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Agro-biological evaluation of different groundnut (*Arachis hypogaea* L.) varieties on the background of phosphorous-potash fertilizers in conditions of semi-desert soil zone

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Abstract. In conditions of semi-desert soil zones of Armenia (1,130 m high above the sea level) the agro-biological properties of groundnut varieties Lia, Virginia, Mocket, TMV 3, Sevahatik (Black Seed) and Chinese have been studied with the aim of selecting their best options for further regionalization in the piedmont zones. The field experiments were conducted in 2020–2022. The calculations and laboratory analyses have indicated that the field germination capacity of the mentioned varieties is rather high fluctuating within the range of 77.5–81.0%, whereas the weight of 1,000 grains equaled to 515–545 g, the average yield - 2.77–3.33 t ha^{-1}, the total nitrogen in the grains were 4.39–4.61%, crude proteinhnւմ (per 5.70 factor of nitrogen) - 25.02–26.28%, total sugar contents - 14.11–16.63%, and fat content - 44.8–48.0%. The Mocket and Chinese varieties were distinguished by their yield capacity and qualitative indices of the yield and thus, the latter have been recommended for the cultivation in the farm households of the mentioned zone.

Key words: grondnut, variety, yield, quality.

INTRODUCTION

In the intensive and organic agricultural systems the permanent application of crop rotation technique is pivotal to ensure soil fertility recovery and to overcome soil fatigue. In this respect the perennial and annual *Fabaceae* plants have exceptional role. Lucerne, sainfoin, trifolium, lupine, ornithopus /common bird's-foot/, chickpea, lentil, pea, bean, soy, groundnut, etc. not only enrich the soil with biological nitrogen, but they are also directly connected with the production of plant and animal protein so important for humanity.

In the croplands of lucerne and trifolium 150–200 kg ha^{-1} N is accumulated annually, whereas in those of annual *Fabaceae* plants - 50–100 kg ha^{-1}, since their root system is unable to get so much strength, as that of the perennial plants (Orlova & Litvak, 1983). Nitrogen accumulated by different genotypic forms of pea (*Pisum sativum* L.) in meadow-black soil conditions of Western Siberia ensured high wheat yield and high

protein content in grain for about 3 years (Nazaryuk et al., 2016). In the Ukrainian soils with low humus content the chickpea plants have fixed 109–288, soybeans - 264–312, while the *Lucerne/alfalfa* - 486 kg ha^{-1} N. In the options without the mentioned *Fabaceae* plants, the nitrogen fixation made about 9%, against the afore stated indices (Tanchyk, et al., 2021).

According to the European Food Program, it is necessary to increase the production of food rich in plant protein, the demand for which is increasing parallel to the growth of the world population, whereas the proteins in the cereal and leguminous plants are evidently indispensable for mankind (Nigam et al., 2004).

In Armenia the leguminous crops are cultivated in limited areas, and the groundnut cultivation started in the last 23 years, whereas for crop rotation, as well as from the point of view of food and ecological security of the country they are critically significant, as it concerns the full supply of the population with plant food products (Matevosyan, 2014, Galstyan & Matevosyan, 2015). To meet the optimal demand of the organism for proteins, fats and carbohydrates, their ratio in the human diet should be 1:1.2:4. Moreover, the proteins in the energy portion of the diet should make 12%, fats - 30–35%, and the rest part is complemented with carbohydrates. According to medicinal justifications the daily intake of total proteins is 100–120 g, the annual optimal intake - 35 kg, out of which 21 kg should be animal proteins. Upon the breakdown of 1 g protein 4 kkal energy is released, from 1 g fat - 9 kkal energy and from 1 g carbohydrate - 4 kkal energy is released (Harutyunyan & Sargsyan, 2018).

Among the leguminous crops, the groundnut is a leading oilseed crop, the seeds of which contains 40–60% fat, 30–37% protein, 26–28% crude protein, while the groundnut cake/pomace produced from the seed contains 8% fat. Groundnut also stands out for its rather high digestibility, as well as for the full amino acid content. The percentage of essential amino acids (tryptophan, phenylalanine, methionine, lysine, valine, leucine, threonine, isoleucine) in the proteins is also rather high (Hammons, 1980, Kishlyan et al., 2020). Groundnut is cultivated in the tropical and subtropical regions. The world production of groundnut in 2015 was 37,535,000 tons. China is the largest producer of groundnut - 16,500,000 tonnes (43% of world production), followed by India (11.9%), Nigeria (8%), the United States (7.5%) and Sudan (4.9%) (Stalker, 2017).

Intensification in the symbiotic function of groundnut occurs at the flowering stage, during which plants actively absorb nitrogen from the atmosphere. All tuber bacteria that enter into a symbiotic relationship with leguminous crops belong to the genus *Rhizobium* (Arrendelle et al., 1988, Basu, 2011). Being fed with nitrogen, groundnut badly needs phosphorus and potassium. If the phosphorus content is low in the soil, the tuber bacteria migrate into the plant roots but don't form tubercles. Air nitrogen fixation occurs with the participation of ATP, the main energy supplier of which is phosphorus. In conditions of phosphorus deficiency, small amount of ATP is formed and air nitrogen is poorly fixed. Nitrogen-fixing activity is also due to the high potassium content, which accounts for the high demand of groundnut for this nutrient, as it ensures the constant movement of carbohydrates from the leaf to the tuber (Jana et al., 1990). A higher yield of early-ripening soybean cultivars in typical black soils of the forest-steppe zone of Ukraine is obtained by the application of $N_{60}P_{60}K_{60}$ pattern when the seeds are treated with rhizobium. Further increase of nitrogen doses (N_{90}, N_{120}, N_{150}, N_{180}) on the plants roots inhibits the development of tuber bacteria (Kalenska et al., 2022).

Groundnut is a non-traditional crop for Armenia, but the climatic conditions of several agricultural zones are favorable for the cultivation of this valuable crop. The lack of high-yielding, early-maturing varieties has been an obstacle to the expansion of groundnut croplands. The only variety cultivated in the republic (Meghri local) has a long vegetation period and is cultivated in the Meghri region with favorable climatic conditions for that variety (630–700 m above sea level), so there is a need for the individual selection of new high-yielding varieties from the global collection of peanuts, which is a relatively quick and available method (Matevosyan et al., 2020). Scientific research activities on the groundnut cultivation have been mainly carried out in conditions of the Ararat valley in the territory of production-experimental farm (853 m high above sea level) at the Scientific Center of Agriculture, since 2000. As a result of the research, varieties with best biological and economic characteristics were selected, which showed high adaptability in the given zone, and some of them were tested in different zones after receiving the status of variety, meanwhile the early-mature variety 'Lia' was also registered in the RA State Register of Selection Achievements in 2015 (registration N 28-L).

Purpose of the research and problems

The aim of the research is to study 5 varieties, identified by the individual selective method from 80 groundnut variety samples of the International Crops Research Institute for the Semi-Arid Tropics (*ICRISAT*) and tested in conditions of Ararat valley, and to test them also in conditions of piedmont zones, to identify their yield capacity against the Lia variety, disclose their qualitative properties and to recommend the selected varieties to the production, which would promote the expansion of groundnut croplands also in conditions of piedmont subzones of semi-desert soil zone, which will be partially involved in the crop rotation alternations of cereal crops. Within the frame of the above stated goal the similar sowing rates and density has been observed, against this background calculation of yield structural elements and analysis of qualitative indicators has been conducted in view of maturation times of the varieties.

Materials and methods

The field expriments were carried out within the period of 2020–2022 years, in the semi-desert soil zone (800–1,250 m high above sea level) on the Virginia, Mocket, TMV 3, Sevahatik, Chinese variety samples, the yield and qualitative indices of which were compared with Lia variety the latter coming forth as a control variant. The experimental pattern of the varieties is introduced in the Table 2–6. The studies were conducted in the land areas near Ashtarak city in the Aragatsotn region/marz, 1,130 m high above sea level on the soils belonging to the light brown subtype. The experiment was set up in 3 replications (70 m^2 each replication) with 70×25 cm feeding area, i.e., 6 plants per 1 m^2. The yielding capacity of the groundnut depending on the plants' density is a very important issue, which has been studied by multiple researchers. In regular conditions the density of plants varies within the range of 4–10 plants per m^2, in case of which the highest ield capacity is ensured. Higher densities than the afore stated range do not increase the yield capacity of pods, whereas in case of the density lower than 4 plants per m^2, yield capacity decline is observed (Morla et al., 2018).

In the experimental years the sowing was implemented in the second decade of April, at the depth of 6–8 cm. During the autumn ploughing the experimental plot was fertilized with the phosphorus-potassium fertilizers with $P_{80}K_{120}$ kg ha^{-1} dosage, as a general background. Before sowing the seeds were subjected to pre-sowing treatment in the 0.5% water solution of carbon + growth stimulant keeping them for 24 hours. Carbon plus stimulator is an organic fertilizer derived from active carbon compounds that contains many components. It contributes to the active development of the root system, promotes the emergence of hair roots, which results in the increase of roots feeding area, absorption of greater amounts of nutrients and moisture from the soil and their active movement from the root to the stem. As a result of all these the yield capacity of the crops and resistance towards high and low temperatures increase (http://agroservice.am/hy/product/504).

The overall area of the experimental plot made 0.2 ha, where the experimental/tested varieties per their replications took up 1,260 m^2, whereas in the other 740 m^2 land area nurseries for the breeding of Lia and Mocket varieties were established. The fall and spring soil cultivation, sowing and weed control during the vegetation period were implemented through the agro-technological methods developed for groundnut cultivation. To struggle against weeds, Gesagard herbicide with 3.5 L ha^{-1} dosage (solution volume- 600 L ha^{-1}) was sprayed across the experimental plot after the first watering. The investigations have indicated that weeds become serious threats in the period of groundnut crops formation. The weed biomass slows down the penetration of groundnut genophores into the soil, interferes with the process of pods maturation, which increases the yield loss amounts (Grichar et al., 2015).

The irrigation water source is the Arzni-Shamiram canal, which starts from Lake Sevan. During the vegetation period the plants were irrigated 6 times (600 m^3 ha^{-1} watering rate), irrigation rate - 3,600 m^3 ha^{-1}. Harvest was carried out in the second decade of October (70 m^2 total yield and qualitative indicators of all replications were estimated).

The climate in this region is rather dry with cold winters and warm summers. The sum of active temperatures (higher than 10 °C) amounts to 3,300–3,800 °C, average annual air temperature is 10.9 °C, maximum temperature - 41 °C, minimum - 29 °C. The annual precipitation amount makes 300–400 mm, annual evaporation deficit is 680 mm, Shashko's humidity coefficient - 0.07–0.15. The crops can't grow in this zone without artificial irrigation (Agroclimatic resources of Armenia, edited by R.S. Mkrtchyan et al., 2011).

During the vegetation, hilling and loosening activities for the plants were conducted thrice, which is not only aimed at the mechanical weed control but it also promotes the penetration of more genophores into the soil developing higher number of pods, which is the main guarantee for getting high groundnut yield. At the shrubbing stage, prior to watering, the plants were treated with foliar feeding through the fulvomix bio-liquid fertilizer with 9 L ha^{-1} dosage (600 L ha^{-1}). Fulvomix fertilizer contains fulvic acids, macro-micro nutrients, as well as amino acids. It strengthens the root system of plants, restores soil microflora (https://brand.am/products/?l =e&barcode=5852886000118).

During the vegetation period phenological observations and biometric measurements were conducted. After harvesting, the yield structural elements in the laboratory conditions were determined. The yield capacity of the varieties was calculated by weighing the total yield of the experimental bed. The laboratory analysis of the soil

and plant was conducted with the general methods (Arinushkina, 1970, Yagodin, 1987). The soil mechanical composition was determined through the classic pipette method and estimated according to the Kachinskiy's grading scale. The hygroscopic humidity was determined through weighing method, pH in the water extract - with potentiometer, humus content - per the method of I.V. Turin, total nitrogen - pe the Kjeldahl's method, mobile nirogen forms - per the methods of I.V. Turin and M.M. Kononova and the phosphorus content - according to the Machigin's method.

The results of yield amount were subjected to mathematical processing according to the method of dispersion analysis by the calculation of the least significant difference (*LSD*) and the relative error of the experiment- Sx, % (Dospekhov, 1985). The crude protein content in legumes according to the total nitrogen determination (Peterburgsky, 1968). Fats were determined by the extraction method with the Soxhlet apparatus (Yagodin, 1987).

In the samples of the average grain the contents of dry matters, crude protein, total sugar and fats were determined in the laboratory of Organic Agriculture at the Armenian National Agrarian University (ANAU).

RESULTS AND DISCUSSION

The land area is a homogeneous plane, and soil sampling was done in the central part of the experimental field from the A and B horizons, taking into account the depth of the groundnut root (*rhizosphere*) distribution (Table 1).

Table 1. Physico-mechanical and agrochemical characteristics of test/experimental site soils

Genetic horizon and depth, cm	< 0.01 mm - sum of particles (phys. clay), %	Hygroscopic humidity, %	Humus, %	The pH of the water draft	Total N, %	Mobile forms mg per 100 g in the soil		
						N	P_2O_5	K_2O
A 0–19	34.2	4.2	2.1	7.7	0.09	4.0	3.0	26.0
B 19–35	39.0	4.7	1.9	8.2	0.07	3.9	2.8	22.5

The table data show that the mechanical composition of the experimental plot is mid clay and sandy, where the physical clay makes 34.2–39.0%, (Soil science edited by J.S. Kaurichev, 1982), hygroscopic humidity is 4.2–4.7% (which is typical to the light brown soils), pH of water extract is basic/alkaline (7.7–8.2), humus content in the accumulative layers fluctuates within 1.9–2.1%, total nitrogen - 0.07–0.09%, the content of available nutrients per the respective scales is characterized by the average indicators (Yagodin, 1987).

Groundnut is a light-demanding plant. Seeds start sprouting in 10–12 °C heat conditions. The sprouts withstand up to - 0.5–1 °C. For the regular growth of the plants 25–28 °C temperature is required. Plants need maximum temperature in the flowering and fruit formation period. Plants are hardy towards the autumn heat up to 0.5 °C, while in conditions of 3 °C they dry out. The seeds harvested under these conditions, which don't get dry in natural way, are characterized with low germination capacity and are unfit as seeds. And the seeds harvested under the conditions of 4 °C become unfit for processing (Taille, 1997). Groundnut can grow under insufficient moisture conditions from the germination to the blossoming period, anyhow, in the period of fruit formation its soil moisture demand is extremely high. The critical stage of moisture demand starts

25–30 days after germination and lasts about 2–3 months. Throughout this period the 20 cm soil layer should be provided with moisture. By the end of vegetation this demand declines and starting from September the water excess can retard the fruit maturation (Roy et al., 1988).

The duration of groundnut vegetation period depends on the varietal characteristcs, cultivation place and climatic conditions. In favorable climatic conditions the sprouts emerge 8–10 days after sowing. After 25–30 days of sprouting, plants enter the flowering stage, which lasts up to the harvesting period. First, the flowers of lower part of stem are developed. Parallel to flowering, the groundnut vegetative part and pods grow up. Such a combination of growing stages is related to the plants demand for moisture and nutrients, particularly at the mass flowering and fruit formation stages. The period from flowering to fruit maturation lasts 1.5–2 months (Colvin et al., 1988).

The vegetation duration of the varieties (Table 2) indicates, that the sprouting stage of the Mocket and Chinese varieties was observed simultaneously with the control variety of Lia and lasted 13 days, while TMV-3 and Sevahatik (black seed) varieties stay behind the Lia variety by 2 days and Virginia variety - by 3 days.

Table 2. Vegetation duration of experimented groundnut varieties, day

Varieties	From seeding to	From sprouting to			
	sprouting	bush formation	flowering	pod formation	pod maturation
Lia (control)	13	15	34	90	179
Virginia	16	17	32	94	189
Mocket	13	13	24	83	172
TMV - 3	15	15	25	86	174
Sevahatik	15	15	25	85	176
Chinese	13	13	24	83	172

The bush formation stage in the Mocket and Chinese varieties started 2 days earlier as compared to Lia variety; in Sevahatik and TMV-3 varieties the bush formation period took place simultaneously with that of the control variety, whereas in Virginia variety it was 5 days later. The pod formation phase in the tested varieties fluctuated within 83–86 days compared to Lia variety, except from the Virginia variety, in case of which the mentioned phase started 4 days later than that of the control variant. At this stage again Mocket and Chinese varieties stand apart, since the pod formation stage in these varieties also started earlier.

As a result, in the tested Mocket and Chinese varieties (except from Virginia variety) the pod formation stage was reduced by 7 days and in case of TMV-3 variety - by 5 days, whereas in case of Sevahatik variety - by 3 days. Virginia variety ripens 10 days later than the control variant, whereas 8–12 days later than the other varieties.

Thus, it can be clearly stated, that the experimented Mocket and Chinese varieties, which can avoid early autumn frostbite in climatic conditions of piedmont zones, are distinguished by early maturation and provide high yield.

The studies have indicated that the tested varieties compared to the Lia variety are endowed with higher laboratory and field sprouting/germination ability (Table 3).

The data of Table 3 show that the laboratory germination of the varieties fluctuates within 85.0–88.0% (in the control variant - 84.0%), while the field germination - within 78.5–81.0% (in the control variant - 77.5%). Hence, as compared to Lia variety the laboratory and field germination ability of the studied varieties is slightly higher.

Table 3. Biological indicators of groundnut varieties in conditions of piedmont zones

Varieties	Laboratory germination		Field germination	
	n	%	n	%
Lia (control)	100	84.0	310	77.5
Virginia	100	85.0	314	78.5
Mocket	100	88.0	324	81.0
TMV - 3	100	86.0	320	80.0
Sevahatik	100	85.0	319	79.7
Chinese	100	87.0	322	80.5

In terms of groundnut yield efficiency increase, bush-type varieties are considered more valuable, which differ from the standing varieties by their biological, morphological and economic features. In the bush-type varieties the genophores resulted after flowering, are usually close to the soil and just by slightly bending are able to easily enter in the soil and develop pods (Patil et al., 1988).

The research results have also indicated that Lia groundnut variey is a rather self-righting variety, it is distinguished by the height of the plants (46.3 cm), which complicates the process of genophores migration into the soil. Mocket, TMV-3 and Sevahatik varieties were of average height (33.6–36.7 cm). The lowest height (30.5 cm) was recorded in the Chinese variety (Table 4).

The study results of the yield structural elements in the piedmont zone have testified, that the mentioned varieties differ from each other in these indicators; as a result different yield amounts are recorded. Thus, the data of Table 4 show, that Mocket and Chinese varieties stand out for the number and weight of plants pods (Table 4). In Mocket variety these indexes have made 98.2 n, and 72.6 g, while in Chinese variety - 91.6 n and 71.9 g, respectively. It should be mentioned, that pods containing 2 grains are prevailing in the Mocket and Chinese varieties.

Table 4. Biological indicators and yield structural elements of groundnut varieties

Varieties	Plans height, cm	Number of stems, n	Per 1 plant				Weight of 1,000 seeds, g
			number of pods, n	weight of pods, g	number of grains/seeds in a pod, n	g	
Lia (control)	46.3	9.3	87.3	70.8	262.0	133.6	515
Virginia	32.2	10.3	90.7	69.9	179.8	106.0	520
Mocket	32.6	12.1	98.2	72.6	206.2	112.3	545
TMV - 3	32.3	11.0	89.0	70.6	179.2	99.3	525
Sevahatik	36.7	10.2	86.5	69.1	169.3	89.7	508
Chinese	30.5	11.8	91.6	71.9	183.2	110.7	535

Besides, the mentioned two varieties exceed the other ones by the grain size. Lia variety exceeds Mocket, Chinese, TMV and Sevahatik varieties by the seeds number per a pod (262 n), though Lia variety concedes the mentioned varieties by the number of pods (87.3 n). This is accounted for the fact that Lia variety has small seeds and mostly develops pods with 2–3 and often 4 grains, which promotes the increase of grains weight in a pod. There is almost no difference between the Virginia and TMV-3 varieties

regarding the yield structural elements, as a result of which equal amounts of yield was developed (3.0 and 3.02 t ha^{-1}). It is also necessary to mention, that pods with 2 grains/seeds prevail in these varieties as well. Sevahatik variety lags behind the other varieties by the number of pods (86.5 n), number of grains per pod (169.3 n) and grains weight (89.7 g).

In the piedmont zone the highest yield capacity and best properties were recorded in the Mocket (3.33 t ha^{-1}) and Chinese (3.28 t ha^{-1}) varieties (Table 5).

Table 5. The yield of groundnut varieties per years

Varieties	Yield t ha^{-1}			Average yield, t ha^{-1}	Yield surplus, t ha^{-1}
	2020	2021	2022		
Lia	2.95	3.00	3.03	2.99	--
Virginia	3.00	3.02	2.99	3.00	--
Mocket	3.32	3.39	3.28	3.33	0.33
TMV3	3.02	2.98	3.00	3.02	0.02
Sevahatik	2.78	2.80	2.74	2.77	--
Chinese	3.25	3.32	3.27	3.28	0.28
Sx, %	5.86	1.29	1.31	0.54	
*$LSD_{05,\ t}$	0.56	0.13	0.13	0.16	

*LSD_{05} – least significant difference.

The study of the grain qualitative properties is significant for the evaluation of leguminous crops (groundnut) efficiency. The content of protein in this crop grain is mostly related to the symbiotic nitrogen fixation efficiency. It is also known, that protein content in grain is related to a number of other factors, such as genotype of the variety, soil and climatic conditions, plants supply with nutrients, particularly with nitrogen, etc. (Babayan, 1980, Onianu, 1981).

Considering the primary significance of protein for the grain quality evaluation, the content of crude protein in the grain of the studied groundnut varieties has also been identified (Table 6). The crude protein in the grain was determined based on the determination of nitrogen by the Kjeldahl's method, then the nitrogen content was multiplied by 5.70.

Table 6. Qualitative indicators of the groundnut varieties

Varieties	Dry matters, %	N, %	Crude protein, %	Total sugar, %	Fat, %
Lia	94.41	4.48	25.54	14.11	44.79
Virginia	94.38	4.40	25.08	15.47	44.88
Mocket	95.21	4.60	26.22	16.63	47.62
TMV-3	94.51	4.47	25.48	15.29	46.67
Sevahatik	93.80	4.39	25.02	15.11	45.43
Chinese	94.89	4.61	26.28	16.55	47.97

The data of the Table indicate that Virginia, TMV-3 and Sevahatik varieties stand behind the Lia variety in crude protein amount. Hence, the crude protein amount in Lia variety has made 25.54%, whereas in Sevahatik, Virginia and TMV-3 varieties - 25.02, 25.08 and 25.48%, respectively. The discussed varieties have exceeded Lia variety (14.11%) by the total sugar content, while in other varieties this index fluctuated within 15.11–16.63%. Upon the results of multiple research works, it has been disclosed that 1–2% fat is accumulated in the grain of leguminous crops (cicer, lentil), anyhow the soybean and groundnut come forth as an exception in which 10–25% and 50% fat is accumulated, respectively.

The studies have indicated that in the grains of Virginia variety fat amount almost equal to that of Lia variety (44.88%) or by 0.09% more fats ate accumulated. All the other varieties were distinguished by high fat content: 45.43 to 47.97%. In the control variant this index makes 44.79%.

CONCLUSION

1. The climatic conditions of piedmont sub-zone at the Armenian semi-desert soil belts are quite favorable for the cultivation of groundnut varieties. The average 3-year yield amount for the studied groundnut varieties has fluctuated from 2.77 (Sevahatik) to 3.33 t ha^{-1} (Mocket), besides, as compared to Lia variety, significant yield difference was observed only in the Mocket and Chinese varieties (LSD_{05} -0.16 tons).

2. Among the experimented varieties Mocket and Chinese varieties stand out for their early-ripening characteristics. The latter can avoid early fall frostbites in the climatic conditions of piedmont zones, thus, ensuring high yield.

3. The studied varieties slightly differed from each other by their crude protein and fat content, whereas the content of total sugars in the tested varieties exceeded that of Lia variety by 1–2.44%.

4. Groundnut cultivation is a great problem in irrigated conditions, which is related to the struggling measures taken against the weed vegetation, since their above-ground mass and root system have an allelopathic (antibiosis) impact on the crops.

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REFERENCES

Agroclimatic resources of Armenia edited by R.S. Mkrtchyan, D.H. Melkonyan & V.H. Badalyan, 2011. Yerevan, 41–49 (in Armenian).

Arinushkina, E.B. 1970. *Guideline to chemical analysis of soils*. M. Publishing house of Moscow State University, 487 pp. (in Russian).

Arrendell, S., Wynne, J.C., Elkan, G.H. & Schneeweis, T.J. 1988. Selection for nitrogen-fixing ability in early hybrid generations of peanuts. (USA), *Peanut Science* **15**(2), 90–93.

Babayan, G.B. 1980. *Balance of nitrogen, phosphorus and potassium in the agriculture of the Armenian SSR*. Yerevan, pp. 13–180 (in Russian).

Basu, T.K. 2011. Effect of Cobalt, Rhizobium and Phosphobacterium Inoculations on Growth, Yield, Quality and Nutrient Uptake of Summer Groundnut (Arachis hypogaea). *American Journal of Experimental Agriculture* **1**(1), 21–26.

Colvin, D.L., Brecke, B.J. &Whitty E.B. 1988. Tillage variables for peanut production. *Peanut Science* **15**(2), 94–97.

Dospekhov, B.A. 1985. *Methodology of Field Practice*. Agropromizdat, Moscow, pp. 207–248 (in Russian).

Galstyan, M. & Matevosyan, L. 2015. *Evaluation of groundnut cultivars by yieldindices and economic efficiency.* Bulletin of National University of Armenia, №4, 5–9 (in Armenian).

Grichar, J.W., Dotray, P.A. & Etheredge, L.M. 2015. Weed Control and Peanut (Arachis hypogaea L.) Cultivar Response to Encapsulated Acetochlor. *American Peanut Research and Education Society,* **42**(2), *Peanut Science,* 100–108.

Hammons, R.O. 1981. Research and increased costs in getting high peanut yields in the United States. *Proc. Int. Workshopgroundnuts*, Patancheree, 13–17 Oct. 1980, AnghraPradesh, pp. 40–43.

Harutyunyan, S.S. & Sargsyan, K.Sh. 2018. *Ecological security*, pp. 266–281 (in Armenian).

Jana, P.K., Barik, A. & Chatak, S. 1990. The influence of mineral fertilizers on the groundnut yield and yield structure of the peanut crop. *Indian J. Agr. Sc.* **60**(1), 49–51.

Kalenska, S., Novytska, N., Kalenskii, V., Garbar, L., Stolyarchuk, T., Doctor, N., Kormosh, S. & Martunov, A. 2022. The efficiency of combined application of mineral fertilizers, inoculants in soybean growing technology, and functioning of nitrogen-fixing symbiosis under increasing nitrogen rates. *Agronomy Research* **20**(4), 730–750.

Kishlyan, N.V., Bemova, V.D., Matveeva, T.V. & Gavrilova, V.A. 2020. Biological peculiarities and cultivation of groundnut (a review). *Proceedings on applied botany, genetics and breeding* **181**(1), 119–127 (in Russian).

Matevosyan, L.G. 2014. Comparative efficiency of groundnut cultivars under the conditions of the Ararat valley. *Agriscience* **3–4**, Yerevan, 122–125 (in Armenian).

Matevosyan, L.G., Barbaryan, A.A. & Avetisyan, S.G. 2020. The Comparative Efficiency in the Cultivation of New Groundnut Varieties in the Piedmont Zones of Armenia. *Agriscience and Technology* **3**(71), 56–59 (in Armenian).

Morla, F.D., Giayetto, O., Fernandez, E.M., Cerioni, G.A. & Cerliani, C. 2018. Plant density and peanut crop yield (Arachisypogaea) in the peanut growing region of Córdoba (Argentina). *American Peanut, Research and Education Society* **45**(2), Peanut Science, 82–86.

Nazaryuk, V.M., Kalimuullina, F.R. & Klenova, M.I. 2016. Aftereffect of biological nitrogen fixed by different pea genotypes. *Agrochemistry* **5**, 3–10 (in Russian).

Nigam, Sh.N., Giri, D.I. & Reddy, A.G.S. 2004. Groundnut Seed Production Guideline. *Int. Research Institute of Plant Production for Semi-Arid Tropics*, India, 32 pp. (in Russian).

Onianu, O.G. & Margvelashvili, G.N. 1981. Balance of nitrogen, phosphorus and potassium and the use of fertilizers in agriculture of the SSR Countries for 1976–1979 years. *Regulation of soil fertility, cycle and balance of nutrients in agriculture of the USSR: Thesis Report. Pushchino*, pp. 112–114 (in Russian).

Orlova, A.N. & Litvak, Sh.I. 1983. *From nitrogen to yield*. Moscow, Publication, pp. 24–29 (in Russian).

Patil, R.B., Bharud, R.W. & Pokharkar, S.M. 1988. Comparative assessment of the damage degree to peanut seeds during manual and machine plowing (India). *Seed Research* **16**(1), 112–113.

Peterburgsky, A.V. 1968. *Workspon on agronomocal chemistry*. Kolos, Moscow, pp. 99–112 (in Russian).

Roy, R.C., Stonehouse, D.P., Francois, B. & Brown, D.M. 1988. The influence of water deficit during the vegetation period on the yield and quality of groundnut pods in the south of the province Ontario (Canada). *Peanut Science* **15**(2), 85–89.

Soil science edited by J.S. Kaurichev. 1982. Kolos, Moscow, pp. 25–30 (in Russian).

Stalker, 2017. Utilizing Wild Species for Peanut Improvement. *Crop Science* **57**(3), 110–1120.

Taille De La 1997. Le nouream plan proteins Vegetables. *Oleoscope* **40**, 7–8.

Tanchyk, S., Litvinov, D., Butenko, A., Litvinova, O., Pavlov, O., Babenko, A., Shpyrka, N., Onychko, V., Masyk, I. & Onychko, T. 2021. *Fixed nitrogen in agriculture and its role in agrocenoses. Agronomy Research* **19**(2), 601–611.

Yagodin, B.A. 1987.*Workshop on agricultural chemistry*. Agropromizdat, Moscow, 512 pp. (in Russian).

http://agroservice.am/hy/product/504

https://brand.am/products/?l=e&barcode=5852886000118