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# Seed Heterogeneity in Dependence of Their Position on the Mother Plant in *Lupinus albus* L.

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***Abstract.*** Seed heterogeneity (regarding some main parameters) in dependence of their position on mother plant was found in a study conducted with 11 varieties of *Lupinus albus* L. At technological maturity, pods (respectively the seeds in them), situated in the lower (1st layer) and upper half (2nd layer) of 20 plants, selected randomly, were collected separately. The results of the conducted analyzes showed that 1000 seeds mass, germination, germ length and weight of the seeds from the 2nd layer were lower in comparison with those from the 1st layer by an average of 12.3, 4.2, 13.1 and 19.5%, respectively. In contrast, the crude protein content of the 2nd layer seeds exceeded the protein content of the 1st layer seeds by a relative value of 15.0%. The seedling vigour index, as a summary indicator for evaluation, showed higher viability of the seeds formed in the pods from the 1st layer (1028) compared to the vigour of the seeds from the 2nd layer (856).

***Keyword***: *seeds, heterogeneity, growth parameters, seedling vigour index, seed-layers effect.*

## Introduction

The main purpose in a seed production program is to achieve maximum seed quality. The quality depends on different factors such as agronomic practices, meteorological conditions, fruit position on the mother plant and others [PASSAM *et al.*, 1997].

With the consent of other authors, heterogeneity found in commercial seeds may due to intra or inter plant variation. Seed development within a crop is not equal [SIDDIQUE *et al.*, 2003]. Prolonged periods of flowering and seed formation could lead to production of seeds with different characteristics and quality [MUASYA, 2001]. That is a prerequisite for heterogeneous seeds and is defined as maternal type heterogeneity [PANAYOTOV, 2005]. Other authors also point out that seed heterogeneity due to pod position on the mother plant and even ovule position in a pod are plant components that contribute to variation in seed quality [PRASAD *et al.*, 2010]. Seed heterogeneity has been shown to have large effects on germination, dormancy and some characteristics of seeds harvested from plants grown in the same environment, between inflorescences (pods) on the same plant, and between different positions of the same inflorescence. Also, the seed position on the parent plant has been suggested as a cause of variability in seed quality [MUASYA, 2001]. The strong impact of maternal heterogeneity has been reported by a number of researchers: [ALAN and ESER, 2007. PANAYOTOV, 2005, 2010] in vegetable crops, [CHEPLICK and SUNG, 1998] and [FOROUGHI *et al.*, 2014] in weed species, [ILLIPRONTI *et al.*, 2000] and [PRASAD *et al.*, 2010] in legumes and others.

The aim of the study was to determine the manifestations of heterogeneity (including 1000 seeds mass, crude protein content, germination, initial growth parameters and seedling vigour index) of white lupine seeds depending on their position on the mother plant.

## Material and methods

The lab experiment was carried out in 2016 at the Institute of Forage Crops (Pleven). The subjects of the investigation were seeds of eleven varieties of white lupine (*Lupinus albus* L.) (Astra, Nahrquell, Ascar, BGR 6305, Shienfield Gard, WAT, Kijewskij Mutant, Hetman, Start, Amiga, Garant), which were harvested in the previous year. At technological maturity, pods (respectively

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the seeds in them), situated in the lower (1st layer) and upper half (2nd layer) of 20 plants, selected randomly, were collected separately. Analyzes were conducted on average seed samples for each variant.

Crude protein content and 1000 seeds mass were determined.

Twenty seeds of each variant in three repetitions were set in Petri dishes (12 cm in diameter), on filter paper.

Distilled water (8 mL) was pipetted into each petri dish. The seeds were placed in a thermostat at 22 °C, and kept moist for 7 days.

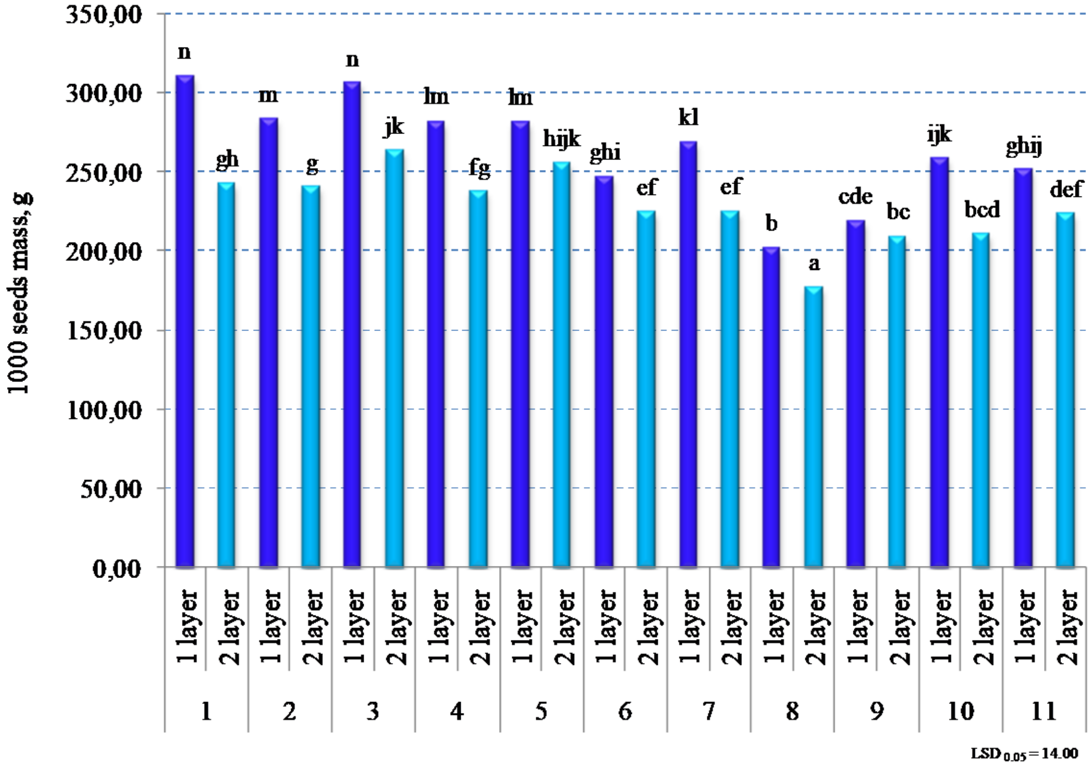
Seed germination (%), weight of primary germ (root + stem) (g), length of primary germ (root + stem) (cm) and seedling vigour index (SVI) (with the consent of other authors) [ABDUL-BAKI and ANDERSON 1973] were calculated.

The data were processed with the software product Statgraphics Plus for Windows Ver. 2.1.

## Results and discussion

The results in the present experiment regarding 1000 seeds mass showed significant differences between the seeds from the two layers in all lupine varieties, except for the variety Start (Figure 1).

The seed mass from the 1st layer varied from 202.02 to 310.72 g, and from the 2nd layer - from 177.26 to 263.32 g. Decrease, expressed in relative values, was in the ranges 4.5 -21.8% (average 12.3%). It was more strongly represented in the large-seeded varieties Astra, Amiga and Kijewskij Mutant.




1-Astra, 2-Nahrquell, 3-Ascar, 4-BGR 6305, 5-Shienfield Gard, 6-WAT, 7-Kijewskij Mutant, 8-Hetman, 9-Start, 10-Amiga, 11-Garant

*Figure 1.* Mass of 1000 seeds in lupine varieties in dependence of seed position on the plant (1st and 2nd layers)

The analysis of the data showed a correlation with a medium positive value (r = 0.437) between the 1000 seeds mass and the percentage decrease of the seeds from the 2nd layer. The results obtained were consistent with those of other authors [MUASYA 2001, ILLIPRONTI *et al.*, 2000b, SIDDIQUE *et al.*, (2003)], found in common bean, soybean and pea varieties, respectively. The higher seed weight in early pods may be related to a higher seed filling rate [MUASYA, 2001]. The higher rate of seed filling in early and middle pods could be due to less competition for the accumulation of insoluble reserves before the formation of all seed [COCKS, 1990]. The early pods also used a large influx of assimilates when the plant passes from vegetative to reproductive phase [BEWLEY and BLACK, 1994]. On the other hand, BERTIN et al., (1998) suggested that meteorological conditions during plant growth could also affect fruit size and weight, along with the pod position on the plant and the sequence of their formation.

According to other authors, the production of heterogeneous seed was one of the strategies to perpetuate higher plants [MATILLA et al., 2005]. I.e., to provide the survival of the offspring, the individual plant might produce seeds that are heterogeneous in terms of the degree of dormancy, germination, and such characteristics such as size, shape, colour.

Position of pods and seeds on the mother plant considerably contributes to the heterogeneity in the physiological qualities of the seeds, including germination [PRASAD et al., 2010]. In this study, higher germination was observed for seeds from the 1st layer (97.7% on average) and lower - for seeds from the 2nd layer (93.5% on average) (Table 1).

**Table 1**

Germination and initial growth parameters in lupine seeds in dependence of their position on the plant

| Cultivar | Seed position | Germination, % | Germ length, cm | Germ weight, g | SVI |
|---|---|---|---|---|---|
| Astra | 1st layer | 96.7 efgh | 7.31 b | 0.344 c | 707 |
| | 2nd layer | 93.3 bcde | 5.91 a | 0.264 a | 551 |
| Nahrquell | 1st layer | 98.3 gh | 9.74 e | 0.407 h | 958 |
| | 2nd layer | 94.4 cdef | 7.92 c | 0.310 b | 748 |
| Ascar | 1st layer | 100.0 h | 11.19 hi | 0.396 fgh | 1119 |
| | 2nd layer | 94.4 cdef | 8.22 c | 0.266 a | 776 |
| BGR 6305 | 1st layer | 100.0 h | 10.61 g | 0.453 ij | 1061 |
| | 2nd layer | 92.5 bcd | 9.59 e | 0.383 efg | 887 |
| Shienfield Gard | 1st layer | 91.7 abc | 10.70 g | 0.476 jk | 981 |
| | 2nd layer | 96.1 defgh | 9.49 de | 0.400 gh | 912 |
| WAT | 1st layer | 95.0 cdefg | 9.18 d | 0.439 i | 872 |
| | 2nd layer | 88.3 a | 8.24 c | 0.373 def | 728 |
| Kijewskij Mutant | 1st layer | 98.3 gh | 11.27 i | 0.461 ij | 1109 |
| | 2nd layer | 95.6 defgh | 10.17 f | 0.364 cde | 972 |
| Hetman | 1st layer | 98.3 gh | 12.71 k | 0.526 l | 1250 |
| | 2nd layer | 90.0 ab | 10.84 gh | 0.406 gh | 975 |
| Start | 1st layer | 100.0 h | 12.25 j | 0.529 l | 1225 |
| | 2nd layer | 93.3 bcde | 10.61 g | 0.404 gh | 990 |
| Amiga | 1st layer | 98.3 gh | 7.95 c | 0.401 gh | 782 |
| | 2nd layer | 93.3 bcde | 7.53 b | 0.356 cd | 703 |
| Garant | 1st layer | 98.3 gh | 12.66 k | 0.540 l | 1245 |
| | 2nd layer | 97.5 fgh | 12.03 j | 0.485 k | 1173 |
| LSD | | 3.92 | 0.371 | 0.023 | |

* Means in each column followed by the same letters are not significantly different ($P > 0.05$)
SVI –seedling vigour index

As a whole, there was a general downward trend in seed germination of the 2nd floor, which was demonstrated in most varieties (except Astra, Kijewskij Mutant and Garant). In a similar experiment, the other authors [ALAN and ESER 2007] proved that the germination percentage of pepper seeds is influenced by the fruit position on the mother plant. Seeds obtained from the $1_{st}$ floor showed the highest germination (91.5%), while seeds from the 2nd and 3rd - 86.0 and 81.8%, respectively. In a study with *Xanthium strumarium*, the other authors [FOROUGHI et al., 2014] found that seeds ripened in the upper and middle third of the mother plant had 67 to 78 % higher germination than those that riped in the lower third of the plant.

Most studies of the maternal impact on seed germination focus on abiotic environmental factors [JIANG et al., 2019].

It is well known that environmental factors such as light, temperature, and

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soil moisture affect seed germination [IKEDA et al., 2008; RIZZARDI et al., 2009]. The other authors also confirmed that differences in seed maturation time in the upper part of the mother plant compared to the lower part might contribute to differences in seed germination [ROMAGOSA et al. 2001].

According to the authors, the endogenous levels of gibberellins and abscisic acid in the seeds, or changes in the sensitivity of the seeds to these hormones, are influenced by environmental conditions during seed reported that seed germination percentages were 40 to 50% lower in seeds maturing in competitive conditions than in non-competitive one's development. In addition, the other authors [BRAINARD et al. 2005, AJSUVAKOVA, et al., 2020. BUTNARIU, et al., 2020, SALEHI, et al., 2020].

**Table 2**

Analysis of variance for seed germination and germ growth depending on the factors studied

| Causes of variation | Degrees of freedom | Sum of squares | Influence of factors | Sum of squares | Influence of factors | Sum of squares | Influence of factors |
|---|---|---|---|---|---|---|---|
| Indicators | | Germination | | Germ length | | Germ weight | |
| Total | 65 | 935.126 | 100.0 | 224.343 | 100.0 | 0.380 | 100.0 |
| Factor A -cultivar | 10 | 196.678 | 21.0* | 183.827 | 81.9* | 0.233 | 61.3* |
| Factor B – seed-layers effect | 1 | 291.48 | 31.2* | 30.860 | 13.8* | 0.126 | 33.1* |
| A × B | 10 | 197.708 | 21.1 | 7.422 | 3.3* | 0.012 | 3.3* |
| Error | 44 | 249.26 | 26.7 | 2.235 | 1.0 | 0.009 | 2.3 |

*LSD at 0.05 probability level

The other authors indicated that the position at which seeds mature on an individual plant have significant effects on their germination and subsequent seedling growth [KIGEL, 1995. CHEPLICK and SUNG 1998, STOLERU, et al., 2019, SHARIFI-RAD, et al., 2020]. As in the previous indicators, in all 11 varieties, the initial growth parameters (germ length and weight) revealed higher and statistically significant values (from 7.31 to 12.71 cm and from 0.344 to 0.540 g, respectively) concerning the seeds from the lower (1st) layer, at values from 5.91 to 12.03 cm and from 0.264 to 0.485 g for those of the upper (2nd) layer. The varieties that were characterized by more essential differences in the seed parameters from the two layers were Astra and Ascar (from 19.2 to 32.8%), while the differences between Amiga and Garant were less pronounced (5.0 ÷ 11.1%).

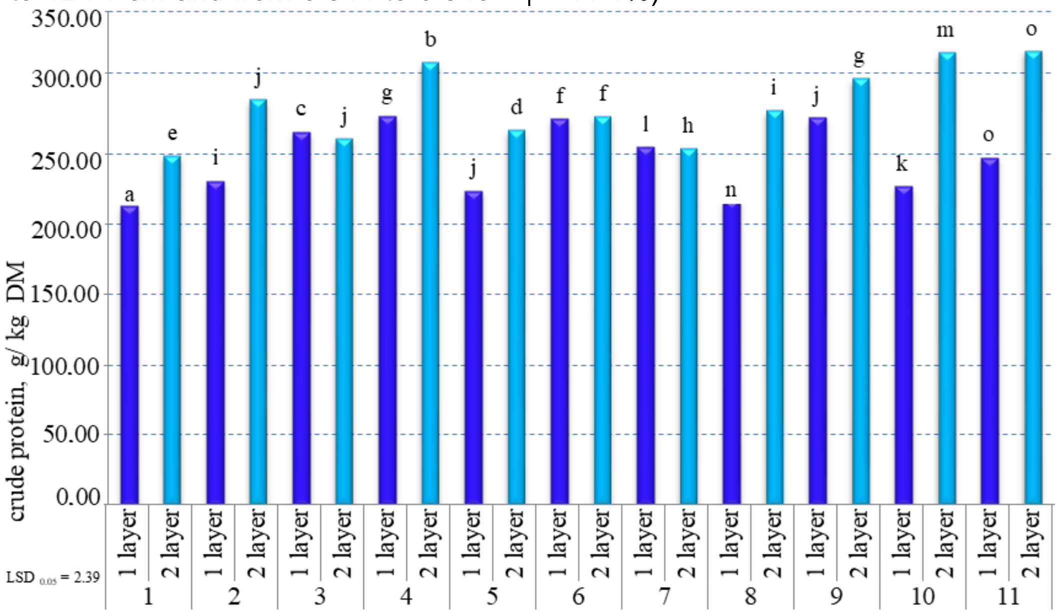


***Figure 2.*** Crude protein content in lupine varieties in dependence of seed position on the plant (1st and 2nd layer)

Vigour represents the total sum of those properties of the seed that determine their level of activity and manifestation during the period of germination and seedling emergence [ISTA, 2003]. It is positively related to the ability of a seed population to provide an optimal stand under optimal and suboptimal environmental conditions [DORNBOS, 1995].

In the studied varieties, the seeds formed in the pods from the 1st layer had increased seedling vigour index (average 1028). Considerably lower, with a variation of 5.8 to 30.6%, was the seedling vigour index in the seeds formed in the pods from the upper layer. The other authors also established that seeds obtained from a single plant, even within a single pod, might differ in their vigor. The authors pointed out that the seeds of the earliest-formed pods in soybeans (cultivar PRS-1) had the greatest vigour [PRASAD *et al.*, 2010. KURZBAUM, *et al.*, 2019, PETRACHE, *et al.*, 2014].

The variance analysis showed significant influence of the factors “variety” and “seed-layers effect" in terms of seed germination and seedling growth (Table 2). The effect of the “variety” factor was dominant in the two parameters of initial growth (81.9 and 61.3%), while in the seed germination, the influence of the “seed-layers effect” (31.2%) was determinative. According to The other authors, in plants with indeterminate growth, the buds and flowers of the same plant develop progressively due to continuous flowering. In this way, the fruits of the plant strongly compete with each other for the available assimilates [ALI and KELLY, 1992]. This competition affects subsequent fruit size and seed quality [STEPHENSON *et al.*, 1988; MARCELIS and BAAN HOFMAN-EIJER, 1995]. The crude protein content, one of the main components determining the feed quality in legumes, varied widely – from 211.35 to 313.40 g kg $DM^{-1}$ in the tested varieties. The differences in the CP content between the seeds from the two layers were unidirectional (245.71 and 280.82 g kg $DM^{-1}$ on average, respectively for the seeds from the 1st and 2nd layer), statistically significant (except for varieties WAT and Kijewskij Mutant) and had an average value of 15.0%. In a similar study with five pea cultivars, the other authors [NANEVA and SACHANSKI, 1972. BUTNARIU and BUTU, 2020 found a higher protein content of the seeds from the lower and middle layers in three of them, and a lack of similar dependence in the other two. In general, researches on this issue in the scientific literature are limited, and in many cases controversial.

## Conclusions

The results of the conducted study proved the presence of heterogeneity (in terms of 1000 seeds mass, germination, initial growth parameters, and protein content) of the seeds, depending on their location on the mother plant, in 11 white lupine varieties. The values of parameters of 1000 seeds mass, germination, germ length and weight of seeds from the upper (2nd) layer were lower compared to those from the lower (1st) layer by an average of 12.3, 4.2, 13.1 and 19.5%, respectively.

In contrast, the crude protein content of the 2nd layer seeds exceeded the protein content of the 1st layer seeds by a relative value of 15.0%.

The seedling vigour index, as a summary indicator for evaluation, showed higher viability of the seeds formed in the pods from the 1st layer (1028) compared to the vigour of the seeds from the 2nd layer (856).

**Conflict of Interest:** The authors declare that they have no conflict of interest.

### References

1. Abdul-Baki, A.; Anderson, J. D. Vigour determination in soyabean seed by multiple criteria. *Crop Science*, **1973**. 31, 630-633.
2. Ajsuvakova O.P. Tinkov A.A. Aschner M. Rocha J.B.T. Michalke B. Skalnaya M.G. Skalny A.V. Butnariu M. Dadar M. Sarac I. Aaseth J. Bjørklund G. Sulfhydryl groups as targets of mercury toxicity. *Coordination Chemistry Reviews*, **2020**. 417, 213343.
3. Alan, O.; Eser, B. Pepper Seed yield and quality in relation to fruit position on the mother plant. *Pakistan Journal of Biological Sciences,* **2007.** 10(23), *4251-4255.*
4. Ali, A.M.; Kelly, W.C. The effects of interfruit competition on the size of sweet pepper (*Capsicum annuum* L.) fruits. *Scientia Horticulturae*,**1992**. 52(1), 69-76.
5. Bertin, N.; Gary, C.; Tchamitchian, M.; Vaissiere, B.E. Influence of cultivar, fruit position and seed content of tomato fruit weight during a crop cycle under low and high competition for assimilates. *Journal of Horticultural Science and Biotechnology*, **1998**. 73(4), 541-548.

6. Bewley, J.D.; Black, M., Seeds: Physiology of development and germination. Plenum press, New York. **1994**.
7. Brainard, D.C.; Bellinder, R.R.; Ditommaso, A. Effects of canopy shade on the morphology, phenology, and seed characteristics of Powell amaranth (*Amaranthus powelli*). *Weed Science*, **2005**. 53(2), 175-186.
8. Butnariu, M., Butu, A. Biotechnology of flavored or special wines in Biotechnological Progress and Beverage Consumption: Volume 19: The Science of Beverages, **2019**, 253–282.
9. Butnariu, M; Sarac, I. Samfira, I. Spectrophotometric and chromatographic strategies for exploring of the nanostructure pharmaceutical formulations which contains testosterone undecanoate. *Scientific Reports* Scientific Reports, **2020**, 10(1), 3569
10. Cheplick, G.P.; Sung, L.Y. Effect of maternal nutrient environment and maturation position on seed heteromorphism, germination, and seedling growth in *Triplasis purpurea* (Poaceae). *International Journal of Plant Sciences*, **1998**. 159(2), 338-350.
11. Cocks, P.S. Dynamics of flower and pod production in annual medics *(Medicago* spp.). I. Spaced plants. *Australian Journal of Agricultural Research*, **1990**. 41(5), 911-921.
12. Dornbos Jr, D.L. Production environment and seed quality. In: Basra A.S. (ed.), Seed quality. Basic mechanisms and agricultural implications. Food Products Press, London, pp. 119-145, **1995**.
13. Foroughi, A.; Gherekhloo, J.; Ghaderifar, F. Effect of plant density and seed position on mother plant on physiological characteristic of cocklebur (*Xanthium strumarium*) seeds. *Planta Daninha*, **2014**. 32(1), 61-68.
14. Ikeda, F.S.; Carmona, R.; Mitja, D.; Guimaraes, R.M. Light and KNO3 on *Tridax procumbens* seed germination at constant and alternating temperatures. *Planta Daninha*, **2008**. 26(4), 751-756.
15. Illipronti, Jr.R.A.; Lommen, W.J.M.; Langerak, C.J.; Struik, P.C. Time of pod set and seed position on the plant contribute to variation in quality of seeds within soybean seed lots. *Netherlands Journal Agricultural Science*, **2000**. 48, 165-180.
16. ISTA. International Rules for Seed Testing. International Seed Testing Association. Bassersdorf, CH-Switzerland. **2003**.
17. Jiang, L.; Wang, L.; Baskin, C.C.; Tian, C. Maternal effects on seed heteromorphism: a dual dynamic bet hedging strategy. *Seed Science Research*, **2019**. 29(2), 149-153.
18. Kigel, J. Seed germination in arid and semiarid regions. In Kigel, J.; Galili, G. (Eds), Seed development and germination. Marcel Dekker, New York, pp. 645–700, **1995**.
19. Kurzbaum, E.; Iliasafov, L.; Kolik, L.; Starosvetsky, J.; Bilanovic, D.; Butnariu, M.; Armon, R. From the Titanic and other shipwrecks to biofilm prevention: The interesting role of polyphenol–protein complexes in biofilm inhibition, *Science of The Total Environment,* **2019**, 658, 1098–1105.
20. Marcelis, L.F.M.; Baan Hofman-Eijer L.R. Effects of seed number on competition and dominance among fruits in *Capsicum annuum* L. *Annals of Botany*, **1997**. 79, 687-693.
21. Matilla, A.; Gallardo, M.; Puga-Hermida, M. Structural, physiological and molecular aspects of heterogeneity in seeds: A review. *Seed Science Research*, **2005**.15(2), 63-76.
22. Muasya, R.M., Crop physiological analysis of seed quality variation in common bean *(Phaseolus vulgaris* L.). PhD thesis, Wageningen University, The Netherlands, **2001**.
23. Naneva, D.; Sachanski, S. The productive properties of pea grains, depending on the position of the pods in storeys. Scientific session of IFC "Problems of protein fodder production", Agricultural Academy, pp.117-121. **1972**.
24. Panayotov, N**.** Heterogeneity of carrot seed in depends on their position on the mother plant. *Folia Horticulture*, **2010.** 22(1), 25-30.
25. Panayotov, N. Technological management and factors influencing seed quality of vegetable crops. In: Ramdane D. (ed.), Vegetables: Growing Environment and Mineral Nutrition. WFL Publisher, Helsinki, Finland, pp. 138-165. **2005**.
26. Passam, H.C.; Lambropoulos E.; Khah E.M..Pepper seed longevity following production under high ambient temperature. *Seed Science Technology*, **1997**. 25(2), 177-185.
27. Petrache, P.; Rodino, S.; Butu, M.; Pribac, G.; Pentea, M.; Butnariu, M. Polyacetylene and carotenes from *Petroselinum sativum* root, *Digest journal of nanomaterials and biostructures*, **2014**, 9(4), 1523–1527.
28. Prasad, B.; Prasad, R.; Prasad, S. Seed quality variation in relation to pod and seed position on the mother plant of soybean *[Glycine max.* (L.) Merrill] seed lot. *Journal of Crop and Weed,* **2010**. 6(1),1-5.
29. Rizzardi, M.A.; Luiz, A.R.; Roman, E.S.; Vargas L. Effect of cardinal temperature and water potential on morning glory (*Ipomoea triloba*) seed germination. *Planta Daninha*, **2009**. 27(1), 13-21.
30. Romagosa, I.; Prada, D.; Moralejo, M.A.; Sopena, A.; Muñoz, P.; Casas, J.S.; Swanston, J.S.; Molina-Cano, J.L. Dormancy, ABA content and sensitivity of a barley mutant to ABA application during

seed development and after ripening. Journal of Experimental Botany, **2001**. 52(360),1499-1506.

31. Salehi B. Butnariu M. Corneanu M. Sarac I. Vlaisavljevic S. Kitic D. Rahavian A. Abedi A. Karkan MF. Bhatt ID. Jantwal A. Sharifi–Rad J. Rodrigues CF. Martorell M. Martins N. Chronic pelvic pain syndrome: Highlighting medicinal plants toward biomolecules discovery for upcoming drugs formulation. Phytotherapy Research, **2020**, 34(4), 769–787.
32. Sharifi-Rad J., Butnariu M., Ezzat Shahira M., Adetunji Charles O., Imran M., Sobhani Seyyed R., Tufail T., Hosseinabadi T., Ramírez-Alarcón K., Martorell M., Maroyi A., Martins N. Mushrooms-Rich Preparations on Wound Healing: From Nutritional to Medicinal Attributes, *Frontiers in Pharmacology* **2020**, 11, 1452, 10.3389/fphar.2020.567518.
33. Siddique, A.B.; Khatun, A.; Rahman, M.M.; Wright, D. Studies on the effects of pod position on the mother plant and sowing density on flowering, pod production, seed yield, yield components and viability of pea seeds. Pakistan Journal of Biological Science, **2003**. 6(7), 680-685.
34. Stephenson, A.G.; Devlin, B.; Horton, J.B. The effects of seed number and prior fruit dominance on the pattern of fruit production in *Cucurbita pepo*. *Annals of Botany*, **1988**.62, 653-661.
35. Stoleru, V.; Munteanu, N.; Stan, T.; Ipatioaie, C.; Cojocaru, L.; Butnariu, M. Effects of production system on the content of organic acids in Bio rhubarb (*Rheum rhabarbarum* L.). *Romanian Biotechnological Letters*, **2019**. 24(1),184–192.

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