to detach the pod's pedicels**

the plants within this accession differed according to their resistance to detachment. The least variation, or homogeneity for this trait was observed in B9E0149 accession.

The agronomical traits of the evaluated accessions varied in the following limits: plant height (29.67–50.83 cm); height to first pod (12.67–23.33 cm); number of branches (1.50–3.14); number of pods per plant (20.50–51.33); number of grains per pod (1.03–1.80); number of grains per plant (24.67–51.83); mass of grains per plant (6.23–22.55 g); mass of 100 grains (13.70–53.05 g); mass of the whole plant (10.48–46.83 g) (Table 2).

Several accessions were selected possessing valuable traits. B9E0014 accession was distinguished by the highest energy required for pedicel's detachment, with tall plants, high formation of the first pod and big mass of 100 grains. The genotype BGR23151 stood out with a big number of branches, pods and grains per plant. The accession B9E0149 had average plant height and number of branches, high formation of the first pod and mass of 100 grains above average for all studied genotypes. The results, obtained from this study corresponded to the results reported from Petrova et al. (2021). The variability of agronomic and biological traits has shown high genetic diversity in evaluated grain legume accessions and increased the possibilities for their use in the breeding-improvement activity (Petrova, 2015; Petrova et al., 2021).

The effect of the genotype, moisture of the grains and their interaction (Genotype  $\times$  Moisture) is presented on Table 3. It was obvious that the energy to detach the pedicel of the pod statistically was most influenced by the interaction between the both factors – Genotype  $\times$  Moisture with a probability of significance  $p = 0.016 < \alpha = 0.05$ , followed by the influence of genotype with  $p = 0.04 < \alpha = 0.05$ . According to the obtained results, the influence of grain moisture at full maturity of chickpea did not significantly affect the resistance of pedicel of the pod  $p = 0.853 > \alpha = 0.05$ .

The phenotypic coefficient of variation has a value of 154.7%, and the genotypic coefficient of variation has a value of 35.7%. According to the argument used by Deshmukh et al. (1986), and both coefficients are with high value and reflect the degree of influence of environment and genotype on the strength of the pod's pedicel. This shows that

**Table 2. Assessment of chickpea accession according to their agronomical traits**

No	Accession	Plant height, cm	Height to the first pod, cm	Number of branches	Number of pods per plant	Number of grains per pod	Number of grains per plant	Mass of grains per plant, g	Mass of 100 grains, g	Mass of the whole plant, g
1	B9E001	38.00	17.67	3.00	29.50	1.20	27.83	8.35	30.05	25.22
2	BGR23151	36.14	16.43	3.14	48.43	1.11	48.00	15.77	33.30	30.87
3	A8E0412	48.00	22.50	2.67	42.17	1.03	42.17	22.55	53.05	46.83
4	Balkan	34.67	17.67	2.33	38.50	1.33	39.50	13.43	34.15	26.77
5	B9E0149	39.50	22.00	2.50	20.50	1.37	24.67	10.14	42.00	23.62
6	B7000117	32.83	12.67	1.50	31.83	1.80	47.50	6.95	14.60	14.35
7	B9E0014	50.83	23.33	2.50	33.33	1.33	36.67	16.53	47.30	33.13
8	A9E0121	49.00	16.17	2.33	51.33	1.10	51.83	19.10	38.10	42.08
9	BGR21208	29.67	15.67	2.50	34.17	1.37	46.67	6.23	13.70	10.48
	x	39.85	18.23	2.50	36.64	1.29	40.54	13.23	34.03	28.15
	min	29.67	12.67	1.50	20.50	1.03	24.67	6.23	13.70	10.48
	max	50.83	23.33	3.14	51.33	1.80	51.83	22.55	53.05	46.83

**Table 3. Analysis of variance for the influence of the studied factors on the energy required to detach the pod's pedicels at grain moisture from 10.30% to 4.37%**

Source	Mean Square	Significance (p)
Corrected Model	0.00109	0.013
Intercept	0.02369	0.000
Genotype	0.00118*	0.040
Moisture	0.00008 ns	0.853
Genotype x Moisture	0.00117***	0.016
Error	0.00053	

ns – non significance

the selection can be effective, based on this trait and its phenotypic manifestation is informative about the genetic potential. The genetic progress was with high value (GAM = 17.0%), which gives reason to consider that there is a rich material in the studied collection to start breeding improvement work in regards to the resistance of the pedicel to detachment.

## Conclusions

The experimentally obtained energy required to detach the pod's pedicels under the experimental conditions ranged from 0.005 to 0.0252 J. The highest average value of energy was obtained for genotype B9E0014, followed by BGR23151 and B9E0149. The lowest one was observed in BGR21208. Homogeneous reaction for this trait i.e. least energy dispersion was established within the plants of accession B9E0149.

The interaction between the factors Genotype x Moisture is statistically the most significant on the resistance to detach the pod's pedicels, followed by the influence of the genotype with  $p = 0.04 < \alpha = 0.05$ .

The carried out investigation helped to select several accessions possessing good resistance to pedicel detachment, combined with other valuable agronomical traits. The BGR23151 accession, possessing these traits, can be implemented directly into practice.

## References

**Anbessa, Y., Warkentin, T. D., Vandenberg, A. & Bandara, M.** (2006). Heritability and predicted gain from selection in components of crop duration in divergent chickpea cross populations. *Euphytica*, 152, 1-8.

**Bansal, R. K. & Sakr, B.** (1992). Development of a vertical conveyor reaper for harvesting chickpeas and lentils in Morocco. *Appl Eng Agr.*, 8(4), 425-428.

**Behroozi-Lar, M. & Huang, B. K.** (2002). Design and development of chickpea combine. *Ama-Agr Mech Asia AF*, 33(1), 35-38.

**Burton, W. G. & Devane, E. H.** (1953). Estimating heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. *Agron. J.*, 45, 478-481.

**Chakraverty, A., Mujumdar, A. S., Raghavan, G. S. V. & Ramaswamy, H. S.** (2003). Handbook of postharvest technology cereals, fruits, vegetables, tea, and spices. Marcel Dekker Inc, NY.

**Deshmukh, S. N., Basu, M. S. & Reddy, P. S.** (1986). Genetic variability, character association and path coefficient analysis of quantitative traits in *Vignia bunch* varieties of ground nut. *Ind. J. Agric. Sci.*, 56, 515-518.

**Gaur, P. M., Jukanti, A. K. & Varshney, R. K.** (2012). Impact of genomic technologies on chickpea breeding strategies. *Agronomy*, 2, 199-221.

**Ghaly, A. E.** (1985). A stationary threshing machine: Design Construction and performance Evaluation Agricultural. *Mechanization in Asia, Africa and Latin America*, 16(3), 19-30.

**Golpirra, H. Tavakoli, T. & Baerdemaeker, J. D.** (2013). Design and development of a chickpea stripper harvester. *Spanish Journal of Agricultural Research*, 11(4), 929-934.

**Haffar, L., Singh, K. B., & Birbari, W.** (1991). Assessment of chickpea grain quality and losses in direct combine harvesting. *Transactions of the ASABE*, 34(1), 9-13.

**Ishpekov, S., Naydenov, N. & Zaykov, R.** (2021). Method for determining the energy consumption for dynamic tearing off the peanut gynophores. *Bulg. J. Agric. Sci.*, 27(4), 810-815.

**Johnson, H. W., Robinson, H. F. & Comstock, R. E.** (1955). Estimates of genetic and environmental variability in soybeans. *Agron. J.*, 47, 314-318.

**Konak, M., Carman, K. & Aydin, C.** (2002). Physical properties of chickpea seeds. *Biosyst Eng.*, 82(1), 73-78.

**Olaoye, J. O.** (2004). An analytical modeling of the performance of tooth peg grain crop thresher. Ph.D. thesis, University of Ilorin, Ilorin, Nigeria.

**Olaoye, J. O., Oni, K. C. & Olaoye, M. M.** (2010). Computer applications for selecting operating parameters of stationary grain crop thresher. *Int. J. Agric. Biol. Eng.*, 3, 8-17.

**FAOSTAT** (2012). Available at: <http://faostat3.fao.org/home/index.html>.

**Paulsen, M. R., Nave, W. R. & Gray, L. E.** (1981). Soybean seed quality as affected by impact damage. *Transac. ASAE (American Society of Agricultural Engineers)*, 24, 1577-1589.

**Patil, B. S., Mansur, P. S., Gaur, M. P., Goyal, A. & Alagundagi, C. S.** (2014). Machine harvest – an economical method of chickpea harvesting. Conference: 6th International Food Legume Research Conference and 7th International Conference on Legume Genetic and Genomics, July 7-11, 2014. At: Saskatoon, Saskatchewan, Canada

**Petrova, S.** (2015). Maintenance, evaluation and use of plant genetic resources from chickpea. Dissertation, Sadovo, Bulgaria.

**Petrova, S., Stoilova, T. & Chavdarov, P.** (2021) Evaluation of indigenous grain legume collections. *Agricultural Sciences*, 29, 77-83.

- Siemens, M. C.** (2006). Effect of guard spacing, guard attachments and reel type on chickpea harvesting losses. *Appl Eng Agr.*, 22(5), 651-657.
- Tado, C. J. M., Wacker, P., Kutzbatch, H. D. & Suministrado, D. C.** (1998). Development of stripper harvesters: a review. *J. Agr. Eng. Res.*, 71, 103-112.
- UPOV** (2019). Guidelines for the conduct of tests for distinctness, uniformity and stability of chickpea (*Cicer arietinum*). International Union for Protection of New Varieties of Plants.
- Varshney, R. K., Ribaut, J. M., Buckler, E. S., Tuberosa, R., Rafalski, J. A. & Langridge, P.** (2013). Can genomics boost productivity of orphan crops. *Nat. Biotechnol.*, 30, 1172-1176.
- Vishwakarma, R. K., Jha, S. N., Anil, D. K., Amanpreet, K., Anil, R. & Tauqueer, A.** (2019). Assessment of harvest and post-harvest losses of major pulses in India. *Agricultural Economics Research Review*, 32(2), 247-258.
- Zeren, Y., Ozcan, T. & Isik, A.** (1991). An investigation on mechanization of chickpea harvest and threshing. *Turk. J. Agric.*, 15, 215-238.

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