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CHICKPEA AS A PROSPECTIVE LEGUME CROP FOR UKRAINIAN FOREST STEPPE

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Value of chickpea crop and the results of studies of 102 samples received from Syria based on the display of main economically valuable features are given in the article. Chickpea samples evaluation was done based on the processability and productivity and its components. Sources of economically valuable features were allocated according to following traits: seed productivity, number of seeds on a bean, number of beans on a plant, high weight of 1000 seeds and suitability for mechanical harvesting. Taking into consideration the results, these samples can be involved in breeding practice in order to increase productivity and processability under the conditions of southern Forest Steppe of Ukraine.

Key words: *chickpeas, value, vegetation period, processability, sample, cultivation perspectives, sources of valuable features.*

Research statement. Under the conditions of global warming, which is recognized worldwide, yield capacity of agricultural crops is decreasing, including such main Ukrainian legume crops as pea and soybean. Taking into consideration a serious climate change, chickpea has a great value – it is a heat- and drought-resistant crop [13].

There is a growing demand for chickpea, and the areas occupied under chickpeas cultivation are increasing in Ukraine. For the last 10 years the territory of chickpeas cultivation has increased more than 10 times, and now it is about 50 – 70 thousand ha [16]. In especially dry years, which happen more and more often lately, chickpea can successfully compete with pea in its productiveness. According to the drought-resistance, it takes second place after the grass pea. Due to the powerful rooting system and saving water consumption, chickpea is the most adapted crop for cultivation in the regions which suffer from frequent droughts in summer period [14]. At the same time, involving chickpea into the crop rotation will help to enrich the soil with nitrogen and to obtain a good predecessor for all cereal (grain) cultures. Yield capacity of winter wheat is 2-4 cwt/ha higher after chickpea than after ley farming. Chickpea does not need nitrogen fertilizers to be used before its cultivation, because the tubers with nitrogen-fixing bacteria are formed on its roots, and these tubers absorb nitrogen from air; and they do not only satisfy chickpea's need in nitrogen, but also after harvesting this crop there is up to 100-150 kg of biological nitrogen on each hectare remaining in the soil [4, 18].

Besides the agricultural benefits, chickpea has high economical value. Under the condition of using high agricultural technologies and depending on the weather conditions chickpeas yield capacity varies in 14-27 cwt/ha of grain [17]. Such yield capacity can be compared to soybean yield, but under droughty conditions it can be very difficult to obtain it. It is also important that demand, and hence the price, for chickpeas is higher than for soybean, and not to mention the peas [13]. Besides chickpea does not have any specific pests which are common for pea (*Bruchus pisorum L., Cydia nigricana, Kakothrips robustus etc*.). Leaves and beans are covered with the hairs which produce oxalic, lemon and malic acids in serious quantity. Therefore pests avoid chickpea. Seeds and sowings of chickpeas do not require treatment with chemicals, and thus pesticide load can be decreased [9]. Cultivation of environmentally friendly product for appropriate price for export can be appealing for farmers of different ownership types [14].

Analysis of main researches and publications which initiated problem solution. In the world production of legumes chickpea takes the fourth place, being behind soybean, common bean and peanut. Its part in total amount is about 15.6% of gross yield of all legumes, or 2472 thousand tones. Pea has a slightly smaller share – 15.3%, which is more widespread in countries with moderate climate [2].

Main chickpea sowings are concentrated in India, Pakistan, Afghanistan, and in dry areas of Europe America and Africa. On the European continent chickpea crop has become known quite recently. Its main commercial producers are Portugal, Spain and countries of former Yugoslavia. Europeans prefer varieties with light coloration of seeds; therefore they give high price for it. Chickpea yearly import in Europe is about 120-150 thousand tones, and it mainly comes from Syria and Mexico [3, 19].

It is possible to use chickpea widely in local areas. Chickpea is commonly used for industrial purposes, and this aspect puts it on the second place after soybean. Chickpea varieties with light seeds coloration obtain better grain boiling characteristics, and they are used for food purposes [10]. Chickpeas grain attractiveness lies in its nutrition value (100g contain 334 kilocalories), sufficient quantity of provitamin A, (100g contain 316 international units of carotene). Besides, it contains 23-32% of protein, 60-70% of starch and 5-7% of fat which digest capacity of 87-97% [9]. Aside from being used for food purposes chickpea can be widely used for feeding animals. Chickpea's protein in its amino acid contents is close to perfect, according to FAO [1], therefore this crop can be a good substitute for meat in manufacturing industry. Chickpeas varieties with dark coloration of seed coat, which obtain the highest amount of protein, are mostly used for animal feeding purposes.

Aside from heat- and drought-resistance chickpea has high frost-resisting qualities. Seedling withstands temperature ranges up till -6 to -8°C, which permits to conduct the seedling in earlier

terms and to use spring soil humidity most productively. Chickpea ripens later than pea, which is why its cultivation can reduce harvesting load. Chickpea can be easily harvested by modern combines due to the upright type of bush, defoliation during ripening, high attachment of beans on a plant and their resistance to cracking [15]. That is why chickpea has a range of advantages if to compare with other legumes: its harvesting does not require special equipment and it can be processed for a longer period of time. It has been counted that grass pea and pea looses up to 30-40% of grain (up to 50% in dry weather) because of abscission during the prolonged harvesting period, while chickpea looses only 10% of grain. Chickpea's disadvantage is the delay of flowering in prolonged rainy weather which causes ovary shedding, and these circumstances lead to grain yield reduction. Also prolonged rainy weather decreases the percentage of flowers (in certain varieties) which form ovaries – 5-45% of this index for sunny weather [15].

This crop can give seriously high yield of valuable grain with minimum labor and resource expenditures, if a right technology of cultivation is used. According to the data provided by Krasnogradska experimental station, during the last 30 years chickpea takes third place in its yield capacity after pea and grass pea, and in droughty years it even exceeds these crops [13]. According to some scientists, pea, soybean and chickpea should not be competing; they have to complement each other. Crops vary in vegetation periods, physiological need in water, resistance to diseases and pests, which is why in different years one of these crops can seriously exceed others. Due to productive work of native breeders, at the moment a range of new highly processable, productive and resistant to diseases varieties have been created, and this fact forecasts further gradual increase in sowing areas occupied by chickpea [6].

Research aim and tasks – to conduct a morpho-biological and economical evaluation of chickpeas samples and select perspective source materials with a stable display of features, to arrange their involvement into breeding programs concentrated on improving plant productivity and adaptability.

Research materials and methods. During 2010-2011 in field and laboratory conditions of Ustymivska experimental station of plant production 102 chickpeas samples originating from Syria (ICARDA) have been studied. Agricultural technology – common for Forest Steppe zone. Method of sowing – wide row, with 45 cm width between rows. 10 seeds were sown in one linear meter. Total area of a plot was about 1.35 sq m, repetition – double, standard was placed within 20 numbers.

Weather conditions during the years of research were contrasting, according to the level of heat and precipitations provided, which contributed to a comprehensive analysis of the material. Vegetation period in 2010 was uneven in temperature conditions on the background of insufficient

hydration and increased temperature in summer. Spring – summer period in 2011 was remarked by slightly lower temperatures and sufficient, even excessive hydration in June – July.

Chickpeas samples were studied according to "Recommendations for foreign agricultural crops samples study" [12] and "Methodological instructions by Vavilov Institute of Plant Industry for studying legumes" [11]. Morphological description, classification based on economical and biological features has been conducted according to the classifier Cicer L. [8].

Research results. Results of research allow giving wide evaluation of chickpeas samples, based on their economical and biological features, and establish the ranges of their variation (Table 1).

1. Chickpea samples characteristics based on main economical and biological indexes, 2010-2011

Index	Average	Min	Max	V, %
Duration of period seedling-flowering, days	39,6	36,8	42,5	2,4
Duration of vegetation period, days	97,4	84,5	103,5	20,8
Plant height, cm	50,9	35,5	68,3	12,0
Height of lowest bean attachment, cm	18,7	11,5	29,3	15,8
Number of beans on a plant, pcs.	36,6	17,1	66,2	26,8
Number of seeds in a bean, pcs.	1,5	1,0	1,9	12,2
Plant productivity, g	14,1	4,3	31,2	38,6
Weight of 1000 seeds, g	363,5	242,7	452,1	8,1

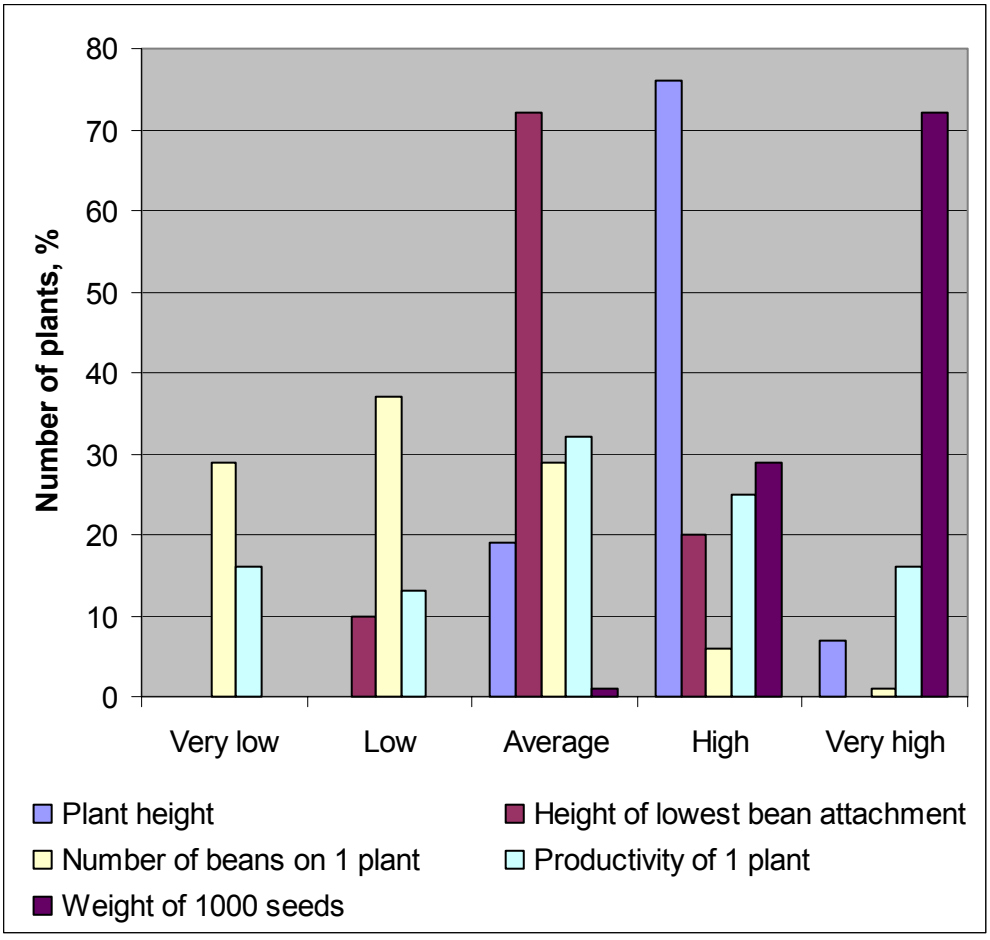
Not depending on conditions of cultivation, the highest index of variation was received from indicator "plant productivity" (V=38.6%) and "number of beans on a plant" (V=26.8%), and the lowest – "duration of period seedling-flowering" (2.4%) and "weight of 1000 seeds" (V=8.1%).

Duration of vegetation period. The bulk of studied material (98.0%) have been attributed to a middle-ripening group (duration of vegetation period 81-100 days); there was also a small group of late-ripening samples – 2.0% (vegetation period 101-120 days. Interfacial period "seedling - flowering" lasted for 37-43 days, and connection between this period and productivity is not determined (r=–0.01). Thus shorter period till flowering allows plants to access quickly the critical phase of water consumption, which helps to use water supplies in the soil more effectively.

Main direction in chickpea breeding is the creation of varieties for industrial purposes, which means creation of varieties with light coloration of seeds [14]. All studied chickpea material had light coloration of seed coat and spherical and angular shape of seeds.

Chickpea varieties improvement is done according to the established model of the variety. This model displays adaptability of future varieties to mechanical harvesting, in particular high

attachment of lowest beans above the surface of soil (higher 25 cm) and total length of the stem of 50-65 cm, which gives opportunity to form a high level of yield based on qualitative mechanical harvesting [16]. Feature "height of lowest bean attachment" depends on two components. First – the length of plant to lowest fertile bean which, in its term, is closely connected to the length of entire stem. Second – the shape of bush. The more compact bush is, the higher above soil surface beans are. That is why samples with compact upright shaped bushes need to be preferred. Among the studied samples most of the general quantity was characterized by upright bush shape, and 25% of samples had half-upright bushes. According to the indicator "lowest bean attachment" samples have distributed as following. Low (<15 cm) accommodation of beans above the soil surface is typical for 10 samples, which is 9.8% of total amount. The most numerous group was average (16-20 cm) height of bean above the soil surface – 72 samples (70.6%). High attachment (> 21 cm) was typical for 20 samples (19.6%) (Picture 1).



Picture 1. Distribution of chickpeas productivity elements according to the groups of features display

Feature "stem length" characterizes the sample not only for its height, but also for the suitability for direct mechanical harvesting. High stem length (46-60 cm) is typical for 76 samples, which is 74.5% of their total quantity. Average length (36-45 cm) was only in 19 samples, which is

18.6%. Samples with very high stem (>60cm) were about 6.7% of general quantity. All samples with high stem length had a compact bush. There were 75 samples allocated with the combination of high stem length and compact bush shape, and also average height of lowest bean attachment, which is 73.5% of general quantity of samples. It is proven by close positive correlation between indicator "plant height" and "height of lowest bean attachment" (r=0.60).

"Productivity" (weight of seeds from 1 plant) – is a complex feature, which depends on number of beans on a plant, number of seeds in a bean and weight of 1000 seeds [7]. Number of beans on a plant was one of the most variable features – variation coefficient was changing depending on the conditions of the year and in average was about 38.6% during the study. All studied samples have been distributed into groups depending on the number of beans on a plant. It has been determined that the biggest group is the one with a small number of beans on a plant (66-85% if to compare with the standard) – 37 samples (36.3%). The next two groups were with very low (<66%) and average number of beans on a plant (86%-115%), to which 29 samples belong (accordingly, 28.4% each). The group with high number of beans on a plant (116%-135%) includes 6 samples (5.9%), and the group with very high (>135%) got only one sample. In average within two years number of beans on a plant varied in the range of 19.2 – 65.2 pcs. Most of samples formed 35-45 beans on a plant. During the years of research in average the highest number of beans on plant was typical for following samples: FLIP82-150C – 66.2 pcs., FLIP05-145C – 57.1 pcs., FLIP05-111C – 53.1 pcs., FLIP05-10C – 57.7 pcs., FLIP05-23C – 57.8 pcs., FLIP03-23C – 52.1 pcs., FLIP06-42C – 51.4 pcs., FLIP05-17C – 50.9 pcs., FLIP05-170C – 50.7 pcs., FLIP03-29C – 52 pcs., ILC-3279 – 55.1 pcs., FLIP06-4C – 48.1 pcs., ILC-482 – 44.9 pcs. There have been 20 samples allocated, which during the years of research had highest number of beans on a plant if to compare with standard. This feature has average correlation with seeds productivity from 1 plant (r=0.34).

Depending on the number of seeds in a bean, samples have been distributed into following groups. The largest share belongs to the group of samples with an average number (1.1-2.0 pcs.) of seeds in a bean – 95.5%, and a seriously lower share belongs to the group with small number (only 1 seed) – 4.5%. Depending on the year of study amount of seeds in a bean varied from 1.0 to 1.9 pcs., and in average it was about 1.5 pcs. 2 seeds in a bean were formed by following samples: FLIP06-19C, FLIP06-143C, FLIP05-86C, FLIP03-29C, FLIP03-98C, FLIP05-170C, FLIP05-147C, FLIP82-150C, ICC 12004.

Weight of 1000 seeds is a valuable economical feature. Price of large-seed varieties on the world market is 1.3-1.6 times higher than it is for small-seed varieties [5]. In average during the years of research weight of 1000 seeds varied from 242.7 to 452.1g. The largest share belongs to the group of samples with very high weight of 1000 seeds (>350g) – 72 samples, which is 70.6% of

their total amount. The second group with medium weight of 251-350g includes 29 samples (28.4%), and only 1 sample belongs to the group with small seeds (151-250g) – 0.98%. The largest seeds have been formed by following samples: FLIP05-156C – 413g, FLIP05-162C – 413g, FLIP06-104C – 422g, FLIP05-80C – 424g, FLIP05-22C – 419g, FLIP05-23C – 452g. Samples with high weight of 1000 seeds (350 seeds and <) have upright shape of bush and, at the same time, length of stem varies within 35 to 55 cm. It has been determined that the weight of 1000 seeds has negative correlation with number of beans on a plant (r=–0.26), which makes it impossible to conduct the breeding process aimed at increasing the level of both these indicators at the same time. Therefore breeding of chickpea varieties should be conducted in order to increase the number of beans on a plant while saving the weight of 1000 seeds on the same level.

Productivity of one plant was in average about 14.1g in experiment during the years of research. It has been determined that the largest part contains a group of samples with average productivity of 86-115% if to compare with the standard – 32 samples (31.4%); second, smaller group is with the weight of 116-135% - 25 samples (24.5%); next group is the one with very high weight (> 136%) – 16 samples (15.7%). Low weight of grain from one plant (66–85%) was typical for 13 samples (12.7%), very low (< 66 %) - 16 samples (15.7%). In average, during the years of research following samples have shown highest productivity: FLIP06-123C – 31.2g, FLIP06-137C – 29.6g, FLIP06-98C – 28.0g, FLIP05-145C – 27.95g. Our research has determined that plant productivity has essential positive connection only to the number of beans on a plant (r=0.34).

Among the studied range of chickpeas, samples have been allocated, based on a complex of economically valuable features, which can be used as sources in practical breeding for creation of new varieties of chickpea with necessary traits (Table 2).

2. Chickpea samples distributed on a complex of economically valuable features

Sample name	Plant productivity, g	Weight of 1000 seeds, g	Number of beans on a plant, pcs.	Number of seeds in a bean, pcs.	Plant height, cm	Height of lowest bean attachment, cm	Vegetation period duration, days
Krasnokutskyy 123, st.	13,0	297,4	45,5	1,3	59,3	29,3	97
FLIP06-123C	31,2	374,6	42,1	1,4	44,9	18,1	96
FLIP05-145C	28,0	385,5	57,1	1,6	53,8	20,5	98
FLIP82-150C	24,6	324,2	66,2	1,9	60,5	20,0	103
FLIP05-10C	19,4	356,0	57,7	1,4	56,0	18,2	95
FLIP05-23C	18,8	452,1	57,8	1,6	66,8	20,0	96
FLIP05-52C	18,6	337,8	49,2	1,6	54,1	21,4	94
FLIP05-28C	17,4	399,5	43,0	1,4	54,1	18,1	95
FLIP05-170C	17,3	334,2	50,7	1,9	52,9	20,8	98
FLIP05-17C	16,4	308,0	50,9	1,6	43,8	14,5	93
FLIP03-23C	15,9	392,1	52,1	1,7	52,3	19,7	97
FLIP05-111C	15,7	335,4	53,1	1,4	43,9	15,9	92
FLIP06-42C	15,3	367,0	51,4	1,6	49,8	16,8	99
FLIP06-4C	15,3	351,4	48,1	1,5	48,0	17,1	96
FLIP03-29C	13,8	336,4	52,0	1,9	45,8	15,6	94
FLIP05-111C	13,6	401,3	46,4	1,7	58,7	19,3	96

Allocated samples exceed standard Krasnokutskyy 123 in plant productivity (for 5-140%), 1000 seeds weight (for 4-35%) and number of seeds in a bean (for 7–46%). Also most of the samples (81.3%) have the duration of vegetation period which is shorter or equal to the standard.

Conclusions. Chickpeas samples originating from Syria have been analyzed based on productivity features and its components and processability parameters. It has been determined that less varying features are “duration of period seedling - flowering” and “weight of 1000 seeds”, and the most variable ones are “plant productiveness” and “number of beans on a plant”. The closest positive correlation is the connection between indicators “plant height” and “height of lowest bean attachment” (r=0.60), and between “productivity” and “number of beans on a plant” (r=0.34); the tightest negative correlation is between “weight of 1000 seeds” and “number of beans on a plant”

(r=-0.26). Sources have been allocated based on a complex of economically valuable features: FLIP06-123C, FLIP05-145C, FLIP82-150C, FLIP05-10C, FLIP05-23C, FLIP05-52C, FLIP05-28C, FLIP05-170C, FLIP05-17C, FLIP03-23C, FLIP05-111C, FLIP06-42C, FLIP06-4C, FLIP03-29C, FLIP05-111C, which are recommended to be included into the breeding process for the creation of middle-ripening highly productive and major grainy varieties of chickpeas with great harvesting processability.

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