Agronomy Research **17**(6), 2195–2202, 2019
https://doi.org/10.15159/AR.19.223

Optimization of plant densities of dolichos (*dolichos lablab* L. var. *lignosus*) bean in the Right-bank of Forest-steppe of Ukraine

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Abstract. The density of the plants of Dolichos bean significantly influenced the economically valuable indicators, because there is always competition for light, moisture and nutrients between plants in the life process. The period from mass sprouting to the technical ripeness was reduced with increasing the plant density. Such a pattern was characteristic of all phases of the growth and development of the Dolichos bean. The plants with high population (71 thousand units ha^{-1}) took short period (60 and 119 days) from germination to the beginning of technical and biological ripeness, respectively, turned out to be the earliest ripening crops. The plants are better illuminated, the soil nutrition conditions are improved and the sanitary-hygienic climate of the crops improves with thinned crops, thereby plant productivity has raised. However, the average yield of scapulabeans and unripe Dolichos seeds is regulated by the density of the plants, and increased in density due to the greater number of plants. The optimum density for Dolichos bean was 71 thousand plants per hectare, at which yields of green shoots and green peas were formed 7.3 and 3.3 t ha^{-1}, respectively.

Key words: beans scapula, dolichos bean, ripening beans, plant density, sowing scheme, stairs, flowering, yield, unripe seeds.

INTRODUCTION

Currently, there are many unsolved problems in the vegetable growing industry, such as, for example, the insufficient species diversity in the range of vegetable crops, the low yield and quality levels in the vegetable production. The issues of providing the population with food rich in protein, which is lacking in the daily diet of each person, are also considered. Very valuable legumes, as important and cheap source of protein, which the poor modern human diet is short of (Chattopadhyay & Dutta, 2010; Upadhyay & Mehta, 2010; Chauhan et al., 2012; Sych & Bobos 2013; Bajwa, 2014; Habib et al., 2017; Arul Ananth & Ramesh Kumar, 2018; Ranaivoson et al., 2019), are among them.

In Ukraine, vegetable farming has now become an attractive business. In recent years, positive results were achieved in the improvement of the yield, the total output, the quality of the vegetables and the volume of exports. At the same time, the analysis

of the current situation in the production of vegetables in farm units of different forms of ownership and the marketing trends gives evidence of the emergence of new challenges, which hamper the positive development of this branch of agriculture. Theseinclude first of all excessive production and strong competition around a very narrow range of vegetable crops. The whole industry relies on the borsch (beetroot and cabbage soup) group of vegetables, tomatoes, cucumbers and some other crops.

Among the main ways of overcoming the mentioned problems, the expansion of the production range is the most promising one. Moreover, this line of development implies increasing not only the number of varieties, but the number of species as well.

The food crop species of the legume family are part of the range of the plants that are currently known and agriculturally promising, but have not yet gained wide recognition in the market.

Among the large legume family, there is one very interesting genus – dolichos (*Dolichos* L.) (Joshi & Rahevar, 2015). Among 60 species, far to the north, only one species has spread – dolichos bean, or hyacinth beans (*Dolichos lablab L*). In the southern countries it is valued for its medicinal properties and edible seed, in Europe it is decorative. Decorative beautiful red leaves and flowers, resembling orchids, with the scent of hyacinth. Beautiful beetroot-colored beans have a parchment layer, so only unripe (type flageoles) and ripe black seeds can be used as food, which is considered an important medicinal raw material for dissolving kidney stones (Bobos, 2016; Bobos & Ivanitskaya, 2018).

The yield of Dolichos bean, like of other crops, is formed in specific soil and climatic conditions of cultivation and is the result of the reaction of plants to them. However, the development of plants is influenced not only by soil and climatic conditions, but also by technological interventions.

Among the main technological measures aimed at increasing yields, an important role belongs to the choice of scientifically based seeding rate and plant density of Dolichos in crops, with the help of which optimal areas of plant nutrition are created. At the choice of the optimal plant density of Dolichos bean there are no scientific and theoretical studies. All this leads to the need to study and establish the most rational feeding areas for the Dolichos plants in the Right-Bank Forest-Steppe of Ukraine, in which optimal conditions for the growth and development of plants and yield formation (Sych & Bobos, 2013) will be created.

The aim of the research was to identify the adaptive properties of Dolichos bean based on the study of the effect of plant density on the yield of scapula beans to obtain unripe seeds in the conditions of the Kyiv region.

MATERIALS AND METHODS

Studies were conducted in 2013–2015 at the collection site of the Department of Vegetable and Closed Ground in the SRI 'Fruit and Vegetable Garden' of the National University of Life and Environmental Sciences of Ukraine in three replications according to the method of single-factor experiments (Bondarenko & Yakovenko, 2001). The subject of research was the specious of dolichos (*Dolichos lablab L*). Sowing schemes: 70×20 (71 thousand units ha^{-1}), 70×30 (48 thousand units ha^{-1}), 70×40 (36 thousand units ha^{-1}), 70×50 (29 thousand) units/ha) were studied. A seeding scheme of 70×40 cm was taken for control. Dolichos bean was grown as per Sych (2010).

The seeds were sown simultaneously (2013–10.05, 2014–07.05, 2015–02.05). The depth of seeding was 2–3 cm. The size of the land area was 5 m^2. The feeding area was regulated by the number of plants in a row.

The research into the growing space for dolichos was carried out using the method of single-factor experiments on humic mesopodzol soil. The object of research was the local cultivar of dolichos selected during the previous investigations at the Vegetable Farming Department, in which the following planting systems had been applied: 70×20, 70×30, 70×40, 70×50 cm. The number of replications was three, with randomization. The recorded plot area was 5 m^2. The records were made for 30 plants – 10 from each replication. Phenological observations, biometric measurements, bean and seed yield accounting and biochemical content of seeds were performed. The results were processed by a statistical program 'Agrostat'.

The obtained data are reflected in the results of the research.

The soil in the plot was dark grey light loam mesopodzol. The humic layer thickness was 24–28 cm.

The experimental plot featured a low humus content of 1.5–2.2% and medium contents of hydrolysable nitrogen - 26–38 mg kg^{-1}, labile phosphorus - 43–61 mg kg^{-1} and potassium - 28–34 mg kg^{-1}.

In the crop rotation system, dolichos succeeded cucumbers. The basic soil preparation for the crop included the autumn operations on the removal of the plant debris from the preceding crop and weeds and deep ploughing. The plot was disked to a depth of 6-8 cm with an LDG-10A disk stubble cleaner aggregated with a T-150 tractor moving in two directions. The autumn ploughing was performed in the second ten-day period of September to a depth of 25–27 cm with the use of a PLN-5-35 plough with coulter aggregated with a T-150 tractor. The plot was harrowed early in the spring diagonally to the line of ploughing with the use of BZTS-1.0 toothed harrows aggregated with an SP-16 multiple hitch and a T-150 tractor. In the second to third ten-day periods of April and prior to seeding, the experimental plot was cultivated to depths of 12–15 cm and 6–8 cm, respectively, with the use of a KPSP-4 cultivator aggregated with a DT-75 tractor and levelled off with the use of a harrow, then the dolichos seeds were drilled.

RESULTS

The results of research proved that the growth and development of plants in the initial stagesoccurred almost simultaneously, the difference in the rates of occurrence of phenological phases was observed within the limits of experimental error – 2–3 days. The emergence of friendly seedlings is often a decisive factor of high yields of agricultural crops. In our experience, the evaluation of the field germination of Dolichos showed that it was almost the same regardless of the density and on average was getting 84%.

Phenological observations of the growth and development of Dolichos plants for different densities were carried out from the emergence of seedlings to the biological ripeness of beans (Table 1). The results of the research revealed that the seeding schemes affected the early maturity of the species. At the same time, dolichos was characterized as a late-ripening species regardless of the seeding scheme. This is due to the extended period of flowering and fruiting species. However, with the high plant density

(71 thousand units ha^{-1}), the vegetation period is shortened by 5 days compared to sparse crops (29 thousand units ha^{-1}) when the species is sown on July 16.

Table 1. The results of phenological observations of the growth and development of plants Dolichos for different densities (average for 2013–2015)

Experimental options	Plant density, ths.pcs·ha^{-1}	Beginning of seed germination (germination start) (10%)	Full shoots (75%)	Beginning of flowering	Beginning of technical maturation of beans	Beginning of the biological maturation of beans
70×20	71	13.05	17.05	24.06	11.07	08.09
70×30	48	14.05	17.05	25.06	14.07	11.09
70×40 (control)	35	16.05	19.05	26.06	14.07	12.09
70×50	29	16.05	19.05	28.06	16.07	15.09

Rather, full shoots appeared in species with thickening (48–71 thousand units ha^{-1}). This is due to the high amount of active temperatures during this period. In sparse crops, full sprouting in species was longer. Low temperatures at the end of May 2014 affected the later appearance of both single and mass shoots.

Weather conditions in May 2014, namely, sharp changes in temperature during the day and night caused later flowering and technical ripeness of the scapula beans for different crop density. However, in the future, the hot weather in July and August 2014 caused rather the passage of technical ripeness of the beans and their biological ripeness compared to 2013 and 2015 years.

The beginning of flowering in this species later was observed for plant densities of 29 thousand units ha^{-1} – 29.06. Moreover, with the thickening of plants, the beginning of flowering and ripening of the beans was noted in 3 days earlier compared with the control. The same trend was observed in species of other seeding schemes.

Table 2. Duration of phenological phases in Dolichos plants by different sowing dates (average for 2013–2015)

Experimental options	Plant density, ths pcs ha^{-1}	Duration of periods, days			
		‘sowing - full shoots’	‘full shoots - the beginning of flowering’	‘full shoots, the beginning of the technical ripeness of the beans’	‘full seedlings, the beginning of the biological ripeness of the beans’
70×20	71	10	44	60	119
70×30	48	11	44	62	123
70×40 (control)	35	12	45	61	123
70×50	29	13	45	64	126

Flowering and fruiting in Dolichos took place during the whole growing season. The duration of the interphase periods of the species was different and depended on the seeding scheme (Table 2). Thus, the duration of the ‘sowing-full seedlings’ period turned out to be the smallest at the highest density itself (48–71 thousand units ha^{-1}) - 10–11 days. This is due to the increased temperature of the soil during the germination of thickened crops, which affected the rapid emergence of plants. A little longer, the

duration of this phase was noted in species with lower plant density (29–35 thousand units ha^{-1}) – 12–13 days. Moreover, in 2014, a sharp amplitude of temperature fluctuations, day and night in May, affected the long duration of this period in varying the density of crops.

Unripe scapula beans in the technical ripeness phase have a very beautiful burgundy color. Dolichos is caracterized by the long flowering of beautiful purple flowers from June to autumn frosts. All of this indicates the possibility of its use in landscaping (Fig. 1).

Figure 1. Mass flowering plants of Dolichos for plant density of 71 thousand units·ha^{-1}.

The duration of the period of 'full sprouts-the beginning of the technical ripeness of the beans' is less found in species with the thickening of crops (71 thousand units ha^{-1}), which was 60 days. A trend has been established, with the increase in plant density, the period from flowering to the beginning of the technical ripeness of the beans has decreased. The density of plants also influenced the duration of the period of 'full sprouting – the beginning of the biological ripeness of the beans', which turned out to be less than 70×20 seeding schemes (119 days). This is due to the rapid warming of the soil surface along the greater density of plants, accelerates the beginning of all phases of the growth and development of Dolichos plants.

The beans on the plant do not ripen at the same time, in result the multiple harvesting of scapula beans. The longest period of the formation of beans turned out to be at the lowest plant density (29 thousand units ha^{-1}) – 129 days.

Thus, the density of plants of Dolichos influenced the duration of the interphase periods. Unequal growing conditions consisting in a cenosis of different density are expressed by the duration of the growing season of plants. When increased the plant density, the period from mass sprouting to the technical ripeness was reduced. Such a pattern was characteristic of all phases of the growth and development of the Dolichos plants. The plants of the crop with the thickening of crops (71 thousand units ha^{-1}) with a short duration of the growing season of 60 days were the earliest ripening crops.

It is established that the density of plants of Dolichos significantly influenced the formation of above-ground mass. The experimental data obtained show that the smallest height of the Dolichos plants was for density 71 thousand units ha^{-1}, and with a decrease in density, it grew. The results of the research indicate that the plants of Dolichos are very sensitive to changes in the area of nutrition. Thickened crops affected the number of shoots in plants (Table 3).

Table 3. Characteristics of the morphological characteristics of plants of Dolichos with different sowing patterns (average for 2013–2015)

Experimental options	Plant density, ths pcs ha^{-1}	Stem length, cm	The number of shoots, pieces	The thickness of the stem at the root collar, mm
70×20	71	153.9 ± 8.2	6.6 ± 0.6	12.7 ± 1.3
70×30	48	163.3 ± 7.2	7.0 ± ±0.5	14.3 ± 1.1
70×40 (control)	35	165.9 ± 6.1	7.3 ± 0.7	15.0 ± 1.2
70×50	29	168.4 ± 5.9	8.2 ± 0.9	16.7 ± 1.5

In the process of analyzing the biometric parameters of plants of Dolichos for different density, it should be noted that plants had the most developed vegetative mass at the lowest plant density (29 thousand units ha^{-1}). Moreover, the results of the confidence interval prove that according to all the morphological characters that were studied there is a significant difference between the plants with the lowest and the highest density. Thus, a significantly greater height was found in plants – 168.4 cm, which is in 14.5 cm more compared to the control. With thickening in species, the height of plants decreased. The same trend was observed in other morphological indicators in Dolichos.

The thickening significantly suppressed the optimal growth of the Dolichos plants. This is due to the unlimited type of growth of crop in favorable growing conditions. Therefore, the thickening accompained the less intensive growth of leguminous plants, incl. Dolichos (Sych & Bobos, 2011; Bobos, 2016).

The results show that different plant densities significantly influenced the biometric indicators, because in the living process between plants there is always competition for light, moisture and nutrients. A more developed vegetative mass was characterized by Dolichos plants for sparse crops. To get the Dolichos scapula beans in open ground without supports, thickened crops (71 thousand units ha^{-1}) were more suitable, in which the length of the stem and the number of shoots were respectively 153.9 cm and 6.6 units. with a stalk thickness at the root collar of 12.7 mm.

Table 4. The yield of commercial scapula beans of Dolichos depending on plant density, thousand units / ha (average for 2013–2015)

Experimental options	Plant density, ths. pcs ha^{-1}	Weight of beans from a plant, gr	Yield of scapula beans, t ha^{-1}			The average yield of beans for three years, t ha^{-1}	Yield increase	
			2013	2014	2015		t ha^{-1}	%
70×20	71	102.4				7.3	+2.4	+49
70×30	48	116.3	2.7	3.8	10.1	5.5	+0.6	+12
70×40 (control)	36	137.3	2.9	3.5	8.4	4.9	0	100
70×50	29	145.9	2.4	3.0	7.3	4.8	-0.1	-2
HIP_{05}		10.7	0.4	0.3	0.8	2.2		

The productivity of the Dolichos plants influenced their average productivity of scapula beans (Table 4). The beans ripened in crops not at the same time with different thicknesses, so the harvest was carried out weekly. The highest mass of beans from the plant was got in Dolichos at the lowest density of 29 thousand units ha^{-1}, amounted to 145.9 g, which is in 43.5 g more compared to the control. A lower difference between

the controls was revealed in species of the greatest density of 71 thousand units ha^{-1}, which amounted to 34.9 g. At the same time, the average yield of the Dolichos beans for this density was higher to 7.9 t ha^{-1}. This is due to the large number of plants per unit of area.

The lowest yield level was obtained for plant density of 29 thousand units ha^{-1} – 4.8 t ha^{-1}. This can be explained by the smaller number of plants per unit of area, despite the fact that the average mass of beans from a single plant of this variant was the greatest.

Dolichos is marked by a long flowering of beautiful purple flowers from July to autumn frosts and simultaneous fruiting (Fig. 2). All this testifies to the possibility of its use in landscaping (Sych & Bobos 2013; Bobos, 2016; Bobos & Ivanitsky, 2018).

Figure 2. Simultaneous flowering and fruiting plants of Dolichos.

Due to the greatest density (71 thousand units ha^{-1}), the plants were characterized by a higher intensity of early yield (Table 5). Moreover, significantly lower yields of unripe seeds were obtained at the lowest density (29 thousand units ha^{-1}) and amounted to 2.1 t ha^{-1}, which is in 1.2 t ha^{-1} less compared to the control. This is due to the smaller number of plants per unit of area and, accordingly, a smaller number of scapula beans in which unripe seeds were formed.

Table 5. The yield of green peas of Dolichos depending on plant density, thousand units·ha^{-1} (average for 2013–2015)

Experimental options	Plant density, ths pcs ha^{-1}	Yield of green peas, t ha^{-1}			Average yield of green peas, t ha^{-1}	Yield increase	
		2013	2014	2015		t ha^{-1}	%
70×20	71				3.3	+0.7	+27
70×30	48	1.7	2.3	4.6	2.9	+0.3	+12
70×40 (control)	36	1.8	2.1	4.0	2.6	0	100
70×50	29	1.5	1.8	2.9	2.1	-1.2	-19
HIP_{05}		0.2	0.7	0.9	0.6		

Plant density 29–48 thousand units·ha^{-1}favoured to the intensive growth of plants compared to a higher density, which influenced the formation of a larger number of scapula beans during the growing season (Table 5). However, such density did not predetermine a high yield of scapula beans and unripe seeds, therefore it is not suitable for growing of Dolichos without supports in open ground in the Forest-Steppe of Ukraine.

CONCLUSIONS

To enrich the protein diversity of the population, cultivation in the right-bank of Forest-Steppe of Ukraine of Dolichos bean with plant density of 71 thousand units ha^{-1}, at which the highest yield obtained in scapula beans (7.3 t ha^{-1}) and green peas (3.3 t ha^{-1}) is perspective now-a-days.

REFERENCES

Arul Ananth, R. & Ramesh Kumar, S. 2018. Screening of dolichosbean (lablab purpureus L. (Sweet) genotypes for growth and yield in coastal region of Tamilnadu. *Plant Archives* **18**(2), 1258–1262.

Bajwa, A.A. 2014. Sustainable weed management in conservation agriculture. *Crop Protection* **65**, 105–113. doi: 10.1016/j.cropro.2014.07.014

Bobos, I.M. & Ivanitsky, A.R. 2018. Qualitative estimation of beans and seeds of dolichos. Modern Scientific Researches, Agriculture (Yolnat PE, Minsk), **4**, 38–40. Available: https://www.sworld.education/msr/msr4-1.pdf.

Bobos, I.M. 2016. The growth and development of dolichos plants in the Right-bank of Forest-Steppe of Ukraine. SWorld Journal "Scientific world". Ivanovo, Vol. **J116**(10). Available: http://www.sworld.education/e-journal/j11609.pdf

Bondarenko, G.L., Yakovenko K.I. 2001. *Methodology of Experimental Case in Vegetable and Melons*. Ed.. Kharkiv, Osnova, 369 pp.

Chattopadhyay, A. & Dutta, S. 2010. Characterization and identification of selection indices of pole type dolichos bean. *Vegetable Crops Research Bulletin* **73**(1), 33–45. doi: 10.2478/v10032-010-0016-9

Chauhan, B.S., Singh, R.G. & Mahajan, G. 2012. Ecology and management of weeds under conservation agriculture: A review. *Crop Protection* **38**, 57–65. doi: 10.1016/j.cropro.2012.03.010

Habib, H.M., Theuri, S.W., Kheadr, E.E. & Mohamed, F.E. 2017. Functional, bioactive, biochemical, and physicochemical properties of the Dolichos lablab bean. *Food and Function* **8**(2), 872–880. doi: 10.1039/c6fo01162d

Joshi, S.K. & Rahevar, H. 2015. Effect of dates of sowing, row spacings and varieties on growth and yield attributes of rabi Indian bean (Golichos lablab L.). *Indian Journal of Agricultural Research* **49**(1), 59–64. doi: 10.5958/0976-058X.2015.00008.6

Methodology of Experimental Case in Vegetable and Melons. 2001. Ed. G.L. Bondarenko, K.I., Yakovenko. Kharkiv, Osnova, 369 pp.

Ranaivoson, L., Naudin, K., Ripoche, A., Rabeharisoa, L. & Corbeels, M. 2019. Effectiveness of conservation agriculture in increasing crop productivity in low-input rainfed rice cropping systems under humid subtropical climate. *Field Crops Research* **239**, 104–113. doi: 10.1016/j.fcr.2019.05.02

Sych, Z.D. & Bobos, I.M. 2013. The new vegetable plants are in the modern vegetable business. Earth Bioresources and Quality of Life. International Electronic Journal of Science. Available: http://gchera-ejournal.nubip.edu.ua

Sych, Z.D. 2010. Recommendations for the growing of leguminous vegetable crops in the forest-steppe Ukraine. Kyiv, NULES of Ukraine, 41 pp.

Upadhyay, D. & Mehta, N. 2010. Biomedical studies in Dolichos Bean (Dolichos lablab L.) for Chattisgarh Plains. *Res. J. Agri. Sci*. **1**(4), 441–447.