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Sources of Economically Valuable Features for Selection of Grass Pea (*Lathyrus sativus* L.) in Conditions of Absheron Peninsula

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ABSTRACT

Background: In a world facing climate change and associated environmental stresses that hamper agricultural productivity and food security, the requirement for more sustainable agriculture is on the rise. In this regard, there is a need to expand the area of cultivation of drought-resistant leguminous crops. The purpose of the research is to study the grass pea collection, to identify forms with economically valuable traits and to create on their basis a new highly productive, technologically advanced, valuable with its quality grass pea grain for a selection in the conditions of the Republic of Azerbaijan.

Methods: The studies were conducted in 2017-2020 at the Institute of Genetic Resources (IGR) of the National Academy of Sciences (NAS) of Azerbaijan. 75 samples were used as research material:25 of them were local forms and 50 were samples obtained from ICARDA. The productivity and structure of the harvest have been analyzed.

Result: As a result of research, the most high-yielding and high-quality samples GP-58, GP-59, GP-65, GP-71, GP-73, İFLA-2973, İFLA-240, İFLA-479, İFLA-1795, İFLA-242, GP-56, GP-87. were revealed in the studied grass pea samples. During the implementation of the breeding program using the results, we have developed a new early ripe, drought-resistant, heat-resistant, disease-resistant and high-yielding variety Zirve by the method of repeated individual selection from the local forms. These studies are an important initial study for the subsequent production of new varieties. We hope that this will lead to an increase in the acreage of grass pea in the Republic of Azerbaijan.

Key words: Alternative, Drought-resistant, Grass pea, Initial material, Legumes, Plant breeding, Protein.

INTRODUCTION

The grass pea is endowed with many properties that combine to make it an attractive food crop in drought-stricken, rain-fed areas where soil quality is poor and extreme environmental conditions prevail (Palmer *et al*., 1989). Despite its tolerance to drought it is not affected by excessive rainfall and can be grown on land subject to flooding (Kaul *et al*., 1986; Rathod 1989; Campbell *et al*., 1994). It has a very hardy and penetrating root system and therefore can be grown on a wide range of soil types, including very poor soil and heavy clays. This hardiness, together with its ability to fix atmospheric nitrogen, makes the crop one that seems designed to grow under adverse conditions (Campbell *et al*., 1994). Compared with other legumes, the grass pea is resistant to many pests including storage insects (Palmer *et al*., 1989).

Grass pea (*Lathyrus sativus* L.) is an annual cool-season grain legume crop, that due to its relatively low input requirements compared to major crops, is considered a model crop for sustainable agriculture and an interesting alternative for cropping systems diversification in marginal lands (Almeida *et al*., 2014; Vaz Patto *et al*., 2006). It is characterized by a wide adaptation to different soils and climates, to low temperatures, showing flood and drought tolerance, insect and disease resistance and high protein content for human and animal feed (Campbell *et al*., 1994; Hanbury *et al*.,1995). Moreover, it is superior in yield, nitrogen fixation and salinity tolerance, when compared to other legume crops (Vaz Patto *et al*., 2006). These traits make it an outstanding crop for ensuring nutritional security, especially in the face of impending climate challenges (Sarkar *et al*., 2019). As an example, the importance of grass pea was recognized by Kew's Millennium Seed Bank which considered it among the priority crops to be used for the adaptation of the world's most important food crops to new climatic conditions production (Dempewolf *et al*.,2014; Lambein *et al*., 2019).

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MATERIALS AND METHODS

The studies were conducted in 2017-2020 at the Institute of Genetic Resources (IGR) of the National Academy of Sciences (NAS) of Azerbaijan. The IGR is located on the Absheron peninsula (80 m above sea level), in a dry

subtropical climate with very sunny and dry summers, warm and sunny falls and mild almost snowless winters. The average temperature is 13.5-14.5°C. Frost in winter is rare. In summer, the temperature climbs up to 38-40°C and since 2010 this can reach to 40-45°C. The driest months are July and August. Most of the rainfalls occur in winter-spring period. Average yearly rainfall is mediocre and constitutes 120-150 mm and relative humidity is 70,6%. Summer is almost always dry. The soil is sandy and very poor. Caspian Sea and semi-arid plains surrounding the peninsula has big impact to the climate. The following method was used during the research: Methodology for the definition of a key set of characterization and evaluation descriptors for grass pea (*Lathyrus sativus* L.) (Alercia, 2011). Sowing of collection samples was carried out in duplicate with an area of food of one plant 10 × 45 cm at the optimum time, in the fall at the end of November. A standard sample was sown after every 10 samples. In the process of growing, the ranks made phenological observations, determined the time of onset of phenological phases. The onset of the phase was noted when there were signs in 10% of the plants and complete - in the presence of signs in 75% of the plants. The height of the plant from the soil to its highest point (cm), the height of attachment of the lower bean (cm), the number of beans per plant, the mass of seeds from one plant and the mass of 1000 seeds (g) have been measured.

The main collection of grass pea (75%) reflects the high level of international cooperation of ICARDA. The sources of formation and replenishment of the gene pool are also genetic lines, hybrids synthesized in the process of various selection and genetic experiments. The main ecological-geographical groups of the ranks described by us are well distinguishable by morphological features and correspond to our groups of varieties. They differ in flower color (white, red, blue-lilac) and seed characteristics (absolute weight of 1000 seeds, seed color (yellowish-white, brown and sandy) and the nature of the pattern (marbling and spotting) (Fig 1-2).

RESULTS AND DISCUSSION

The cheapest, high-quality, highly digestible protein is given by leguminous crops. Of the legumes for fodder purposes, grass pea, chick peas and broad beans are important. One of such species of interest for cultivation in the conditions of the central lowlands of the Republic of Azerbaijan is the grass pea (*Lathyrus sativus* L.), which is still classified as a non-traditional crops. Grass pea is little cultivated, underestimating the biological and energy potential. In recent years, climate change towards warming has been noted. All large areas are periodically affected by drought. In this regard, in agriculture there is a need to expand the area of cultivation of drought-resistant leguminous crops. The cultivation of leguminous crops is extremely important in the conditions of the Republic of Azerbaijan, where animal husbandry is the leading industry and the yield of these crops and the productivity of fodder lands are still relatively low (Asadova *et al*., 2016).

The purpose of the research is to study the grass pea collection, to identify forms with economically valuable traits and to create on their basis a new highly productive, technologically advanced, valuable with its quality grass pea grain for a selection in the conditions of the Republic of Azerbaijan.

For selection it is important to know the amplitude of the variability of the growing season for certain varieties and forms. It is crucial to study vegetation period not only in total, but also according to separate phases of growth and development. Growing period largely determines the suitability of a variety for cultivation in a particular area. Many economic and biological characteristics and properties of the species are connected with the duration of the growing season (resistance to drought, diseases and pests, quality of the product and, ultimately, crop yield (Kobyzeva *et al*., 2013).

According to our observations, depending on meteorological conditions, the duration of the sowing harvest period has a high volatility (158-214 days). The duration of this period depends on the species' characteristics of the grass pea.

The average height of plants at the standard was 117 cm, for collection samples from 40 to 198 cm. The height of attachment of the lower bean sat the standard was 15 cm, for collection samples-from 11 to 31 cm.

The number of beans per plant was 48 for standard, for collection samples from 14 to 122 beans. The number of

A. White. V. Red. C. blue-lilac

Fig 1: Coloring of flowers.

seeds per plant was146 for standard and 56 to 402 for collection samples of seeds. The seed weight per plant is 24 g for a standard, 5 to 51 g for collection samples. The mass of 1000 seeds for the standard was 212 g, for collection samples from 35 to 195 grams. The mass of seeds from 1 m^2 for standard was 300.0 g. This indicator for collection samples varied from 160.0 g tom 497 g.

As a result of our studies, the degree of variation of signs that are important in productivity was determined in collection samples belonging to the species under study grass pea *(Lathyrus sativus* L.) (Table 1).

Correlation coeûcients among the diûerent quantitative

Traits from the experience of breeding it was found that one of the main conditions was the study by the breeder the correlation between the elements of fertility. The choice of one indicator directly or indirectly affects changes in the other. In this case, the correlation of elements is measured by its volume and characteristics of the impact and the degree of correlation from the relativity of variability and dependence on the year of study. Correlation coefficients are the most convenient indicator for studying the interdependence of quantitative traits. In this case, the correlation of elements is measured by its volume and impact characteristics and the degree of correlation is measured by relative variability and dependence on the year under study (Davletov, 2008; Kanimoli Mathivathana *et al*., 2015). The results of the study of correlations are of interest when creating adaptive genotypes and obtaining the required performance characteristics.

The indicators obtained during our studies suggest that all the structural elements of all the samples included in the selection are interdependent and the increase in one of them does not lead to an increase in overall fertility. The results of the correlation analysis revealed a correlation of genotypes of Indian pea fertility indicators (Table 2).

Analysis of the study of the relationship between the morphological and biological features of the samples studied

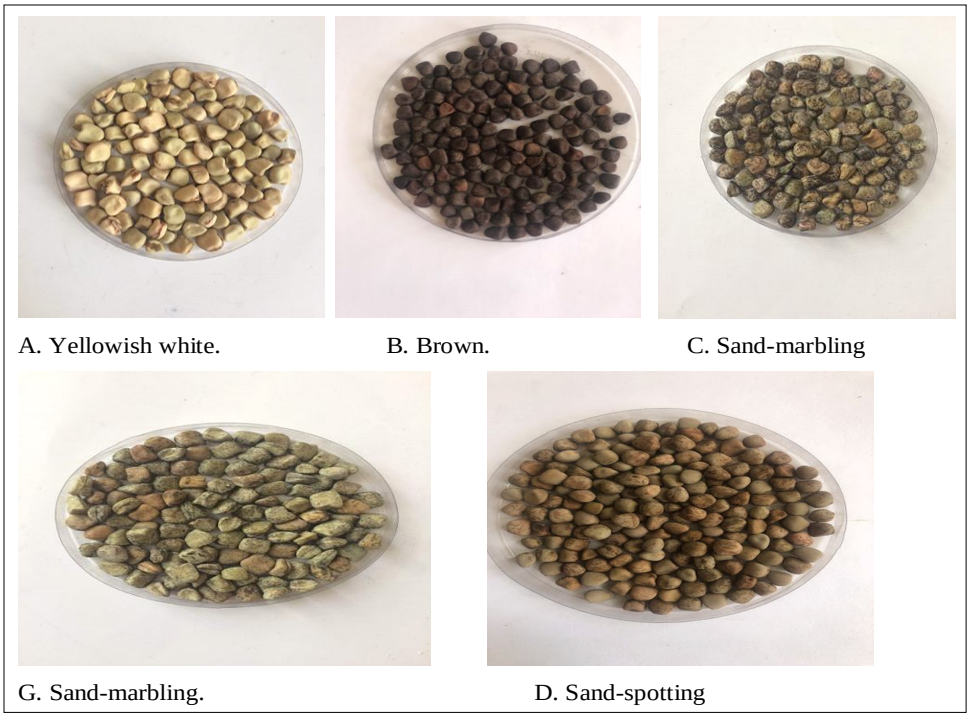

Fig 2: Seed signs.

Table 1: Values of mean, maximum, minimum, standard deviation and Coefficient of variation for the important productivity in the 75 samples grass pea.

Signs	Min	Max	Medium	Standard deviation	Coefficient of variation
Plant height	40	198	83.24±3.43	29.58	87.25
Height to the junction of the 1st bean (cm)	11	31	16.29±0.61	5.22	27.28
Number of beans in the plant	14	122	51.20±2.39	20.58	42.80
Number of grains in the plant	56	402	166.39±09.92	85.38	7.29
Mass of the grains in the plant (g)	5	51	18.56±1.01	8.72	76.11
Mass of 1000 grains (g)	35	195	120.36±5.32	45.79	2.09
Fertility per m^2 (g)	160	497	336.72±10.34	89	7.92

on average for 2017-2020, showed that a high positive relationship was noted between the weight of seeds on the plant and the yield (r = 0.928), between the number of seeds on the plant and yield (r = 0.862), between the number of beans on the plant and the yield (r = 0.654).

The average positive relationship was noted between plant height and yield (r = 0.559), between the number of seeds on the plant and the number of beans on the plant (r = 0.561), between the number of seeds on the plant and the mass of seeds on the plant (r = 0.559), between plant height and yield (r = 0.559).

Negative connections were observed between the number of beans and the weight of 1000 seeds (r = -0.363), the height of the plant and the number of beans on the plant (r = -0,045).

It is necessary to create new varieties, models of which combine, along with morphological features (compact bush, high attachment of the lower bean) and a set of economically useful traits. In order to compare the samples of productivity and suitability more accurately for mechanized harvesting of the samples of beans, they were divided into groups using cluster analysis (Stoilova *et al*., 2013). To construct the dendrograms, the Euclidean distance and the method of unweighted pairwise grouping with averaging (UPGMA-unweighted pair group method using arithmetic averages) were used. According to the most important economically valuable attributes (plant height, height of attachment of the lower bean, number of beans and seeds per plant, seed weight per plant and 1000 seed weight, biological productivity), a statistical analysis was performed using the SPSS software package with further grouping. In Fig 3 it can be seen that all the studied genotypes according to the aggregate morphological characters were classified into 3 main clusters. The resulting dendrogram made it possible to group genotypes depending on the level of seed productivity (Fig 3).

As a result of the study of variety samples of grass pea, promising samples were identified that can be successfully

Table 2: Correlation coeûcients among important productivity traits of grass pea.

	Plant height	Number of beans on the plant	Number of seeds on the plant	Weight of seeds on the plant	Weight of 1000 seeds	Yield
Plant height	1.000	-0.045	0.184	0.148	0.414*	0.559**
Number of beans on the plant		1.000	0.561**	0.245*	-0.363	0.654**
Number of seeds on the plant			1.000	0.559**	0.346	0.862**
Weight of seeds on the plant				1.000	0.451*	0.928**
Weight of 1000 seeds					1.000	0.457*
Yield						1.000

*=P 0,05, **= P 0,01.

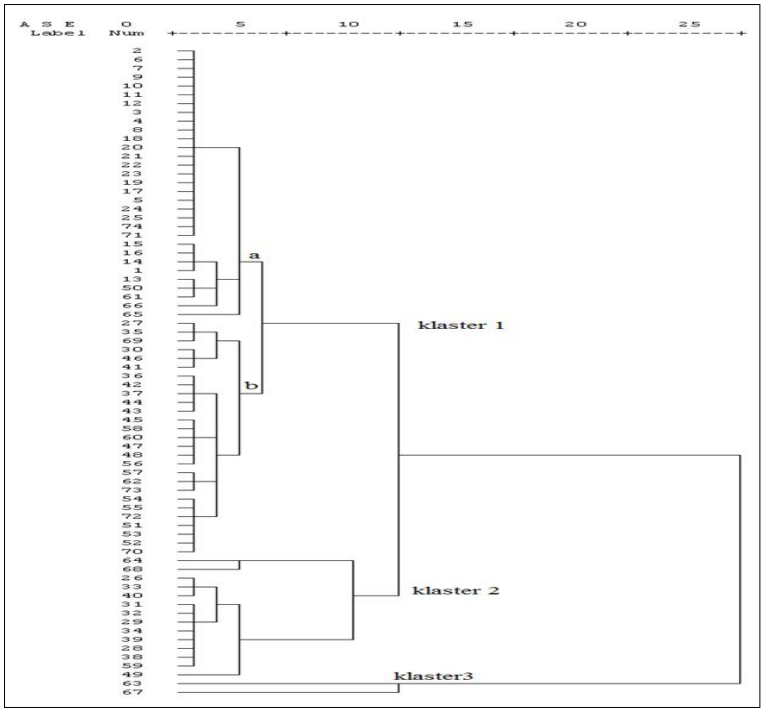

Fig 3: Dendrogram of clustering of grass pea samples on the elements of productivity and suitability for mechanical collection.

used as the starting material for the selection of grass pea. When creating new varieties of grass pea as a source material, it is necessary to pay more attention to plants belonging to the second cluster. When creating new varieties of grain and fodder (green mass) as a starting material, it is necessary to pay more attention to plants belonging to the first cluster. The plants of these samples have a complex of positive economically valuable traits, the selection of which is most desirable for the selection of grass pea for high productivity and suitability for mechanized harvesting.

We need to discover correlational interconnectedness among features of grass peas and on which features the selection should be carried out. A regression analysis has been made among quantitative elements in order to identify features which have more influence on biological productivity. On the basis of the regression analysis, the linear relationship among studied quantitative elements of biological productivity is visualized in the Fig 4-5.

As a result of the research, a new variety of grass pea Zirve was created, which we obtained by repeated individual selection from the local collection.

The plant is semi-branched and spreading, the height of the trunk is 100-120 cm. The leaves are oblong-lanceolate, 5.38 cm long and 0.4 cm wide. The beans are oblong-elliptical, 4.0-1.3 cm in size and have 3-4 seeds. The seeds are medium-sized and tooth-shaped or wedge-shaped. The color is yellowish, greenish-yellow. Weight of 1000 seeds is 201.0-231.0 g, productivity (seed) is 18.0- 20.5 s/h. The number of beans in the plant is 52-60; The number of days from full emergence to flowering is 111-125 days (autumn sowing), 45-65 days from full flowering to maturity, 23-31 days from the beginning to the end of flowering. The first bean is formed at a height of 14-27 cm, at the 6th-10th joint. It is resistant to drought, disease and pests (Fig 6).

The variety was regionalized in 2018 (Patent no. 00241).

Grass pea, a smart and healthy food crop

Besides being a model crop for sustainable agriculture, grass pea provides food and nutrition security to many low-income communities, being a highly nutritive food crop (Rubiales *et al*., 2020). Grass pea is considered a smart and healthy food crop, being valued and cultivated for its high protein content in seeds. The seed of L. sativus has high amounts of protein, low fat and high starch content. Grass pea protein content (18-34% in seeds and in mature leaves (17%), is higher than field pea (*P. sativum*) or faba bean (*Vicia faba*), but lower than soybean (*Glyxine max*). Grass pea proteins, mainly composed of globulins, albumins and glutelins, are rich in amino acids such as lysine but usually poor in sulphur-rich methionine and cysteine amino acids (Lambein *et al*., 2019; Fikre *et al*., 2008). Besides that, grass pea is rich in L homoarginine, a nonprotein amino acid present in concentrations up to 1% of the dry weight. Indeed, it is the only known dietary source of L-homoarginine, an alternative substrate for nitric oxide biosynthesis, with advantages in cardiovascular physiology and general wellbeing. A daily intake of *L. sativus* as part of a normal diet could provide enough of this healthy compound (Rao, 2011). Moreover, L-homoarginine is also associated with benefits in overcoming the consequences of hypoxia associated with cancer tumor development (Jammulamadaka *et al*., 2011;

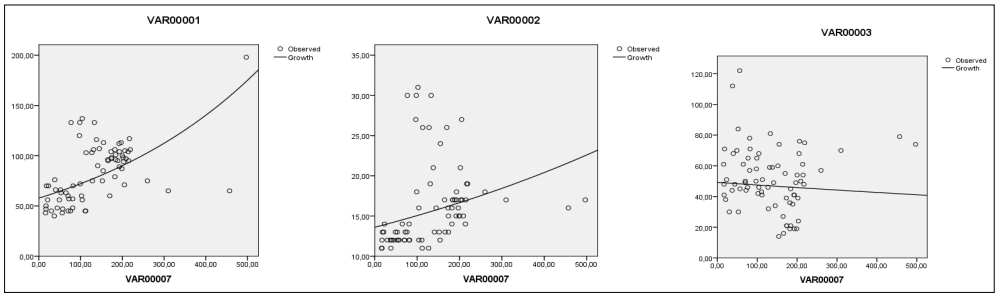

Fig 4: Relationships: Yield (VAR00007) of one plant with plant height (VAR00001); Yield (VAR00007) with the height of attachment of the lower bean (VAR00002), yield (VAR00007) of one plant with the number of beans per plant (VAR00003).

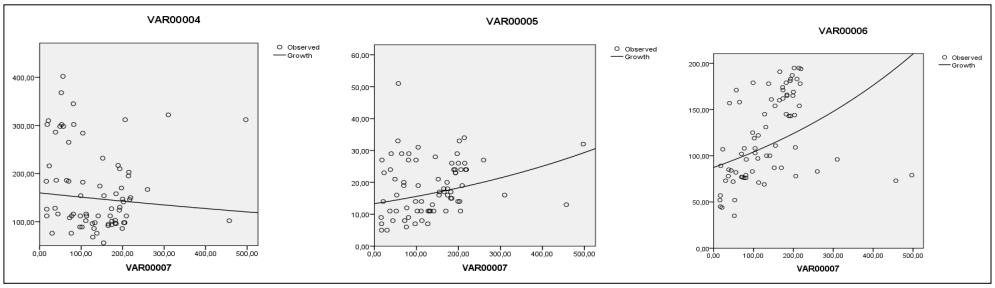

Fig 5: Relationships: Yield (VAR00007) of one plant with the number of seeds per plant (VAR00004), yield (VAR00007) of one plant with the mass of seeds per plant (VAR00005); Yield (VAR00008) with a mass of 1000 seeds (VAR00006).

A.Variety Zirve flower

B. Variety Zirve forming beans

C. Seed of Zirve variety

Fig 6: Variety zirve.

Fikre *et al*., 2011) found that, in grass pea, glutamic acid is usually present at high concentrations (0.03-0.08%), followed by aspartic acid (0.01-0.04%), arginine (0.01-0.05%) and asparagine (0.03-0.15%) in a similar pattern as for soybeans and lentils. Additionally, (Grela *et al*., 2010) found that grass pea seeds are rich in potassium (9.8 g kg^{-1} DM) and several minerals such as copper, zinc, iron and manganese for which average levels were 5.1, 44.1, 62.1 and 23.7 mg kg^{-1} DM, respectively. Furthermore, grass pea is an interesting source of health-beneficial dietary lipids, with a high polyunsaturated fatty acid proportion (58%) and phenolic compounds with high antioxidant activity, such as an average value of 68 mg/100 g of Gallic acid (Pastor-Cavada *et al*., 2009).

Despite those advantages, grass pea is still an underused crop due to its low yields but also its content on the neuroexcitatory b-N-oxalyl-l-a,b-diaminopropionic acid (b-ODAP) considered the cause of the neurodegenerative disease-lathyrism, if consumed as a staple food for extended periods of time (Lambein *et al*., 2007). Since the identification of b-ODAP in grass pea in 1964 (Rao *et al*.,1964), this harsh and resilient crop suffered from a reputation of being toxic. However, under an equilibrate diet, including cereals and fruits, lathyrism can be prevented and grass pea can be safely consumed (Getahun *et al*., 2003). Taking the above in consideration, grass pea breeding has focused mainly on enhancing yield and yield stability as well as on producing seeds with high nutritional value, meaning high protein and reduced b-ODAP content (Sellami *et al*., 2020; Chatterjee *et al*., 2019).

Thus, one of the main factors in expanding the sown area of a plantation is the acquisition of forms with a low level of productive and harmful substances. In this regard, the 23 samples with low levels of ODAP (beta-oxalyl amino alanine acid) included in our collection from ICARDA are of great importance. These examples have been carefully studied and all potentialities have been explored. For use in breeding work, new for our republic forms GP 97, GP 30, GP 62, GP 70, GP 77, GP 76, GP 71, which have a low level of ODAP, were selected. These samples, new to our republic, are intended for use as food and fodder.

CONCLUSION

Analysis of the study of the relationship between the morphological and biological features of the samples studied on average for 2017-2020, showed that a high positive relationship was noted between the weight of seeds on the plant and the yield (r = 0.928), between the number of seeds on the plant and yield (r = 0.862), between the number of beans on the plant and the yield (r = 0.654); the average positive relationship was noted between plant height and yield (r = 0.559), between the number of seeds on the plant and the number of beans on the plant (r = 0.561), between the number of seeds on the plant and the mass of seeds on the plant (r = 0.559), between plant height and yield (r = 0.559); negative connections were observed between the number of beans and the weight of 1000 seeds (r = -0.363), the height of the plant and the number of beans on the plant (r = -0.045).

The results of the research collection, samples were selected GP 97, GP 30, GP 62, GP 70, GP 77, GP 76, GP 71, with a low level of harmful substances (acid betta-oksalyl amino alanine). We hope that this will lead to an increase in the acreage of legumes in our republic. Newly-obtained and resistant to bending variety "Zirve" will also play an important role in expanding the plow cultivation area in Azerbaijan.

Conflict of interest: None.

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