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RESULTS REGARDING VARIABILITY OF PRODUCTION AND SOME ELEMENTS OF PRODUCTIVITY TO FOUR PEA (*Pisum sativum*) GENOTYPES AT DIFFERENT SOWING TIMES

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Abstract

The present paper presents the results obtained within a multifactorial experience at the Research and Development Station of the University of Craiova, SCDA Caracal, in the period 2021-2022. The biological material was represented by four pea varieties (Omega, Tiara, Favorit and Trinity), each of them being sown in two different seasons. The variability of production, plant height and some elements of productivity were monitored, such as: number of plants/m^2, number of pods/plant, length of pods, number of grains in pod and weight of 1000 grains. The results obtained showed a high variability, both in terms of production and productivity elements. Thus, the highest average production value was recorded by the Omega variety (4500 kg/ha) and the lowest one, Trinity (3635 kg/ha). The mass of 1000 grains had average values between 190.8 g (Omega) and 135.9 g (Tiara). Also, the ratio between plant weight and grains weight recorded average values from 1.74 (Tiara) and 1.59 (Favorit). These results confirm the very good suitability of the researched pea varieties for cultivation in the environmental and soil conditions of the South-West area of Oltenia.

Key words*: genotypes, pea, production, sowing times, variability.*

INTRODUCTION

Food security is approached as a multidimensional concept that takes into account both the need to ensure a sufficient agricultural supply, as well as ensuring the economic access of the population to food, the stability of the supply and the way of using food at the individual level (Amundson et al., 2015; Bonciu, 2019).

The responsibility for the availability of food falls mainly to agriculture, which must ensure a sufficient food supply to satisfy the food and nutritional needs of the population, and access to food is a problem that depends on the general situation of the economy, which ensures, through the level of the population's income, the purchasing power of food.

A systemic understanding of how agriculture, the economy and environmental health are interconnected is essential for identifying best practices available (Ahmad et al., 2019; Cotuna et al., 2022a, 2022b, 2022c). This is all the more necessary after some periods with serious consequences in the economy, like pandemic crisis which has put a lot of pressure on agriculture in a number of ways (Short et al., 2020).

The pea (*Pisum sativum*) is one of the most important legumes and is cultivated for its grains, which can be used for human consumption or animal feed, having an exceptional food and fodder value. It is highly appreciated for the high protein content in the green beans, but also carbohydrates, mineral salts and vitamins (Jain et al., 2014; Santos et al., 2019). The large amount of protein substances is remarkable, much higher (25%) compared to wheat (12.9%), as well as their special quality, given by the weight of essential amino acids: lysine, tryptophan, methionine and cysteine. The protein content is determined on the one hand by hereditary factors and on the other hand by culture conditions (Shanthakumar et al., 2022).

Regarding the forage quality of peas, the optimization of fodder rations with peas is more than timely, especially since, against the background of the prohibition of the use of antibiotics as growth promoters, the need has

arisen to find fodder solutions for good health and good growth performance in animals, doubled by health protection of the consumer of animal products (Cola and Cola, 2021). In this respect, for each drug there is a waiting period for human protection. The waiting period is the time required for the antibiotic residue to reach concentrations below the tolerance levels (Cola and Cola, 2022). Maximum residue limits in European Union legislation guarantee consumer protection (Cola and Cola, 2019).

From the botanical point of view, pea is an annual herbaceous legume from the *Fabaceae* family, cultivated for its edible seeds and pods. The root system is strong and penetrates into the soil up to 40-60 cm deep, but, if the soil allows, it can penetrate up to one meter. The stem is hollow inside and slightly branched. The leaves are pinnately compound, alternately arranged, consisting of 2-3 pairs of leaflets, the last leaflet being transformed into a prison. Flowering takes place 30-50 days after sowing, and on a plant, flowering lasts 10-25 days. The fruit is a pod, straight or arched with a length between 3 and 12 cm. Pea seeds are yellow or green in the dry state.

The flowers, white or slightly purple-reddish, are arranged in the underside of the leaves, one for the early varieties and 2-5 for the late ones. The corolla has a butterfly shape. The stamens - the male reproductive organs - in peas are 9 in number through their filaments and the 10th free. In the middle of the flower is the gynoecium which is monocarpic - the carpels are modified leaves and adapted to the function of multiplication.

Pea plants are naturally self-pollinating. In self-pollination, pollen grains from anthers on one plant are transferred to stigmas of flowers on the same plant. The pollination is done directly, the pollen reaching the stigmas of the same flower, but cross-pollination is not excluded, when the pollen passes from one flower to another, through wind, insects, water and under human action (Bonciu et al., 2022).

The pea is considered a very good precursor plant for most vegetable species, as it leaves the land clean of weeds and especially rich in nitrogen, coming from the atmosphere due to the symbiosis that exists between the plants and the bacterium *Rhizobium leguminosarum* found on the nodules of the roots. Field peas alongside lentil (*Lens culinaris* Medik.) are pulse crops capable of forming a symbiosis with rhizobia for biological nitrogen fixation. As such, their inclusion in cropping systems is an important part of efforts to improve the sustainability of agriculture and decrease the reliance on nitrogen chemical fertilizers (Bourgault et al., 2022; Jiang et al., 2020; Pecetti et al., 2019).

Pea is a drought-resistant plant, but requires higher amounts of water during flowering to grain formation (Bourion et al., 2002; Larmure and Munier-Jolain, 2019).

The cultivation technology is generally simple. Peas are grown by sowing directly in the field. The most expensive work is the repeated harvesting of the green pods, which requires a lot of labor, mechanical harvesting being only partially solved for now. Garden pea culture requires some of the lowest production costs in the vegetable sector, as the technology allows full mechanization of the work (Sarūnaitė et al., 2022).

Expectations and forecasts for food security and agriculture worldwide indicate a slowdown in the general growth rate of agricultural production in the medium and long term, with the growth of agricultural production being focused, in the future, on developing countries. Food demand will continue to grow in the coming years as the world's population will increase considerably, and climate change will begin to put more and more pressure on water and soil resources.

Peas are one of the sustainable green crops, because they improve the quality of the soil, thus reducing the use of chemical fertilizers or fertilizers (Annicchiarico and Filippi, 2007).

MATERIALS AND METHODS

The demographic explosion and the current climate changes make future food security and safety dependent on the sustainability of soil fertility and the provision of water and energy resources, scientific research contributing to finding new sources and means leading to the sustainable provision of food needs. In this context, the present paper presents the results obtained within a polyfactorial experiment with four varieties of peas sown in two different

times, at the Research Station of the University of Craiova, SCDA Caracal, in the period 2021-2022. The biological material was represented by four pea varieties (Omega, Tiara, Favorit and Trinity), each of them being sown in two different seasons (Figure 1).

Variability of production, plant height and productivity elements such as: number of plants/m^2, number of pods/plant, length of pods, number of grains per pod and mass of 1000 grains were monitored. For each of these indicators, the coefficient of variability (CV%) was calculated, using the Excel program, as the ratio between the standard deviation value and the average value.

The experiment was carried out on a typical argic (non-carbonic) chernozemic soil, with a well-defined profile and insignificant differences regarding the physical, hydric and chemical properties. The main characteristics of the soil were the following: humus content: 2.2%; total nitrogen: 104 ppm; phosphorus: 47 ppm; potassium: 244.5 ppm; pH: 5.4.

RESULTS AND DISCUSSIONS

The climatic conditions recorded during the entire vegetation period allowed obtaining optimal harvests. The temperatures during the growing season of the pea crop from 2022 were close to normal, in February registering +3.3^{0}C (Table 1).

Table 1. The evolution of the main climatic factors during the vegetation period of the pea genotypes tested at S.C.D.A. Caracal (2022)

Specification		I	II	III	IV	V	VI	TVP
T (°C)	Mmin	-9.2	-9.8	-8.5	-0.5	3.5	12.2	
	Mmax	15.5	17.4	22.5	26	32	38.6	
	Mavr	2.0	4.1	4.5	11.1	18.2	23	
	N	-1.3	0.8	6	12	17.7	21.6	
	Diff ± N	+0.7	+3.3	-1.5	-0.9	+0.5	+1.4	
Pp (mm)	Mtotal	19.2	4.8	13.2	77.8	44.6	14.2	173
	Mltavr	30.8	26.3	34.2	47.8	58.6	69.7	267.4
	Diff± N	-11.6	-21.5	-21	+30	-14	-55.5	-93.6
RH (%)	Avr	83.9	74.2	67.6	77.2	68	69	
	Min	59.8	43	37.8	44.4	31.5	32	

T - Temperature; Pp - Precipitations; RH - Relative air humidity; Mmin - Monthly minimum; Mmax - Monthly maximum; Mavr - Monthly average; N - Normal; Diff - Difference; Mtot - Monthly total, Mltavr - Multiannual average; Avr - Average; Min - Minimum; TVP - Total vegetation period.

Deviations of the average monthly temperatures compared to the multi-year average were also recorded in the months of January, March, April, May and June, but close together. These values led to an optimal development of the plants. Regarding precipitation, in the period January 2022-June 2022, 173.8 mm of precipitation was recorded, 93.6 mm less than the multiannual average (267.4).

The precipitation recorded in January and February was in deficit compared to the multi-year average, but contributed to a good preparation of the seed bed and an optimal emergence of the plants. In April, the amounts of precipitation were higher than the multiannual average by +30 mm and had a favourable influence on the development of crops. The relative humidity of the air oscillated on average between 68% in May and 83.9% in January.

The soil works consisted of plowing, harrowing, fertilizing with 100 kg/ha NPK 20-20-0 complex fertilizers and preparing the germination layer with the combiner. The four pea varieties were each sown in two different seasons, shown in Figure 1. The predecessor plant was maize.

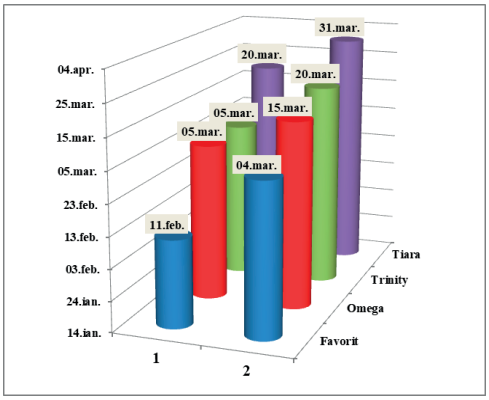

Figure 1. Sowing date in two different periods for each pea variety at SCDA Caracal (2022)

The width of each sown plot was 4 m, with a length of 100 m and an area of 400 m^2. Sowing depth: 5 cm, and the distance between rows: 12.5 cm. After the plants emerged, a herbicide work with Butoxone was carried out, respectively two phytosanitary treatments with the products Krima 20 SG (acetamiprid) and Decis Expert 100 EC (deltamethrin).

Figure 2 shows images from the experimental field.

Figure 2. Pea culture at SCDA Caracal

The phenological observations and biometric determinations carried out on the four pea varieties sown in the first season are shown in Table 2, respectively in Table 3 for the second sowing season. Thus, in the first sowing period, the number of plants/m^2 was between 120 (Omega and Tiara) and 125 (Favorit and Trinity); the height of the plants had values between 49.3 cm (Trinity) and 53.8 (Favourite); the number of pods/plant was between 5 (Tiara and Trinity) and 7 (Favorite) and the number of grains in the pod was between 6 (Omega, Tiara, Trinity) and 7 (Favorite).

The weight of the grains per plant recorded values between 5.11 g (Tiara) and 6.20 g (Omega), while the mass of 1000 grains was between 137 g (Tiara) and 190.8 (Omega).

Table 2. Phenological observations and biometric determinations to peas tested at SCDA Caracal (Sowing season I)

Variety	NP /m^2	BT	PH (cm)	NPP	PL (cm)	NGP	GW (g)	MMB (g)
Omega	120	15.05	50.3	6	4.8	6	6.20	190.8
Tiara	120	18.05	52.1	5	5.6	6	5.11	137.0
Favorit	125	4.05	53.8	7	5.7	7	6.14	165.2
Trinity	125	16.05	49.3	5	5.2	6	5.42	181.3
CV(%)	2.3	-	3.9	16.6	7.7	8.0	9,4	13.9

NPm^2 - No.plants/m2; BT - Bloomng time; PH - Plant height; NPP - No.pods/plant; PL - Pods length; NGP - No.grains/pod; GW - Grain weight/plant; MMB - Mass of 1000 grains; CV - Coefficient of variability (%).

Table 3. Phenological observations and biometric determinations to peas tested at SCDA Caracal (Sowing season II)

Variety	NP /m^2	BT	PH (cm)	NPP	PL (cm)	NGP	GW (g)	MMB (g)
Omega	120	21.05	56.2	5	4.9	6	6.11	180.2
Tiara	120	8.05	56.3	4	5.7	7	4.88	135.9
Favorit	125	11.05	55.7	6	6.1	6	5.79	163.5
Trinity	125	7.05	53.5	5	5,5	5	5.17	177.3
CV (%)	2.3	-	2.4	16.3	9.0	13.6	10.2	12.3

NPm^2 - No.plants/m2; BT - Bloomng time; PH - Plant height; NPP - No.pods/plant; PL - Pods length; NGP - No.grains/pod; GW - Grain weight/plant; MMB - Mass of 1000 grains; CV - Coefficient of variability (%).

In the second sowing season, the plant height of the four pea varieties was between 53.5 cm (Trinity) and 56.3 (Tiara); the number of pods/plant was between 4 (Tiara) and 6 (Favourite), and the number of grains in the pod was between 5 (Trinity) and 7 (Tiara). The weight of the grains per plant recorded values between 4.88 g (Tiara) and 6.11 g (Omega), while the mass of 1000 grains was between 135.9 g (Tiara) and 180.2 (Omega).

Analysing the obtained results, a high variability was found, both in terms of production and productivity elements. Thus, the highest average production value between the two sowing seasons was recorded by the Omega variety (4500 kg/ha), followed by Favorit (3900 kg/ha), Tiara (3700 kg/ha) and Trinity (3635 kg/ha) (Figure 3). Also, the ratio between plant weight and grains weight recorded average values from 1.59 in the Favorit variety to 1.74 in the Tiara variety (Figure 4).

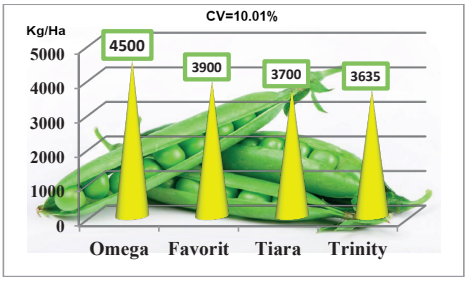

Figure 3. Variability of production for peas (average of two different sowing seasons) to SCDA Caracal
CV - Coefficient of variability (%)

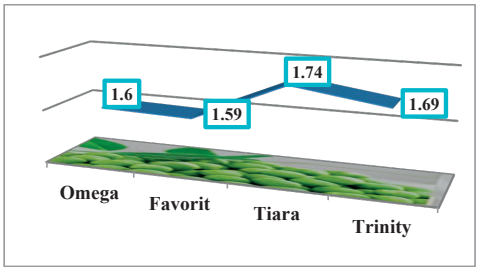

Figure 4. Variability of the plant weight and grain weight ratio in peas grown at SCDA Caracal

Sirohi et al. (2006) reported high phenotypic and genetic coefficients of variability to pea for plant height, number of pods per plant and grains yield per plant indicating greater scope of selection for these traits. Similarly, the results obtained within the SCDA Caracal experiences confirm the high variability of production and productivity elements.

Reduced seed abortion and improved of seeds number per pod is correlated with pea yield in both stressful and favourable conditions, as other authors have suggested (Kumar et al., 2013; Sadras et al., 2019; Sibhatu et al., 2016; Smith et al., 2005). In order to make pea crops more efficient, it is necessary to use high-performance combines, which perform simultaneously with the harvesting and threshing of the green pods, directly in the field.

The grains yield of pea depends on a several factors, such as genotype, growing conditions and genotype and environment interaction (Carlson-Nilsson et al., 2021). In our experiment, the variability of the grain yields of pea tested genotypes was high. However, the climate changes have a negative impact on crop productivity globally, including leguminous crops; they also have an indirect impact on biotic constraints, which may lead to the invasion of weeds, pests, and pathogens in previously unaffected areas (Paraschivu et al., 2022, 2021; Cotuna et al., 2021; Velea et al., 2021). It is necessary, from this point of view, to introduce into the culture technologies a variety of cultivation resistant to diseases and pests, with high productive potential and increased yield of grains/pods (Namatsheve et al., 2020).

The results obtained in this study confirm the very good suitability of the four pea varieties tested at SCDA Caracal for sustainable cultivation in the environmental and soil conditions of the experimented area.

CONCLUSIONS

The results obtained showed a high variability, both in terms of production and productivity elements. Thus, the highest average production value between the two sowing seasons was recorded by the Omega variety (4500 kg/ha), followed by Favorit (3900 kg/ha), Tiara (3700 kg/ha) and Trinity (3635 kg /ha).

The mass of 1000 grains also showed high variability, with average values between 190.8 g (Omega) and 135.9 g (Tiara). On the other hand, the ratio between plant weight and grain weight recorded average values from 1.59 in the Favorit variety to 1.74 in the Tiara variety.

The obtained results confirm the very good suitability of the four pea varieties for sustainable cultivation in the environmental and soil conditions of the South-West area of Oltenia. We consider, on the other hand, that considerable profits can be obtained by using very early varieties or by establishing crops in autumn, in this way realizing extra-early pea productions, which are valued at high prices.

REFERENCES

Ahmad, M.I., Daradkeh, J., Malkawi, M., Al Delaimy, W.K. (2019). Challenges in environmental health research and sustainability in a less developed country: a case study from Jordan. *Current Environmental Health Reports*, *6*(4), 327–337.

Amundson, R., Berhe, A.A., Hopmans, J.W., Olson, C., Sztein, A.E., Sparks, D.L. (2015). Soil and human security in the 21st century. *Science, 348*. 1261071.

Annicchiarico, P., Filippi, L. (2007). A field pea ideotype for organic systems of Northern Italy. *J. Crop. Improv., 20.* 193–203.

Bonciu, E. (2019). The climate change mitigation through agricultural biotechnologies. *Annals of the University of Craiova-Agriculture, Montanology, Cadastre Series*, *49*(1), 36–43.

Bonciu, E., Roşculete, E., Păunescu, R.A., Roşculete, C.A., Păunescu, G. (2022). Cyto-palynological observations on some pea (*Pisum sativum*) genotypes. *Scientific Papers. Series A. Agronomy, LXV*(1), 221–225.

Bourgault, M., Lamb, P., McPhee, K., McGee, R. J., Vandenberg, A., Warkentin, T. (2022). Genotypic variability in root length in pea (*Pisum sativum* L.) and lentil (*Lens culinaris* Medik.) cultivars in a semi-arid environment based on mini-rhizotron image capture. *The Plant Phenome Journal, 5*, e20037.

Bourion, V., Duparque, M., Lejeune-Henaut, I., Munier-Jolain, N.G. (2002). Criteria for selecting productive and stable pea cultivars. *Euphytica, 126*. 391–399.

Carlson-Nilsson, U., Aloisi, K., Vågen, I.M., Rajala, A., Mølmann, J.B., Rasmussen, S.K., Niemi, M., Wojciechowska, E., Pärssinen, P., Poulsen, G., Leino, M.W. (2021). Trait Expression and Environmental Responses of Pea (*Pisum sativum* L.) Genetic Resources Targeting Cultivation in the Arctic. *Front. Plant Sci., 12*, 688067.

Cola, M., Cola, F. (2022). Study regarding the identification of some antibiotic waste in treated cows' milk. *Scientific papers. Series D. Animal science, LXV*(1), 341–346.

Cola, M., Cola, F. (2021). Research regarding the effect of the number of milkings a day on milk production at primiparous cows. *Scientific Papers. Series D. Animal Science, LXIV*(1), 312–319.

Cola, M., Cola, F. (2019). Study on breeding a Holstein-Friesian line of cows to improve milk quality. *19th*

International Multidisciplinary Scientific GeoConference SGEM, *book 6.1, 19*, 913–922.

Cotuna, O., Paraschivu, M., Sărățeanu, V., Horablaga, M.N., Durău, C.C. (2022a). Research regarding the contamination with *Fusarium spp*. of the wheat grains from the variety *Triticum aestivum ssp. spelta* before and after the treatment with bio-fungicide - case study. *Scientific Papers. Series A. Agronomy, Vol. LXV*(1), 266–273.

Cotuna, O., Paraschivu, M., Sărățeanu, V., Horablaga, M.N., Ciobanu, A., Kincel, K., Panda, A.O., Ștef, R. (2022b). Research regarding the identification of the fungus *Phomopsis mali* Roberts (*Phomopsis* fruit tree canker) in a two years old ecological apple orchard - case study. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, *22*(4), 177–184.

Cotuna, O., Paraschivu, M., Sărățeanu, V. (2022c). Charcoal rot of the sunflower roots and stems (*Macrophomina phaseolina* (Tassi) Goid.) - an overview. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 22*(1), 107–116.

Cotuna, O., Paraschivu, M., Bulai, A., Toma, I., Sărățeanu, V., Horablaga, N.M., Ciprian Buzna, C. (2021). Behaviour of some oat lines to the attack of the fungus *Blumeria graminis* (D.C.) *f. sp. avenae* EM. Marchal. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 21*(4), 161–170.

Jain, S., Kumar, A., Mamidi, S., McPhee, K. (2014). Genetic diversity and population structure among pea (*Pisum sativum* L.) cultivars as revealed by simple sequence repeat and novel genic markers. *Mol. Biotechnol., 56*, 925–938.

Jiang, Y., Lindsay, D.L., Davis, A.R., Wang, Z., MacLean, D.E., Warkentin, T.D., Bueckert, R.A. (2020). Impact of heat stress on pod-based yield components in field pea (*Pisum sativum* L.). *Journal of Agronomy and Crop Science, 206*. 76–89.

Kumar, B., Kumar, A., Singh, A.K., Lavanya, G.R. (2013). Selection strategy for seed yield and maturity in field pea (*Pisum sativum* L. *arvense*). *African Journal of Agricultural Research, 8.* 5411–5415.

Larmure, A., Munier-Jolain, N.G. (2019). High Temperatures During the Seed-Filling Period Decrease Seed Nitrogen Amount in Pea (*Pisum sativum* L.): Evidence for a Sink Limitation. *Front. Plant Sci., 10*. 1608.

Namatsheve, T., Cardinael, R., Corbeels, M., Chikowo, R. (2020). Productivity and biological N2-fixation in cereal-cowpea intercropping systems in sub-Saharan Africa. A review. *Agron. Sustain. Dev., 40*. 30.

Paraschivu, M., Matei, G., Cotuna, O., Paraschivu, M., Drăghici, R. (2022). Management of pests and pathogens in rye crop in dry marginal environment in Southern Romania. *Scientific Papers. Series A. Agronomy, Vol. LXV*(1), 466–474.

Paraschivu, M., Matei, G., Cotuna, O., Paraschivu, M., Drăghici, R. (2021). Reaction of rye cultivars to leaf rust (*P. recondita* f. sp. *secalis*) in the context of climate change in dry area in southern Romania. *Scientific Papers. Series A. Agronomy, Vol. LXIV*(1), 500–507.

Pecetti, L., Angelo, M.R., Luigi, R., Massimo, R., Paolo, A. (2019). Adaptation of field pea varieties to organic farming across different environments of Italy. *Crop Pasture Sci., 70*. 327–333.

Sadras, V.O., Lake, L., Kaur, S., Rosewarne, G. (2019). Phenotypic and genetic analysis of pod wall ratio, pehnology and yield components in field pea. *Field Crops Research, 241*. 107551.

Santos, C.S., Carbas, B., Castanho, A., Vasconcelos, M.W., Vaz, P.M.C., Domoney, C., Brites, C. (2019). Variation in Pea (*Pisum sativum* L.) Seed Quality Traits Defined by Physicochemical Functional Properties. *Foods*, *8*(11), 570.

Sarūnaitė, L., Toleikienė, M., Arlauskienė, A., Razbadauskienė, K., Deveikytė, I., Supronienė, S., Semaškienė, R., Kadžiulienė, Ž. (2022). Effects of Pea (*Pisum sativum* L.) Cultivars for Mixed Cropping with Oats (*Avena sativa* L.) on Yield and Competition Indices in an Organic Production System. *Plants, 11*(21), 2936.

Shanthakumar, P., Klepacka, J., Bains, A., Chawla, P., Dhull, S.B., Najda, A. (2022). The Current Situation of Pea Protein and Its Application in the Food Industry. *Molecules, 27*. 5354.

Short, K.R., Kedzierska, K., Van de Sandt, C.E. (2020). Back to the future: lessons learned from the 1918 influenza pandemic. *Front. Cell Infect. Mi., 8*. 1-19.

Sibhatu, B., Berhe, H., Gebrekorkos, G., Abera, K. (2016). Determination of planting spacing for improved yield and yield components of Dekoko (*Pisum sativum* var. *abyssinicum*) at Raya Valley, Northern Ethiopia. *African Journal of Plant Science, 10*. 157–161.

Sirohi, S.P.S., Ramashray, Y., Malik, S. (2006). Genetic variability, correlations and path coefficient analysis for seed yield and its component characters in pea (*Pisum sativum* L.). *Plant Archives., 6*(2), 737–740.

Smith, A.B., Cullis, B.R., Thompson, R. (2005). The analysis of crop cultivar breeding and evaluation trials: An overview of current mixed model approaches. *Journal of Agricultural Science, 143*. 449–462.

Velea, L., Bojariu, R., Burada, C., Udristioiu, M.T., Paraschivu, M., Burce, R.D. (2021). Characteristics of extreme temperatures relevant for agriculture in the near future (2021-2040) in Romania. *Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering, X*. 70–75.