UDK 635.657:631.53.01 (477.7)

Chickpea Seed Productivity on Non-irrigated Soils of Southern Ukraine

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Purpose. *To determine the influence of herbicide application periods on crop weediness, water consumption and seed productivity of chickpea in non-irrigated conditions of Southern Ukraine.* ***Methods.*** *The field method was used to study the interaction of the research object with biotic and abiotic factors; the mathematical-statistical method was used to conduct dispersion analysis and statistical processing of data in order to assess the reliability of the obtained research results; the comparative-calculation method was used for the economic assessment of crop cultivation.* ***Results.*** *According to the results of research in 2018–2020 of chickpea crops in non-irrigated conditions of southern Ukraine, it was found that the main type of weed complex in the experiment was Ambrosia artemisiifolia, the share of which was 78.9%; Chenopodium album, the share of which was 13.6%. Echinochloa crus-galli, Amaranthus retroflexus, Solanum nigrum, and other types of weeds were insignificant in number, i.e., low in harmfulness. The maximum rate of total water consumption (3424 m^3/ha) was fixed for the use before sowing the crop of the drug "Imi Vit" at a dose of 1.0 l/ha, the minimum values of this indicator (3391 m^3/ha) were determined when using the herbicide "Merlin 750WG" at a dose of 0.13 l/ha after sowing the crop. In the control variants, the highest average indicator of total water consumption (3455 m^3/ha) was determined in the plots of Control 1 (without herbicides), the lowest (3433 m^3/ha) in the plots of Control 2 (manual weeding). For the use of herbicides, the lowest coefficient of water consumption (2058 m^3/t) was established on the variants of the experiment, where the*

drug "Merlin 750WG" was applied with a dose of 0.13 l/ha after sowing the crop. Under the herbicides influence, the maximum average seed yield (1.62 t/ha) of crops was formed by using the drug "Merlin 750WG" at a dose of 0.13 l/ha after sowing the crop. On the variants, where treatment with herbicides was not carried out, the highest average yield (1.97 t/ha) was obtained in Control 2 (manual weeding). ***Conclusions.*** *The use of the herbicide "Merlin 750WG" with the active substance isoxaflutol at a rate of 0.13 l/ha after sowing chickpeas is promising for effective control of weeds in crops and ensuring optimal water consumption and increasing the yield of chickpea seeds in non-irrigated conditions of southern Ukraine.*
Key words: *seeds, weeds, herbicide, term of use, water consumption, productivity.*

Chickpea (*Cicer arietinum L.*) ranks third in the world after soybeans and beans in terms of cultivated area and gross seed yield. It is one of the most demanded agricultural crops, characterized by high nutritional value, the content of a large number of essential and replaceable amino acids, micro- and macro-elements. In the conditions of global climate change, it can become a very profitable marginal crop for farmers, which is in demand in foreign and domestic markets, along with sunflower and rapeseed. The spread of chickpea is primarily due to the fact that it is able to accumulate a significant amount of proteins in its seeds [1, 2].

The sufficiently high cost of the seed material ensures extremely high profitability of cultivation and the interest of the world market in this rare agricultural crop. Along with the expansion of sown areas, an important condition for increasing the gross harvest of chickpea seeds is the increase of its yields, mainly due to the widespread introduction of intensive cultivation technology, which is based on modern achievements of science and advanced practice. The main condition for the high efficiency of the new technology is the validity of each technological operation and the focus on improving the conditions for the growth and development of crop plants [3, 4].

At present, one of the main reasons for the decrease in chickpea seed productivity is the weediness of crops, the presence of a significant amount of weed seeds in the soil creates significant problems for its cultivation. The problem of combating segetal vegetation constantly exists throughout the practice of world agriculture. Potential weed seed reserves in the soil and the duration of its viability are factors influencing the quantitative signs of crop weediness. The presence of harmful plants in chickpea crops has a negative effect on the subsequent yield of this culture seeds and its quality characteristics. The decrease in seed productivity due to the

clogging of crops is very significant and depends on the species composition and density of the weed complex, as well as on the duration of the period of competition between crop plants and weeds [5–7].

Monitoring of chickpea crops indicates that the core of the weed coenosis is mainly formed by annual dicot species, among which the most common are *Matricaria perforata*, *Chenopodium album*, *Raphanus raphanistrum*, *Amaranthus retroflexus*, *Acroptilon, Galium aparine*, *Echinochloa crus-galli*, *Setaria viridis*. Among perennials, *Cirsium arvense* and *Convolvulus arvensis* are most common in crops, and *Elymus repens* among rhizomes. In years with favorable climatic conditions, weeding has a more significant effect on the reduction of crop yield than in dry years. The fight against weeds in the fields is one of the important reserves for increasing the agrocenoses productivity [8, 9].

Currently, the technology of growing chickpea seeds has not been sufficiently developed in the non-irrigated conditions of the south of Ukraine. The elements of agricultural technology require a more detailed study, namely the effectiveness of the use of herbicides at different times of their application [10–12].

In this regard, the study of the herbicides effect on the processes of water consumption and the formation of the chickpea seeds yield, as well as the development of technology for their use, are of significant scientific interest and are relevant.

Purpose. To determine the influence of herbicide application periods on crop weediness, water consumption and seed productivity of chickpea in non-irrigated conditions of Southern Ukraine.

Materials and methods. Research was conducted during 2018–2020 at the experimental field of the Institute of Irrigated Agriculture of the National Academy of Agriculture Sciences (now the Institute of Climate Smart Agriculture of the National Academy of Agriculture Sciences). The soil of the experimental site is dark chestnut, medium loam slightly saline at a deep level of groundwater, on carbonate loess. The field moisture capacity of a meter-long soil layer is 20.5%, the moisture content withering is 9.5%, the volumetric weight of the 0-100 cm soil layer is 1.41 g/cm^3.

The research was carried out by the method of a field two-factor experiment with four repetitions. Based on the specifics of the research, the experiment was laid out in the area where the presence of *Ambrosia artemisiifolia* was recently observed. Basic soil herbicides, which, according to their characteristics, are highly effective against this type of weeds were included in the experiment scheme:

- factor A (herbicide):

- Control 1 (without herbicides),
- Control 2 (without herbicides, manual weeding);
- Steals – 2.5 l/ha,
- Merlin 750WG – 0.13 l/ha,
- Imi vit – 1.0 l/ha;

- factor B (herbicide application period):
  - before sowing,
  - after sowing.

The implementation of the experimental options was carried out using the method of split plots. The sowing area of the second order was 120 m^2, the accounting area was 100 m^2. Agrotechnics of crop cultivation was generally accepted for the south of Ukraine. The planning and conducting of the research were carried out in accordance with generally accepted methods of conducting field experiments, methodical recommendations and manuals [13, 14].

Results and discussion. The influence of herbicide application periods on crop weediness, water consumption and seed productivity of chickpea in non-irrigated conditions of southern Ukraine was established. In particular, the most effective herbicide against weeds in chickpea crops with mandatory destruction of *Ambrosia artemisiifolia* at the level of 90-100% was determined. For this purpose, the influence of soil herbicides applied before and after sowing on weediness of crops, water consumption and yield of crop seeds was investigated. During the years of research for the May-July period on average 97.4 mm of precipitation fell. This amount of moisture and its combination with high temperature indicators of the air influenced the development of the phytocenosis of crops in all variants of the experiment. This amount of moisture, in combination with high temperature indicators of the air, influenced the development of the phytocenosis of crops in all variants of the experiment. On the variants of Control 1 (without herbicides), this situation contributed to the increased growth of weeds, the total number of which was, on average, 68.3 weeds/m^2, which subsequently created an almost continuous "layer" of them over the chickpea plants (Table 1).

The main species of the weed complex in the experiment was *Ambrosia artemisiifolia*, the share of which was 78.9%. Chenopodium album was in second place in terms of number (13.6%). *Echinochloa crus-galli*, *Amaranthus retroflexus*, *Solanum nigrum* and other types of weeds were insignificant in number, that is, they also had low harmfulness. Precipitation also had a peculiar effect on the nature of the action of

herbicides. First of all, this applies to “Merlin 750WG”, for which there were favorable conditions for the implementation of the process of converting isoxaflutol into a more active diketonitrile compound. The action of the herbicide was manifested during almost the entire growing season, but during the ripening of the seeds of the crop, the weeds began to gain weight, and their new shoots also appeared. At the same time, among options with the use of herbicides, chickpea crops treated after sowing with “Merlin 750WG” at a rate of 0.13 l/ha were the cleanest.

Table 1. Effectiveness of herbicide application at different application times in chickpea crops (average for 2018–2020)

Factor A (herbicide), l/ha	Factor B (herbicide application period)							
	before sowing				after sowing			
	pre-harvest weediness							
	quantity, pcs./m^2	crude weight, g/m^2	decrease relative to control, %		quantity, pcs./m^2	quantity, pcs./m^2	decrease relative to control, %	
			quantity	crude weight			quantity	crude weight
Control 1 (without herbicides)	68.3	2125	×	×	71.5	2179	×	×
Control 2 (without herbicides, manual weeding)	×	×	×	×	×	×	×	×
Steals, 2.5	49.7	1902	18.1	7.2	45.3	1789	24.5	12.9
Merlin 750WG, 0.13	9.4	538.6	57.9	48.6	6.9	492.1	61.0	52.3
Imi vit, 1.0	53.7	2298	14.3	5.1	52.8	2064	17.8	4.1

On average, during the period of research, the reduction of weediness in this variant compared to Control 1 was: by applying “Merlin 750WG” before sowing, the quantity decrease relative to control of weeds was 57.9%, and their crude weight ones was 48.6%. By applying the drug after sowing, the decrease in indicators was almost at the same level. The quantity of weeds was 61.0%, and by their crude weight was 52.3%.

In such conditions, the action of “Imi Vit” was insufficient. The quantity decreases relative to Control 1 of weeds ranged from 14.3 to 17.8%, and their raw weight ones, when it was applied before sowing, even increased by 5.1% compared to Control 1. The drug had a negative effect for plants and caused bending of the stem, twigs. Over time, these phenomena disappeared, but the plants lagged behind in growth and development.

The use of “Stels” herbicidal drug was also insufficiently effective. In contrast to “Imi Vit”, the herbicide did not cause a negative effect on crop plants, but its effectiveness against weeds was low in both periods of application. On average, the quantity of weeds decreased by 18.1-24.5%, and their crude mass decreased by 7.2-12.9% relative to control 1.

Research carried out in 2018–2020 showed that herbicides and the timing of their application affected the total water consumption of chickpea crops (Table 2).

2. Total water consumption of chickpea plants in the 0–100 cm soil layer, depending on the factors of the experiment, m^3/ha (average for 2018–2020)

Factor A (herbicide), l/ha	Factor B (herbicide application period)	Total water consumption	Average by factor	
			A	B
Control 1 (without herbicides)	before sowing	3459	3455	3429
	after sowing	3450		3419
Control 2 (without herbicides, manual weeding)	before sowing	3437	3433	
	after sowing	3429		
Steals, 2.5	before sowing	3416	3412	
	after sowing	3408		
Merlin 750WG, 0.13	before sowing	3407	3399	
	after sowing	3391		
Imi vit, 1.0	before sowing	3424	3420	
	after sowing	3416		

Assessment of the significance of partial differences:

least significant difference (LSD_{05}), t/ha: A = 0,06; B = 0,09

Assessment of the significance of average (main) effects:

least significant difference (LSD_{05}), t/ha: A = 0,10; B = 0,17

It was found that according to factor A (herbicide), the maximum average indicator of the total water consumption of chickpea crops (3455 m^3/ha) was established on the variants of Control 1 (without herbicides). The lowest value of this indicator (3391 m^3/ha) was determined on the variants where the drug “Merlin 750WG” was used by doze of 0.13 l/ha immediately after sowing the crop. Observations revealed that the largest amount of moisture for the formation of a unit of crop from soil reserves was used by crops where herbicides were applied before sowing.

According to factor B (herbicide application period), the maximum average value of the total water consumption indicator was determined for the use of herbicide preparations before sowing chickpeas. The maximum indicator of total water consumption, on average for 2018–2020, for the use of herbicides (3424 m^3/ha) was established in the experimental variants, where the drug “Imi Vit” was used by dose of 1.0 l/ha before sowing the crop. As for the Control variants, crops where herbicides were not applied (Control 1) had higher total water consumption (3450–3459 m^3/ha) than Control 2 plots (hand weeding). This is explained by weed-free crops and, accordingly, less moisture use.

Based on the yield and total water consumption indicators, the water consumption coefficient was established. According to the results of the three-year research, the lowest average water consumption coefficient (1553 m^3/t) was observed on the variants of Control 1 (without herbicides) (Table 3).

3. The coefficient of water consumption of chickpea plants in the 0–100 cm soil layer depending on the factors of the experiment, m3/t (average for 2018–2020)

Factor A (herbicide), l/ha	Factor B (herbicide application period)	Coefficient of water consumption	Average by factor	
			A	B
Control 1 (without herbicides)	before sowing	12314	12087	9583
	after sowing	11859		7539
Control 2 (without herbicides, manual weeding)	before sowing	1586	1553	
	after sowing	1519		
Steals, 2.5	before sowing	10647	10181	
	after sowing	9714		
Merlin 750WG, 0.13	before sowing	2058	2026	
	after sowing	1994		
Imi vit, 1.0	before sowing	21312	16962	
	after sowing	12611		

Assessment of the significance of partial differences:

least significant difference (LSD_{05}), t/ha: A = 0,07; B = 0,12

Assessment of the significance of average (main) effects:

least significant difference (LSD_{05}), t/ha: A = 0,14; B = 0,19

By the herbicides use, the lowest coefficient of water consumption (2058 m^3/t) was established in the variants of the experiment, where the drug “Merlin 750WG” was used by a dose of 0.13 l/ha after sowing the crop. The high average indicators of the water consumption coefficient (12087 m^3/t) of Control 1 (without herbicides) and variants where “Stels” was applied by a dose of 2.5 l/ha and “Imi Vit” by a dose of 1.0 l/ha, 10181 and 16962 m^3/t, respectively, are due low yield of these options. The analysis of the structure of the total water consumption shows that the maximum amount of moisture for the formation of the crop of chickpea seeds (86.9–88.4%) was obtained from precipitation. The share of participation of soil reserves in the formation of crop yield under natural moisture was minimal and amounted to 11.6–13.1%.

The effect of herbicide application periods on the seed productivity of crops has been established. The results of the yield calculation showed that, depending on the agrotechnical elements, the productivity of the crop according for the experimental variants on average for 2018–2020 varied from 0.12 t/ha to 1.98 t/ha (Table 4).

4. Yield of chickpea seeds depending on the use of herbicides at different periods of their application, t/ha (average for 2018–2020)

Factor A (herbicide), l/ha	Factor B (herbicide application period)	Seed yield	Increase in yield to Control	Average by factor	
				A	B
Control 1 (without herbicides)	before sowing	0,19	–	0,20	0,82
	after sowing	0,21	–		0,86
Control 2 (without herbicides, manual weeding)	before sowing	1,98	1,78	1,97	
	after sowing	1,95	1,75		
Steals, 2.5	before sowing	0,27	0,07	0,30	
	after sowing	0,32	0,12		
Merlin 750WG, 0.13	before sowing	1,54	1,34	1,58	
	after sowing	1,62	1,42		
Imi vit, 1.0	before sowing	0,12	– 0,08	0,15	
	after sowing	0,17	– 0,03		

Assessment of the significance of partial differences:

least significant difference (LSD_{05}), t/ha: A = 0,09; B = 0,24

Assessment of the significance of average (main) effects:

least significant difference (LSD_{05}), t/ha: A = 0,05; B = 0,12

Under the influence of herbicides, the maximum average seed yield (1.62 t/ha) of chickpea crops was formed for the use of the drug “Merlin 750WG” by a dose of 0.13 l/ha after sowing the crop.

The formation of the highest average yield of chickpea seeds with the use of herbicides (factor A) at the level of 1.58 t/ha was facilitated by the use of the drug “Merlin 750WG” by a dose of 0.13 t/ha. The use of “Stels” herbicides by a dose of 2.5 l/ha and “Imi Vit” by a dose of 1.0 l/ha led to a decrease in yield, respectively, by 81.01–90.50%. Among the control variants, the highest average yield (1.97 t/ha) was obtained in Control 2 (hand weeding), which exceeds the similar indicator in Control 1 (without herbicides) by 1.77 t/ha. According to factor B (herbicide application period), the maximum average yield (0.86 t/ha) was obtained with the use of herbicides after sowing chickpeas.

Conclusions. According to the results of research conducted in 2018–2020 in the non-irrigated conditions of the Southern Ukraine, it was established that the cultivation of chickpeas in combination with the use of herbicides at different times of their application are one of the main factors in the formation of productivity, which depend on the soil and climatic conditions of the zone, agricultural technology cultivation and morphological and biological features of plants. Among options with the use of herbicides, chickpea crops treated with “Merlin 750WG” by doze 0.13 l/ha after sowing were the cleanest. The reduction of weediness in this variant compared to Control 1 was: for the application of herbicide before sowing, the quantity of weeds was 83.9%, and their crude weight was 71.6%.

If the drug was applied after sowing, the decrease in indicators was almost at the same level. At the same time, the number of weeds was 89.4%, the raw mass of which was 75.8%. Under the influence of herbicides, the lowest coefficient of water consumption (2058 m^3/t) and the maximum average seed yield (1.62 t/ha) of chickpea crops were formed with the use of the drug “Merlin 750WG” with a dose of 0.13 l/ha after sowing the crop. Among the control variants, the highest average yield (1.97 t/ha) was obtained in Control 2 (manual weeding), which exceeds the similar indicator in Control 1 (without herbicides) by 1.77 t/ha. For effective weed control of chickpea crops, it is rational to apply Merlin after sowing the crop at a rate of 0.13 l/ha.

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