www.incda-fundulea.ro; doi.org/10.59665/rar4127 First Online: January, 2024. DII 2067-5720 RAR 2024-74

Impact of Some Pre- and Post-Emergent Herbicides Applied to the Chickpea Crop (*Cicer arietinum* L.)

Valentin-Marius Ciontu[1,2*], Marga Grădilă[1], Daniel Jalobă[1,2], Andrei Chiriloaie Palade[1,2], Mihai Gîdea[2]

[1]Research-Development Institute for Plant Protection, Bucharest, District 1, Romania
[2]University of Agronomic Sciences and Veterinary Medicine, Bucharest, District 1, Romania
[*]Corresponding author. E-mail: ciontu.valentin96@yahoo.ro

ABSTRACT

Because of its drought resistance, chickpea cultivation tends to become increasingly widespread in the current climate change context. The chickpea crop is easily taken over by weeds in the early growing season, as it has a slow growth rate and the plant does not have an imposing stature. This paper focuses on the importance and the main purpose of weeds control in chickpea crop in order to achieve a high increasing yield. The objectives during two years aimed at assessing the degree of selectivity and the efficacy of some simple, complex or associated herbicides, applied pre-emergently and post-emergently. The sample in chickpea crop consisted of pre-emergence application of aclonifen 600 g/l at a rate of 4 l/ha, s-metolachlor 960 g/l at a rate of 1.5 l/ha, isoxaflutole 240 g/l + cyprosulfamide 240 g/l at a rate of 0.25 l/ha, s-metalochlor 312.5 g/l + terbuthylazine 187. 5 g/l at a rate of 4.5 l/ha and in post-emergence application of isoxaflutole 240 g/l + cyprosulfamide 240 g/l at a rate of 0.18 l/ha, pyridate 450 g/kg at a rate of 1.2 kg/ha, quizalofop-p-tefuryl 40 g/l at a rate of 1 l/ha, 40 g/l, imazamox 40 g/l at a rate of 0.8 l/ha. Chickpea crop was infested by a large number of weeds, as well perennial dicotyledonous species hard to control like: *Convolvulus arvensis, Cirsium arvense, Sonchus arvensis* etc. The best weeds control was obtained when preemergently applied herbicides were followed by those postemergently applied. Perennial dicotyledonous species weren`t sufficiently controlled in any variant. Phytotoxicity symptoms were recorded at herbicide imazamox, 40 g/l, applied in post-emergence, which delayed the harvest and provided low yields.

Keywords: herbicides, *Cicer arietinum* L., weeds, yield, control.

INTRODUCTION

The chickpea (*Cicer arietinum* L.) is a valuable crop due to its kernells rich in proteins, fibres and essential amino acids, for an increasing world population, so that it will become more and more important since climatic changes occured (Muehlbauer and Sarker, 2017; Bulti et al., 2019). The grain legumes crops have developed in last years a bigger influence in crop systems and are more frequently used in crop rotation and the surfaces sown with these have been extending year by year (Watson et al., 2017; Petcu et al., 2021).

Chickpeas, one of the most drought-resistant legume species, can be grown successfully in areas with frequent drought climates, where beans and soybeans do not perform well without irrigation. Chickpeas have the ability to cease their activity during periods of water stress and resume it when favourable conditions arise, without significantly affecting production levels (Rahbarian et al., 2011).

According to the latest FAO data (https://www.fao.org/faostat/en/#data/QCL), world chickpea crop production in 2021 was 15.87 million tonnes, grown on 15.00 million ha, of which 84.37% or 13.39 million tonnes were produced in Asia. The global chickpea area has been increasing sharply in recent years, averaging 10.59 million ha between 2000 and 2010 and 13.57 million ha between 2011 and 2021. In Europe, on average for the period 2017-2021, were cultivated on 525 thousand ha, of which 1231 ha were present in Romania in 2017.

Weed management in this crop is a very important link. Chickpea being slowly growing in the early period and being a short, grassy plant is disposed to excessive weed

Received 30 November 2023; accepted 31 January 2024.

competition and often loses considerable yield up to 75-80% when weeds are not controlled (Vaishya et al., 1996; Ratnam et al., 2011; Singh et al., 2020). Plew et al. (1994) shows that without weed management, compared to weed-free crops, the results have dramatically dicreased in plants biomass ranging 42-70% and in seeds yields with 40-87%, depending on crop density, the degree of weed infestation and weeds species that damaged.

In a study conducted in Iordania, Al-Thahabi et al. (1994) also obtained similar results so that the seeds yield was reduced with even 81% and plant biomass to 63% when fields remained weed-infested until harvest, in comparision with no weeds conditions as long as the whole growing season. Although many comprehensive studies are proceeded in Asia concerning weed infestation, in Romania they very limitated in chickpea crop.

Generally, chickpea crop is sensitive to many herbicides, so that there are very few opportunities to be used in weed control (Cojocaru and Marin, 2021). In conformity with MADR data (https://aloe.anfdf.ro/), there are just a few authorized herbicides for chickpea crop for the 2022-2023, for the dicotyledonous weeds in particular. There are not authorized postemergent herbicides for dicotyledonous weeds control and anything for perennial dicotyledonous weeds. Thus, weeds like perennial thistle (*Cirsium arvense* L. Scop.), perennial sowthistle (*Sonchus arvensis* L.) but mostly bindweed (*Convolvulus arvensis* L.) represent a real challenge in order to have a free-weed chickpea crop. Thus, weed management is imperative in chickpea to realize maximum yields and also to maintain high quality of produce (Gaur at al., 2013).

The study aimed to simple, complex or associated herbicides application, pre-emergently and post-emergently applied at chickpea crop, in order to establish the selectivity and efficacy and consequently to outline their influence on yield.

MATERIAL AND METHODS

Research was carried out during 2022 and 2023, in the Experimental Didactic Field of University of Agriculture in Moara Domnească village, Ilfov County. Depending on the year, the experimental field were placed to different plots, the geographical coordinates where the experience was located 2022 are 44,501307 latitude and 26,249451 longitude and for 2023 they were 44,50294 latitude and 26,24996 longitude. Type of the soil is reddish preluviosoil, having in the first 20 cm a clay-loam texture, with an acid moderate pH ranging 5,4 and an organic matter content near 2.2% (Mihalache et al., 2010).

The variety used was Burnas, sown after the oat crop in 2022 and after the wheat crop in 2023, with the distance between rows of 50 cm, with a density of around 40 plants/m^2 and at a sowing depth of 4-5 cm. Before sowing, the land was prepared in the autumn with plowing at a depth of 25 cm and in the spring with the cultivator.

The trials were placed in a randomized complete block design, 21 m^2 experimental plot area (3,5 x 6) and three replicates per each treatment were conducted. Ten experimental variants were placed for weed control where different rates of herbicides were applied in distinct periods (Table 1). For the purpose of better monitoring and a clearer image of the effect of weed infestation on production yield, in addition to the untreated variant, two other variants have materialised as follows: manually hoeing, which almost completely eliminated weeds, and mechanical plows in two passes, the basic variant in organic farming.

The establishment of rates and application times were assessed and recommended by chickpea growers in Romania.

Table 1. The experimental variants for weed control to chickpea crop, 2022-2023

No.	Experimental variants	Time of application	Active substance content	Dose
V1	Untreated	-	-	-
V2	Ut.2 - manually hoeing	-	-	-
V3	Ut.3- mechanical plows	-	-	-
V4	Challenge 600 SC	pre-emergence	600 g/l, aclonifen	4 l/ha
V5	Dual Gold 960 EC + Merlin Flexx	pre-emergence	960 g/l, s-metolachlor + 240 g/l, isoxaflutole + 240 g/l, cyprosulfamide (safener)	1.5 l/ha + 0.25 l/ha
V6	Gardoprim Plus Gold 500 SC	pre-emergence	312.5 g/l s-metalochlor + 187.5 g/l terbuthylazine	4.5 l/ha
V7	Gardoprim Plus Gold 500 SC + Merlin Flexx	pre-emergence	312.5 g/l s-metolachlor + 187.5 g/l terbuthylazine + 240 g/l, isoxaflutol + 240 g/l, cyprosulfamide (safener)	4.5 l/ha + 0.25 l/ha
V8	Gardoprim Plus Gold 500 SC + Merlin Flexx	pre-emergence + post-emergence	312.5 g/l s-metolachlor + 187.5 g/l terbuthylazine + 240 g/l, isoxaflutol + 240 g/l, cyprosulfamide (safener)	4.5 l/ha + 0.18 l/ha
V9	Lentagran 45 WP + Pantera 40 EC	post-emergence	450 g/kg, pyridate + 40 g/l, quizalofop-p-tefuryl	1.2 kg/ha + 1 l/ha
V10	Dual Gold 960 EC + Pulsar 40	pre-emergence + post-emergence	960 g/l, s-metolachlor + 40 g/l, imazamox	1.5 l/ha + 0.8 l/ha

Identification of weed species and determination of percent ground cover was done when the chickpea plants were 10 cm tall. These observations were made only on the untreated plot at the time of post-emergent herbicide application. The degree of selectivity was determined at 7, 14 and 28 days after herbicide application according to the EWRS scale, where values from 1 to 9 were given, where value 1 was given for chickpea plants that had no phytotoxic symptoms and value 9 for crop slopes totally destroyed. Herbicide efficacy results were obtained by visual assessment estimated at 14, 21 and 48 days after treatment. Weed biomass measured in grams dry matter (g.d.m.) and the ratio of dicotyledonous and monocotyledonous was determined at harvest. Statistical calculation and interpretation of data was performed according to analysis of the variance (Săndoiu, 2020).

RESULTS AND DISCUSSION

In terms of water, during growing season (february to august), in 2022 chickpeas benefited 180.6 mm of rainfall, that was extremely dry compared to the multiannual average recorded in Romania. In the first part of the vegetation period, the rainfall ammount was favourable especially in April (71.5 mm) but after that the drought came down (36,7 mm in May, 20.2 mm in June and 7 mm in July). Rainfall during the growing season in 2023, was similar in the first part to the previous year (being for March 14 mm, April 72.5 mm and May 32.5 mm), with June and July recording significantly higher rainfall (32 and 70 mm, respectively). The total amount of precipitation recorded during the growing season in 2023 was 242 mm (Figure 1).

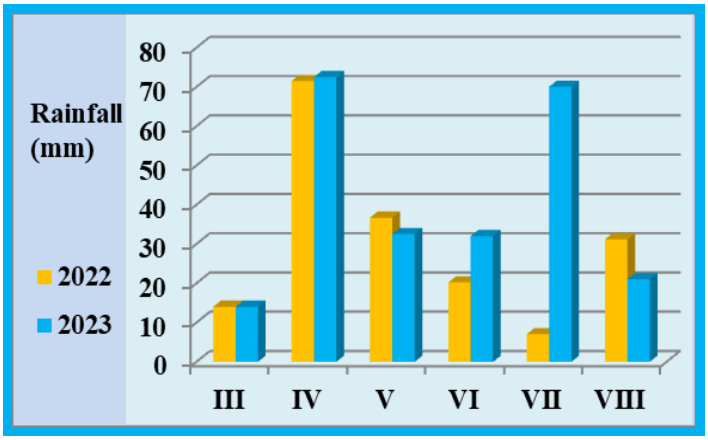

Figure 1. The evolution of precipitations at Moara Domnească, 2022-2023

From the first part of the vegetation period (March), the crop was a little bit delayed, but the rainfall ammount of April offered a first good start for growth. Although, the productions obtained in 2022 and 2023 for chickpeas were slightly affected by the water deficit.

Regarding temperatures (°C), the two years were almost similar, with very high temperatures and severe drought (Figure 2).

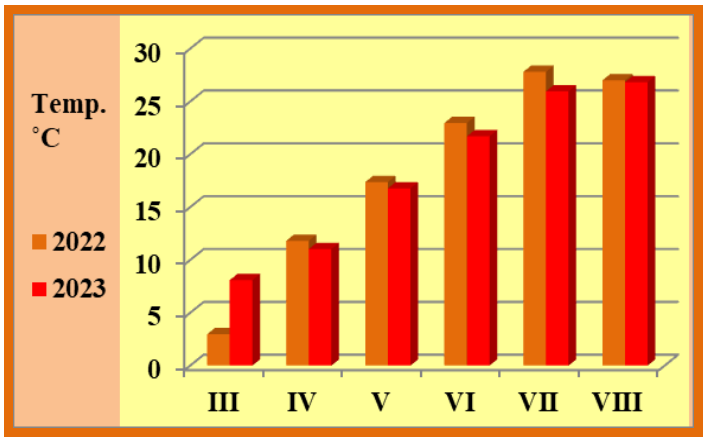

Figure 2. Temperature evolution at Moara Domnească, 2022-2023

It is well-known that hot weather does not impact the crop so that chickpea can be grown.

The assessments and determinations of the two years of research highlighted that the dicotyledonous species were the dominant ones and among them, the most harmful species in chickpea crop are the perennial as follows: *Convolvulus arvensis*, *Cirsium arvense* and *Sonchus arvensis*.

Among the annual dicotyledonous weeds, there were found *Chenopodium album* (L.), *Amaranthus retroflexus* (L.), *Polygonum aviculare* (L.), *Polygonum convolvulus* (L.) sin. *Fallopia convolvulus* (L.) A. Löve, *Solanum nigrum* (L.), *Centaurea cyanus* (L.) and *Galium aparine* (L.). Other dicotyledonous weed species were also monitored but in a very low density of less than 2 plants/m^2, these were *Daucus carota* (L.), *Portulaca oleracea* (L.), *Rumex* sp., *Capsella bursa-pastoris* (L.) Medicus, *Erigeron annuus* (L.) Persoon, *Xanthium* sp., *Veronica* sp., *Plantago major* (L.). Annual monocotyledonous species were less numerous, with: *Setaria* sp., *Echinochloa crus-galli* (L.) P. Beauv., *Digitaria sanguinalis* (L.) Scop. and volunteer *Avena sativa* (L.). Aspects on the degree of weed infestation of the chickpea crop are presented in Figure 3 and the degree of ground coverage by weeds at untreated is presented in Figure 4.

Figure 3. Aspects regarding the experimental plots

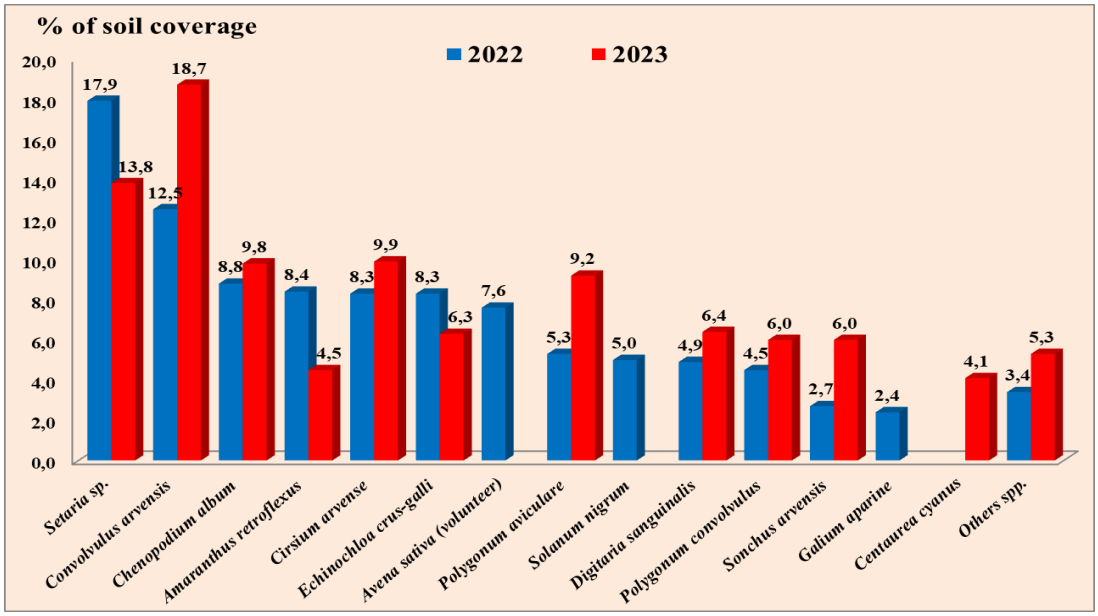

Figure 4. The degree of soil coverage of weeds from the untreated variant in the years 2022-2023

The species with the highest degree of soil coverage, in the year 2022, was *Setaria* sp. in percentage of 17.9%, followed by *C. arvensis* with 12.5% and in the year 2023 these two inverted their places, *C. arvensis* being first with 18.7% followed by *Setaria* sp. with 13.8%. The perennial dicotyledonous weed *C. arvensis* was in a high percentage of ground cover and not having viable solutions to stop it lead to yield decreases. In a rather high percentage of soil coverage, was *C. arvense*, with 8.3% in 2022 and 9.9% in 2023. The subsequent weed species had a degree of coverage between 8.8 and 2.4% in 2022 and between 9.8 and 4.1 in 2023 (Figure 4).

Assessments on the selectivity of herbicides applied to chickpea in the two years showed that only the experimental variant (V10) when herbicide Pulsar 40 based on imazamox 40 g/l where applied post-emergent showed phytotoxicity. The chickpea plants failed to develop and the leaflets yellowed, resulting in delayed harvest and lower yield. Based on the three observation periods after treatment, EWRS scores was 4 at 7 days after treatment, 4 at 14 days after treatment and 3 at 28 days after treatment.

Regarding the efficacy of the weed control measures of herbicides in the chickpea crop show that the degree increased in all variants by more than 62% compared to untreated. The best result was obtained with the combination of Gardoprim Plus Gold 500 SC (4.5 l/ha) applied pre-emergent and Merlin

Flexx (0.18 l/ha) applied post-emergent (V8) with an average control rate of 91%. The next most successful herbicide variants were Gardoprim Plus Gold 500 SC (4.5 l/ha) + Merlin Flexx (0.25 l/ha) applied pre-emergent (V7) with 89% efficacy, followed by Dual Gold 960 EC (1.5 l/ha) + Merlin Flexx (0.25 l/ha) applied pre-emergent (V5) with 81%. For V10, (Dual Gold 960 EC, 1.5 l/ha + Pulsar 40, 0.8 l/ha) we can say that the presence of phytotoxicity, which delayed the crop, leads to the validation that this is not a viable variant for weed control. These results are reported by similar results of other researchers from other countries (Jefferies et al., 2016; Nath et al., 2018; Delchev, 2021; Kashyap et al., 2022). The remaining variants 4, 6 and 9 gave less satisfactory results, the control percentage raging between 62 and 68% (Table 2).

Assessments made on weed biomass at the time of harvest showed that in the untreated plot, an average of 260 g.d.m./m^2 was recorded for the two years. In the variants with herbicides the weed biomass was considerably reduced being between 23 and 102 g.d.m./m^2, the most satisfactory variants were those in which Merlin Flexx herbicide was applied in combination with Gardoprim Plus Gold 500 SC and Dual Gold 960 EC. Determinations of weed species in the treatment variants showed that dicotyledonous were in a considerably higher ratio than monocotyledonous ones.

Table 2. Efficacy of herbicides in control of weeds at chickpea crop in 2022 and 2023

No.	Experimental variants	Time of application	Degree of control (%)				Biomass of weeds	
			14	21	48	Average	g.d.m./m^2	% of mono./dico.
			days					
V1	Untreated	-	0	0	0	0	260	
V2	Ut.2 - manually hoeing	-	100	100	100	100	-	-
V3	Ut.3 - mechanical plows	-	67	65	60	64.00	98	66/34
V4	Challenge 600 SC	pre-emegence	68	65	63	65.33	102	19/81
V5	Dual Gold 960EC + Merlin Flexx	pre-emegence	84	83	81	82.66	47	14/86
V6	Gardoprim Plus Gold 500 SC	pre-emegence	72	69	68	69.66	70	11/89
V7	Gardoprim Plus Gold 500 SC + Merlin Flexx	pre-emegence	91	92	89	90.66	26	7/93
V8	Gardoprim Plus Gold 500 SC + Merlin Flexx	pre-emegence + post-emergence	92	92	91	91.66	23	5/95
V9	Lentagran 45 WP + Pantera 40 EC	post-emergence	73	64	62	66,33	88	5/95
V10	Dual Gold 960 EC + Pulsar 40	pre-emegence + post-emergence	88	86	85	86,33	24	7/93

For these two years the chickpea crop at Moara Domnească had in the manually hoeing (V2) 1586 kg/ha and in the untreated (V1) 533 kg/ha. However, manually hoeing is not a solution for farmers. But mechanical plows (V3) are used in organic farming and can also be a solution in conventional farming if combined with herbicides. In our experience with two applications of mechanical plows (V3) the yield was 1117 kg/ha. Moreover the results of the variants with herbicides gave yields ranging from 794 to 1337 kg/ha. The best yields compared to the untreated were recorded when herbicide combinations were applied pre- and post-emergently. These were

Gardoprim Plus Gold 500 SC applied pre-emergence + Merlin Flexx applied post-emergence (V8) with a yield 250.84% higher than the untreated with 1337 kg/ha, followed by Gardoprim Plus Gold 500 SC + Merlin Flexx applied pre-emergence (V7) with 245.59% higher than the untreated with 1309 kg/ha and Dual Golg 960 EC + Merlin Flexx applied pre-emergence (V5) with 232.83% higher than the untreated with 1241 kg/ha (Table 3). By comparison with the untreated (V1), it was statistically demonstrated that all variants gave very significantly positive yield increases. However, a comparison with manually hoeing (V2) shows very significantly negative values. This proves that on fields infested with perennial dicotyledonous weeds, like the one at Moara Domnească, we cannot have a weed-free chickpea crop and other herbicide combinations must be found and tested. And in comparison with the application of mechanical plows (V3) variants 8, 7 and 5 stand out with distinctly significant and significant yields. Thus by applying Merlin Flexx herbicide (s.a 240 g/l isoxaflutole + 240 g/l cyclosulfamide) pre- and post-emergence in combination with other herbicides (Gardoprim Plus Gold 500 SC or Dual Gold 960 EC) higher yields are obtained compared to mechanical control and is currently a solution to obtain good chickpea yields.

Table 3. Mean yield of chickpea crop in 2022 and 2023

No.	Experimental variants	Time of application	Production yields		Difference from the untreated (kg/ha)		
			kg/ha	%			
V1	Untreated	-	533	100	Ut. 1	-1053^{ooo}	-584^{ooo}
V2	Ut.2 manually hoeing	-	1586	297.56	1053^{***}	Ut. 2	469^{***}
V3	Ut.3 mechanical plows	-	1117	209.57	584^{***}	-469^{ooo}	Ut. 3
V4	Challenge 600 SC	pre-emegence	824	154.59	291^{***}	-762^{ooo}	-293^{ooo}
V5	Dual Golg 960 EC + Merlin Flexx	pre-emegence	1241	232.83	708^{***}	-345^{ooo}	124^{*}
V6	Gardoprim Plus Gold 500 SC	pre-emegence	1056	198.12	523^{***}	-530^{ooo}	-61
V7	Gardoprim Plus Gold 500 SC + Merlin Flexx	pre-emegence	1309	245.59	776^{***}	-277^{ooo}	192^{**}
V8	Gardoprim Plus Gold 500 SC + Merlin Flexx	pre-emegence + post-emergence	1337	250.84	801^{***}	-249^{ooo}	220^{**}
V9	Lentagran 45 WP + Pantera 40 EC	post-emergence	911	170.92	378^{***}	-675^{ooo}	-206^{oo}
V10	Dual Gold 960 EC + Pulsar 40	pre-emegence + post-emergence	794	148.97	261^{***}	-792^{ooo}	-323^{ooo}

DL 5% = 76.25; DL 1% = 136.15; DL 0.1% = 221.60.

CONCLUSIONS

The 2022 and 2023 crop years were dry, with similar temperatures and rainfall, except for July when rainfall was high in 2023 but did not help enough the chickpea crop, which appeared late in the growing season.

The results regarding herbicides selectivity in these two years showed that herbicide Pulsar 40 (imazamox 40 g/l), applied in post-emergence in chickpea crop showed phytotoxicity, which resulted in decreased yield.

The degree of weed control in the treated variants was over 62%. The most effective variants with the highest yields were recorded at Gardoprim Plus Gold 500 SC (4.5 l/ha) applied pre-emergence + Merlin Flexx (0.18 l/ha) applied post-emergence with 250.84%, followed by Gardoprim Plus Gold 500 SC (4.5 l/ha) + Merlin Flexx (0.25 l/ha) applied pre-emergence with 245.59% and Dual Golg 960 EC (1.5 l/ha) + Merlin Flexx (0.25 l/ha) applied pre-emergence with 232.83% over the untreated control.

The results obtained are useful for chickpea growers, weed infestation being the main problem in the crop technology.

ACKNOWLEDGEMENTS

Grateful thanks to Didactic Farm Board for all the support provided.

REFERENCES

Al-Thahabi, S.A., Yasin, J.Z., Abu-Irmaileh, B.E., Haddad, N.I., Saxena, M.C., 1994. *Effect of Weed Removal on Productivity of Chickpea (Cicer arietinum L.) and Lentil (Lens culinaris Med.) in a Mediterranean Environment*. J. Agronomy and Crop Science, 172: 333-341.

Bulti, M., Nano, A., Fatih, Y., 2019. *Integrated weed management in chickpea (Cicer arietinum L.)*. Cogent Food and Agriculture, 5(1): 1-30.

Cojocaru, J.M., and Marin, D.I., 2021. *Selectivity and effectiveness of herbicides applied to chickpeas culture under the conditions of SCDA Teleorman*. Scientific Papers, Series A, Agronomy, LXIV(1): 196-206.

Delchev, G., 2021. *Efficacy of herbicides, herbicide combinations and herbicide tank mixture on chickpea (Cicer arietinum L.)*. Scientific Papers, Series A, Agronomy, 64(1): 283-290.

Gaur, P.M., Jukanti, A.K., Samineni, S., Chaturvedi, S.K., Singh, S., Tripathi, S., Singh, I., Singh, G., Das, T.K., Aski, M., Mishra, N., Nadarajan, N., Gowda, C.L., 2013. *Large genetic variability in chickpea for tolerance to herbicides imazethapyr and metribuzin*. Agronomy, 3(3): 524-536.

Jefferies, M.L., Willenborg, C.J., Tar'an, B., 2016. *Response of conventional and imidazolinone-resistant chickpea (Cicer arietinum L.) cultivars to imazamox and/or imazethapyr applied post-emergence*. Canadian Journal of Plant Science, 96(1): 48-58.

Kashyap, A.K., Kushwaha, H.S., Mishra, H., 2022. *Effect of herbicides on weeds, yield and economics of chickpea*. Indian Journal of Weed Science, 54(2): 182-186.

Mihalache, M., Ilie, L., Marin, D.I., 2010. *Research concerning the evolution of physical and chemical properties of reddish preluvosoil from Moara Domnească*. Scientific Papers, USAMV Bucharest, Series A, 53: 61-66.

Muehlbauer, F.J., and Sarker, A., 2017. *Economic importance of chickpea: Production, value, and world trade*. In: Varshney, R., Thudi, M., Muehlbauer, F. (eds.), The Chickpea Genome. Springer: 5-12.

Nath, C.P., Dubey, R.P., Sharma, A.R., Hazra, K.K., Kumar, N., Singh, S.S., 2018. *Evaluation of new generation post-emergence herbicides in chickpea (Cicer arietinum L.)*. National Academy Science Letters, 41: 1-5.

Petcu, V., Radu, I., Grădilă, M., Stanciu, V., Bărbieru, A., 2021. *Soybean seed scanning for size, genotype color and Cercospora blight detection*. Scientific Papers, Series A, Agronomy, LXIV(1): 527-533.

Plew, J.N., Hill, G.D., Dastgheib, F., 1994. *Weed control in chickpeas (Cicer arietinum)*. Proceedings Agronomy Society of N.Z., 24: 117-124.

Rahbarian, R., Khavari-Nejad, R., Ganjeali, A., Bagheri, A., Najafi, F., 2011. *Drought stress effects on photosynthesis, chlorophyll fluorescence and water relations in tolerant and susceptible chickpea (Cicer arietinum L.) genotypes*. Acta Biologica Cracoviensia, Series Botanica, 53(1): 47-56.

Ratnam, M., Rao, A.S., Reddy, T.Y., 2011. *Integrated weed management in chickpea (Cicer arietinum L.)*. Indian Journal of Weed Science, 43(1): 70-72.

Săndoiu, D.I., 2020. *Tehnică experimentală în agricultură și horticultură*. Ed. Printech, București.

Singh, A., Rana, S.S, Bala, A., 2020. *Weed management strategies in Chickpea (Cicer arietinum): A review*. Agricultural Reviews, 41(2): 153-159.

Vaishya, R.D., Fayaz, M., Srivastava, A.K., 1996. *Integrated weed management in chickpea*. Indian Journal of Pulses Research, 9: 34-38.

Watson, C.A., Reckling, M., Preissel, S., Bachinger, J., Bergkvist, G., Kuhlman, T., Lindström, K., Nemecek, T., Topp, C.F.E., Vanhatalo, A., Zander, P., Bokern, D.M., Stoddard, F.L., 2017. *Grain legume production and use in European agricultural systems*. Advances in Agronomy, 144: 235-303.

*** https://aloe.anfdf.ro/, 2023. MADR.

*** https://www.fao.org/faostat/en/#data/QCL, 2023. Food and Agriculture Statistics (FAO).