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APPLICATION OF FOLIAR HERBICIDES FOR SOME DICOTYLEDONOUS WEEDS CONTROL IN *Triticum aestivum* L.

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Abstract

During the period 2023-2024, a field study with common wheat, Avenue variety was conducted. The experiment was set up in a production field in the village of Dobroplodno, Vetrino municipality, Bulgaria. The evaluated herbicidal products were Biathlon® 4 D (714 g/kg tritosulfuron + 54 g/kg florasulam), Ergon® WG (68 g/kg metsulfuron-methyl+ 682 g/kg tifensulfuron-methyl), Acurat Extra® WG (682 g/kg tifensulfuron-methyl + 70 g/kg metsulfuron-methyl), Aminopielic® 600 SL (600 g/l 2,4 amine salt), and Corida® 75 WDG (750 g/l tribenuron-methyl). The herbicidal products were applied as foliar treatments. The weed infestation of the experimental field was presented by Anthemis arvensis L., Lamium amplexicaule L., Consolida regalis S.F. Gray, Papaver rhoeas L., Sinapis arvensis L. and Convolvulus arvensis L. The infestation with these weeds resulted in a very low average grain yield for the untreated control (3.97 t ha-1). The highest biological yield of grain is obtained after using Biathlon 4 D (4.96 t/ha^{-1}) was found.

Key words*: Triticum aestivum, weedy plants, herbicidal products, efficient.*

INTRODUCTION

The role of food, and in particular the crops' production, is key to the survival of the population. This explains the great number of scientific studies aimed at the successful production of agricultural crops (Panayotov et al., 2024; Panchev & Shopova, 2024; Balabanova et al., 2023; Rankova et al., 2023; Shopova, 2023; Komitov et al., 2020; Dimtrova et al., 2019; Marinov-Serafimov et al., 2017; Mishra et al., 2016; Ditta et al., 2015; Fita et al., 2015; Shopova & Cholakov, 2015; Yanev, 2015; López-Bellido et al., 2014; Shopova & Cholakov, 2014; Panta et al., 2014; Yanev et al., 2014a). Winter wheat is one of the most important crops in the world. Weeds are a major competitor during the growing season of Triticum aestivum L. because they compete with crop plants for light, moisture, nutrients and space (Cheema and Farooq, 2007; Khan et al., 2001; Reddy, 2000). Weeds account for 10-80 percent yield reduction depending upon the weed species and infestation and caused depletion of soil water up to 6.5 cm (Ranjit et al., 1998; Afentouli and Eleftherohorinos, 1996; Khera et al., 1995; Mehra and Gill, 1988). Uncontrolled weeds are reported to cause up to 66% reduction in wheat grain yield (Kumar et al., 2011) or even more depending upon the weed densities, type of weed flora and duration of infestation. A formidable factor that limits its productivity is severe weed competition, which competes with crop plants for water, nutrients, space and solar radiation resulting in reduction of yield by 29% (Pandey et al., 2006). Wheat productivity depends on several factors such as irrigation, weed control, fertilizer management and other agronomic practices. Among these factors, the hidden war with the crop starts with weeds. Weeds are a major problem for sustainable crop production as weeds determine most agronomic practices for crop production and cause huge losses (Verma et al., 2015). Weeds also increase the cost of harvesting and degrade the quality of the produce. Therefore, they need to be controlled to obtain optimal wheat yield with good grain quality. Wheat is usually stressed by dicotyledonous weeds. The presence of weeds, especially in the early stages of crop development, proves detrimental to the yield obtained from it. Losses are highest when resources are limited and weeds germinate along with it (Hussain et al., 2015). There is a strong correlation between the duration of weed competition and wheat yield reduction (Fahad et al., 2014; Bekelle, 2004). Wheat crop is infested majorly with *Avena fatua*, *Chenopodium album*, *Cirsium arvense*, *Convolvulus arvensis*, *Coronopus didymus*, *Cynodon dactylon*, *Dichanthium annulatum*, *Melilotus indica*, *Phalaris minor*, *Polygonum plebejum*, *Polypogon fugax*, *Rumex dentatus* and *Spergula arvensis* weeds (Waheed et al., 2009). Wheat grain yield losses due to presence of these weeds were estimated to be 20 to 30% (Marwat et al., 2006). Apart from significantly reducing grain yield, weeds also reduce soil fertility. Timely weed control is essential for maximum yield (Vasudev et al., 2017). It is economically advantageous to use chemical weed control agents (Khalil et al., 1999). Herbicides are one of the most commonly used substances for weed management. Choosing the proper herbicide is a responsible moment, because it must meet a number of requirements such as: selectivity to the crop, efficacy against the weeds and to be safe for the produced food and soil health (Parven et al., 2025; Semenov et al., 2025; Morar et al., 2024; Rai et al., 2024; Yanev, 2024; Yanev, 2023; Atwood et al., 2022; Goranovska et al., 2022; Li et al., 2022; Yanev, 2022; Govindasamy et al., 2021; Yanev, 2021; Mandal et al., 2020; Tripathi et al., 2020; Yanev, 2020; Yanev & Kalinova, 2020; Martinez et al., 2018; Goranovska & Yanev, 2016; Kostadinova et al., 2016; Kumar et al., 2016; Rose et al., 2016; Hristeva et al., 2015; Kalinova & Yanev, 2015; Raj et al., 2015; Semerdjieva et al., 2015; Hristeva et al., 2014; Lee et al., 2014; Yanev et al., 2014b; Marin-Morales et al., 2013; Zabaloy et al., 2011). Herbicidal weed control is considered most effective and economical method in wheat (Ashiq et al., 2003). The integrated weed management approach is advantageous because one technique rarely achieve complete and effective control of all weeds during crop season and even a relatively few surviving weeds can produce sufficient number of seeds to perpetuate the species (Nayak, 2006; Walia et al., 1997) .An average decrease in grain yield by 15.42 % was observed due to season-long weed-crop competition. Lowest dicot weeds were observed with weed free treatment. The most popular herbicides on winter wheat are chemicals based on active ingredients: tribenuron-methyl, dicamba, florasulam, etc. (Zand et al., 2007). The best weed control efficiency in case of dicot (82.8%) was achieved with metsulfuron-methyl, respectively compared to other herbicide namely 2,4-D (Patel et al., 2017; Paighan et al., 2013; Maninder et al., 2007; Singh and Ali, 2004; Nayak et al., 2003; Kurchania et al., 2000). Ashiq et al. (2007) recorded the highest WCE of bromoxynil+ MCPA against broadleaf weeds *Chenopodium album, C. murale, Fumaria indica* and *Convolvulus arvensis* in wheat. It is also true that most of the dicot herbicides do not give a 100% control of all broadleaf weeds (Zimdahl, 1993). This is due to differential phytotoxic action of herbicides against a range of broadleaf weeds (Ashiq et al., 2007). According to Abbas et al. (2009) the best herbicides against broad leave weeds is Buctril Super 60 % EC - 825 ml ha^{-1}, as it out yielded all herbicides by producing 2300 kg ha^{-1} grain yield except T5 Starane-M - 875 ml ha^{-1}, which produced grain yield to the tune of 2245 kg ha^{-1}.

The present study was conducted with an objective to identify herbicides more effective in controlling broad leaf weeds and increasing wheat's yield. This trial was done to assess the efficacy of post-emergence herbicides for weed control in wheat and its effect on grain yield.

MATERIALS AND METHODS

In 2023 and 2024, a field experiment with the winter wheat variety "Avenue" was conducted in the village of Dobroplodno, Vetrino municipality, Bulgaria. The experiment was set up using the block method in 4 replications with a total size of the working plot of the four replications of 80 m². Before the treatment with herbicides, a weed count was carried out in the experimental field. Six widespread broadleaf weeds were identified in wheat. The average density of weeds in the two experimental years, per 1 m² is as follows: *Anthemis arvensis* L. - 6.5 exemplar; *Lamium amplexicaule* L. - 19.5 exemplar; *Consolida regalis* S.F. Gray - 5 exemplar; *Papaver rhoeas* L. - 5.5 exemplar; *Sinapis arvensis* L. - 7 exemplar; *Convolvulus arvensis* L. - 5 exemplar. The study included the following variants: 1. Untreated control; 2. Biathlon 4 D (714 g/kg tritosulfuron + 54 g/kg florasulam) - 0.055 kg ha^{-1}, Ergon® WG (68 g/kg metsulfuron-methyl + 682 g/kg tifensulfuron-methyl) - 0.09 kg ha^{-1}, Acurat Extra® WG (682 g/kg tifensulfuron-methyl +

70 g/kg metsulfuron-methyl) - 0.05 kg ha^{-1}, Aminopielic® 600 SL (600 g/l 2,4 amine salt) - 1.25 l ha^{-1}, and Corida® 75 WDG (750 g/l tribenuron-methyl) - 0.015 kg ha^{-1}. The herbicides were applied in the tillering phase of the wheat (BBCH 21-29). The herbicide spraying was carried out with a backpack sprayer with a working solution volume of 210 l ha^{-1}.

Before sowing the crop, fertilization was carried out with NPK 15:15:15 at a fertilizer rate of 200 kg ha^{-1}. Sowing was carried out at the optimal time for wheat with a small-sized Wintersteiger seeder for crops with a merged surface at a row spacing of 12 cm, with a seeding rate of 400 germinating seeds per m². In the spring, in the tillering phase, wheat was nourished with NH_4NO_3 at a fertilizer rate of 200 kg ha^{-1}. Weeds were assessed for efficacy on days 14, 28 and 56 after the application of the herbicide products. The 10-point EWRS (European Weed Research Society) scale was used for visual assessment of herbicide efficacy. The 9-point EWRS scale was used to assess herbicide selectivity.

The results for wheat yields were processed using the Duncan method.

RESULTS AND DISCUSSIONS

The efficacy of herbicides against Anthemis arvensis L. is shown in Table 1. On the 14th day after treatment, the highest herbicidal efficacy was recorded for variant 2 (Biathlon 4 D), and the lowest herbicidal effect was recorded for variant 5 (Aminopielic 600 SL). This trend was maintained at the last reading, carried out on the 56th day after the application of the herbicides. With the exception of variant 5, in all other treated variants with the products Biathlon 4 D, Ergon WG, Akurat Extra WG and Corida 75 WDG, we report almost complete weed destruction (95-100%).

Table 1. Avarage herbicidal control (%) against *A. arvensis*

Variants	Days after application		
	14	28	56
1. Untreated control	-	-	-
2. Biathlon 4 D - 0.055 kg ha^{-1}	70	90	100
3. Ergon WG - 0.09 kg ha^{-1}	60	80	95
4. Acurat Extra WG - 0.05 kg ha^{-1}	60	85	95
5. Aminopielic 600 SL - 1.25 l ha^{-1}	50	60	70
6. Corida 75 WDG - 0.015 kg ha^{-1}	55	75	95

Table 2 shows the dynamics of the herbicidal efficacy against *L. amplexicaule* L. High herbicidal efficacy was reported on all reporting dates. At the first reporting date, the efficacy of the individual products was almost the same, ranging from 80 to 85%. On the 28th day after herbicide treatment, this difference in the efficacy of the products persist, reaching 90-95%. At the last date, the weed completely vanished.

Table 2. Avarage herbicidal control (%) against *L. amplexicaule*

Variants	Days after application		
	14	28	56
1. Untreated control	-	-	-
2. Biathlon 4 D - 0.055 kg ha^{-1}	85	95	100
3. Ergon WG - 0.09 kg ha^{-1}	80	90	100
4. Acurat Extra WG - 0.05 kg ha^{-1}	80	95	100
5. Aminopielic 600 SL - 1.25 l ha^{-1}	85	95	100
6. Corida 75 WDG - 0.015 kg ha^{-1}	80	90	100

Against *C. regalis* (Table 3), none of the experiment's variants showed 100% efficacy. This indicates the greater resistance of the weed to the tested herbicides. On the 14th day after treatment with the herbicides, the efficacy was slightly higher in the variants with Biathlon 4 D and Aminopielic 600 SL. On the second date, the lowest herbicidal efficacy against weed was reported for the product Ergon WG. The highest herbicidal effect was reported from the products Biathlon 4 D and Aminopielic 600 SL (90%) 56th days after treatments. The other variants also have satisfactory herbicidal efficacy, around 85%.

Table 3. Avarage herbicidal control (%) against *C. regalis*

Variants	Days after application		
	14	28	56
1. Untreated control	-	-	-
2. Biathlon 4 D - 0.055 kg ha^{-1}	65	80	90
3. Ergon WG - 0.09 kg ha^{-1}	60	75	85
4. Acurat Extra WG - 0.05 kg ha^{-1}	60	80	85
5. Aminopielic 600 SL - 1.25 l ha^{-1}	65	85	90
6. Corida 75 WDG - 0.015 kg ha^{-1}	60	80	85

Herbicidal efficacy of the products against *P. rhoeas* is shown in Table 4. On the first reporting date for treatments 3 and 4 the weed efficacy was 65%. There was only 60% efficacy against the weed in the other treatments of the trial. The efficacy of the herbicide Aminopielic 600 SL on the same date was very low - 40%. On the 28th day after treatment, the percentages of efficacy in all variants increased. In variant 5, the efficacy is low again. With the exception of the herbicide Aminopielic 600 SL, where the efficacy was unsatisfactory (60%), the efficacy of the remaining treated variants at the last reporting was high (90%).

Table 4. Avarage herbicidal control (%) against *P. rhoeas*

Variants	Days after application		
	14	28	56
1. Untreated control	-	-	-
2. Biathlon 4 D - 0.055 kg ha^{-1}	60	80	90
3. Ergon WG - 0.09 kg ha^{-1}	60	85	90
4. Acurat Extra WG - 0.05 kg ha^{-1}	65	80	90
5. Aminopielic 600 SL - 1.25 l ha^{-1}	40	50	60
6. Corida 75 WDG - 0.015 kg ha^{-1}	60	80	90

Table 5. Avarage herbicidal control (%) against *S. arvensis*

Variants	Days after application		
	14	28	56
1. Untreated control	-	-	-
2. Biathlon 4 D - 0.055 kg ha^{-1}	50	85	100
3. Ergon WG - 0.09 kg ha^{-1}	55	80	100
4. Acurat Extra WG - 0.05 kg ha^{-1}	55	80	100
5. Aminopielic 600 SL - 1.25 l ha^{-1}	55	80	100
6. Corida 75 WDG - 0.015 kg ha^{-1}	50	85	100

S. arvensis (Table 5) is the easiest to control compared to all other weeds present in the experiment. Of all the herbicide products used in the trial, report 100% efficacy the weed, reported at the last reporting date.

Table 6. Avarage herbicidal control (%) against *C. arvensis*

Variants	Days after application		
	14	28	56
1. Untreated control	-	-	-
2. Biathlon 4 D - 0.055 kg ha^{-1}	80	50	40
3. Ergon WG - 0.09 kg ha^{-1}	60	40	30
4. Acurat Extra WG - 0.05 kg ha^{-1}	65	40	30
5. Aminopielic 600 SL - 1.25 l ha^{-1}	80	70	50
6. Corida 75 WDG - 0.015 kg ha^{-1}	70	50	30

On the 14^{th} day after the application of the herbicides, only the products Biathlon 4 D and Aminopielic 600 SL showed a satisfactory effect on *C. arvensis* (Table 6). The efficacy of Ergon WG, Acurat Extra WG and Corida 75 WDG was unsatisfactory varying from 60 to 70%. On the second date, we reported a decrease in efficacy for all products tested in the experiment. On the last date, field bindweed was controlled very poorly in all treated variants. The herbicide Aminopielic 600 SL reported 50% efficacy. With the other products, it was even and reached only 30 - 40%. These low efficacy percentages are due to the strong secondary growth of the weed.

Table 7 shows the average yields obtained for 2023-2024. The herbicidal efficacy of the products also determines the differences in yields in the individual variants of the experiment. Weeding with highly competitive species leads to a minimum yield of the untreated control (3.97 t/ha^{-1}).

Table 7. Productivity of wheat, t/ha^{-1}

Variants/ Yields	
1. Untreated control	3.97 a
2. Biathlon 4 D - 0.055 kg ha^{-1}	4.96 *c
3. Ergon WG - 0.09 kg ha^{-1}	4.92 *c
4. Acurat Extra WG - 0.05 kg ha^{-1}	4.91 *c
5. Aminopielic 600 SL - 1.25 l ha^{-1}	4.55 *b
6. Corida 75 WDG - 0.015 kg ha^{-1}	4.86 *c

Legend: Values marked with different letters differ significantly according to Duncan's test at P 0.05.

According to Duncan's test, three separate groups of herbicides are distinguished by the degree of statistical evidence (a, b, c). It was observed that all variants, except for Aminopielic 600 SL, were from group (c) furthest from the untreated control group (a), that was with the highest yields. The reason is mainly due to the fact that Aminopielic 600 SL has lower efficacy against *A. arvensis* and *P. rhoeas*, compared to the higher efficacy of the other evaluated products.

CONCLUSIONS

The herbicides Biathlon 4 D, Ergon WG, Acurat Extra WG, Aminopielic 600 SL and Corida 75 WDG were excellently effective against *L. amplexicaule* and *S. arvensis*.

The product Aminopielic 600 SL was not sufficient compared to the other studied herbicides against *A. arvensis* and *P. rhoeas*.

The weed *C. regalis* was controlled equally well by all tested products (from 85 to 90%).

The weed *C. arvensis* was not controlled successfully by any of the tested herbicides.

Visual signs of phytotoxicity were not detected in any of the trial treatments during the two experimental years.

The average yield of the variant treated with the herbicide Biathlon 4D is the highest compared to the other treated variants.

The lowest yield is from Aminopielik 600 SL (3.97 t/ha^{-1}).

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REFERENCES

Afentouli, C. G., Eleftherohorinos, I.G. (1996). Littlseed canary grass (*Phalaris minor*) and short spiked canary grass (*Phalaris brachystachys*) interference in wheat and barley. *Weed Sci*. 44 : 460-565.

Ashiq, M., Nayyar, M.M., Ahmad, J. (2003). Weed Control Handbook for Pakistan. Directorate of Agronomy, Ayub Agric. Res. Institute., Faisalabad, Pakistan.

Ashiq, M., Muhammad, N., Ahmad, N. (2007). Comparative efficacy of different herbicides against broad leaf weeds in wheat. *Pak. J. Weed Sci. Res.* 13(3-4): 149-156.

Atwood, L. W., Racette, K. A., Diggelmann, M., Masala, C. A., Maund, S., Oliver, R., Screpanti, C., Wironen, M., & Wood, S. A. (2022). Soil health: new opportunities to innovate in crop protection research and development. *Frontiers in Environmental Science*, *10*, 821742.

Balabanova, D., Neshev, N., Yanev, M., Koleva-Valkova, L., & Vassilev, A. (2023). Photosynthetic performance and productivity of maize (Zea mays L.), exposed to simulated drift of imazamox and subsequent therapy application with protein hydrolysates. *Journal of Central European Agricultur*e, 24(1), 126-136.

Bekelle, A. (2004). Assessment and management of weeds in wheat in Debark woreda, NorthGonder.M.SC thesis, Haramaya-Ethiopia.

Cheema, Z.A., Farooq, M. (2007). Agriculture in Pakistan. Agriculture in Pakistan: Problems of small farmers and their solutions. 23 p. Allied Book Center, Urdu Bazar, Lahore, Pakistan

Dimitrova, M., Minev, N., Yordanova, N., Valcheva, V., & Yanev, M. (2019). Effect of planting density of different maize hybrids on crop growth and yield. *Scientific Papers. Series A. Agronomy*, Vol. LXII, № 2, 73-76.

Ditta, A., Arshad, M., & Ibrahim, M. (2015). Nanoparticles in sustainable agricultural crop production: applications and perspectives. *Nanotechnology and plant sciences: nanoparticles and their impact on plants*, 55-75.

Fahad S., Hussain S., Saud S., Hassan S., Muhammad H., Shan D, ... (2014). Consequences of narrow crop row spacing and delayed *Echinochloa colona* and *Trianthema portulacastrum* emergence for weed growth and crop yield loss in maize. *Weed Research*, 54:475-483.

Fita, A., Rodríguez-Burruezo, A., Boscaiu, M., Prohens, J., & Vicente, O. (2015). Breeding and domesticating crops adapted to drought and salinity: a new paradigm for increasing food production. *Frontiers in Plant Science*, 6, 978.

Ghulam Abbas, M. Anjum Ali, Zafar Abbas, Muhammad Aslam and Muhammad Akram (2009). Impact of different herbicides on broadleaf weeds and yield of wheat. *Pak. J. Weed Sci. Res*. 15(1): 1-10.

Goranovska, S., Kalinova, S., & Yanev, M. (2022). Influence of herbicides and foliar fertilizers on the yield, the structural elements of yield and technological qualities of the maize grain. *Bulgarian Journal of Agricultural Science*, 28(1), 137-144.

Goranovska, S., Yanev, M. (2016). Economic efficiency of the chemical control of the weeds in maize. *Proceedings of Science-Technical Conference with International Participation - Ecology and Health*, 82–85.

Govindasamy, P., Singh, V., Palsaniya, D. R., Srinivasan, R., Chaudhary, M., & Kantwa, S. R. (2021). Herbicide effect on weed control, soil health parameters and yield of Egyptian clover (Trifolium alexandrinum L.). *Crop Protection*, *139*, 105389.

Hristeva, Ts, Yanev, M., Kalinova, Sht., & Bozukov, H. (2014). Comparative analysis of some herbicides from amide and dinitroaniline families on the soil microorganisms. *Turkish Journal of Agricultural and Natural Sciences*, Special Issue, 2, 1447–1454.

Hristeva, Ts., Yanev, M., Bozukov, Hr., & Kalinova, Sht. (2015). Condition of soil microbial communities when exposed to some chloroacetamide herbicides. *BJAS*, 21(4), 730–735.

Hussain S., Khaliq A., Matloob A., Fahad S., Tanveer A, 2015. Interference and economic threshold level of little seed canary grass in wheat under different sowing times. *Environmental Science Pollution Research*, 22:441-449.

Kalinova, Sht., & Yanev, M. (2015). Influence of soil herbicides on technological parameters of oriental tobacco. *Scientific Works of the Agricultural University of Plovdiv*, LIX(3), 65–70.

Khalil, A., Shah, Z., Inayatullah, A., Khan, H. and Khan, H. (1999) Effect of Some post Emergence Herbicides on Wheat (*Triticum aestivum* L.) and Associated Weeds. *Sarhad Journal of Agricultur*e, 9, 323-326.

Khan, I., Muhammad, Z., Hassan, G. and Marwat, K.B. (2001). Efficacy of Different Herbicides for Controlling Weeds in Wheat Crop-1. Response of Agronomic and Morphological Traits in Variety Gaznavi-98. Scientific Khyber, 14, 51- 57.

Khera, K. I., Sandhu, B.S., Aujla, B.S., Singh, T.S., Kumar, K. (1995). Performance of wheat (Triticum aestivum) in relation to canary grass (P. minor) under different levels of irrigation, nitrogen and weed population. *Indian Jour. of Agri. Sci*. 65 : 717-722

Komitov, G., Mitkov, I., Harizanov, V., Neshev, N., & Yanev, M. (2020). Justification of Agrotechnical Indicators of Agrorobot. *2020 7th International Conference on Energy Efficiency and Agricultural Engineering (EE&AE)*, Ruse, 1-5. doi: 10.1109/EEAE49144.2020.9279046

Kostadinova, S., Kalinova, Sht., & Yanev, M. (2016). Sunflower productivity in response to herbicide diflufenican (Pelican 50SC) and foliar fertilizing. *Agriculture & Food*, 4, 122–128.

Kumar, R., Singh, R. S., Dev, J., & Verma, B. K. (2016). Effect of tillage and herbicides on rhizospheric soil health in wheat. *Indian Journals of Weed Science*, 48(2), 220-221. DOI : 10.5958/0974-8164.2016.00054.X

Kumar, S., Angiras, N. N. and Rana, S. S. (2011). Bio-efficacy of clodinafop-propargyl+ metsulfuron-methyl against complex weed flora in wheat. *Indian J. Weed Sci*. 43 : 195- 98.

Kurchania, S.P., Bhalla, C.S., Paradkar, N.R. (2000). Bio-efficacy of metsulfuron methyl and 2,4-D combinations for broad-leaf weed control in wheat. *Indian Journal of Weed Science* 32 (1&2): 67- 69.

Lee, S., Clay, D. E., & Clay, S. A. (2014). Impact of herbicide tolerant crops on soil health and sustainable agriculture crop production. *Convergence of food security, energy security and sustainable agriculture*, 211-236.

Li, M., Ma, X., Wang, Y., Saleem, M., Yang, Y., & Zhang, Q. (2022). Ecotoxicity of herbicide carfentrazone-ethyl towards earthworm *Eisenia fetida* in soil. *Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology*, *253*, 109250.

López-Bellido, L., Wery, J., & López-Bellido, R. J. (2014). Energy crops: prospects in the context of sustainable agriculture. *European journal of agronomy*, 60, 1-12.

Mandal, A., Sarkar, B., Mandal, S., Vithanage, M., Patra, A. K., & Manna, M. C. (2020). Impact of agrochemicals on soil health. In *Agrochemicals detection, treatment and remediation. Butterworth-Heinemann*, 161-187.

Maninder K., Gill, B.S., Brar, L.S. (2007). Competitive ability of wheat types against wild oats (*Avena ludoviciana* Dur.) as influenced by sowing date. Environment and Ecology 25(2): 333- 336.

Marin-Morales, M. A., de Campos Ventura-Camargo, B., & Hoshina, M. M. (2013). Toxicity of herbicides: impact on aquatic and soil biota and human health. In *Herbicides-current research and case studies in use*. IntechOpen.

Marinov-Serafimov, P., Golubinova, I., Kalinova, Sht., Yanev, M., & Ilieva, A. (2017). Allelopathic activity of some parasitic weeds. *BJAS*, 23 (№ 2), 219-226.

Martinez, D. A., Loening, U. E., & Graham, M. C. (2018). Impacts of glyphosate-based herbicides on disease resistance and health of crops: a review. *Environmental Sciences Europe*, *30*, 1-14.

Marwat, K.B., Z. Hussain, B. Gul, M. Saeed and Siraj-ud-Din. (2006). Survey on weed problems in wheat crop in district Mardan. *Pak J. Weed Sci. Res*. 12(4): 353-358.

Mehra, S. P., Gill, H.S. (1988). Effect of temperature on germination of P. minorRetz. and its competition in wheat. *Punjab Agri. Uni. Res. Jour*. 25 : 529-533.

Mishra, S., Mishra, D., & Santra, G. H. (2016). Applications of machine learning techniques in agricultural crop production: a review paper. *Indian J. Sci. Technol*, 9(38), 1-14.

Morar, G., Jigau, R., Șmuleac, A., & Pascalau, R. (2024). Soil health and regeneration: building resilient agricultural systems. *Research Journal of Agricultural Science*, *56*(4).

Nayak, M., Pradhan, A.C., Satapathy, M.R., Mohapatra, B.K. (2006). Effectiveness of weed management in wheat (Triticum aestivum L.) under different tillage systems. *Crop Research Hisar* 32(3): 294-299.

Nayak, S., Rawat, A.K., Sharma, R.S. (2003). Effect of metsulfuronmethyl and 2,4-D alone and in combination for control of broad leaf weeds in irrigated wheat. *Jawaharlal Nehru Krishi Vishwa Vidyalaya Research Journal* 37(1): 104-106.

Paighan, V.B., Gore, A.K., Chavan, A.S. (2013). Effect of new herbicides on growth and yield of wheat. *Indian Journal of Weed Science* 45(4): 291–293

Panayotov, N., Panchev, V. & Shopova, N. (2024). Assessment of the storability of tomatillo (Physalis Ixocarpa Brod.) seeds. *Journal of Mountain Agriculture on the Balkans,* 27(2), 296 – 317.

Panchev, V. & Shopova, N. (2024). Influence of Treatment of Tomato Seeds with Ultrasound on Their Biological Manifestations. In *Journal of Mountain Agriculture on the Balkans.* 27(6), 422–438.

Pandey, A.K., Gopinath, K.A., Gupta, H.S. (2006). Evaluation of sulfosulfuron and metribuzin for weed control in irrigated wheat (Triticum aestivum). *Indian Journal of Agronomy* 51(2): 135- 138.

Panta, S., Flowers, T., Lane, P., Doyle, R., Haros, G., & Shabala, S. (2014). Halophyte agriculture: Success stories. *Environmental and experimental botany*, *107*, 71-83.

Parven, A., Meftaul, I. M., Venkateswarlu, K., Segovia, A. C., & Megharaj, M. (2025). Potted garden pea grown in presence of pre-emergence herbicides: Impacts on soil enzymes and human health. *Journal of Food Composition and Analysis*, 138, 106985.

Patel, B. D., Chaudhari, D.D., Patel, V.J., Patel, H.K, Mishra, A., Parmar, D.J. (2017). Influence of broad spectrum herbicides on yield and complex weed flora of wheat (*Triticum aestivum* L.). Res. on Crops 18 (3):433-437, DOI : 10.5958/2348-7542.2017.00075.4

Rai, K. N., Rai, T. N., & Rai, S. K. (2024). Effect of different herbicides on growth, yield and economics of transplanted rice (Oryza sativa L.) and soil health in up. *Agriculture*, *7*(1), 83-87.

Raj, S. K., Syriac, E. K., Devi, L. G., Meenakumari, K. S., Kumar, V., & Aparna, B. (2015). Impact of new herbicide molecule bispyribac sodium+ metamifop on soil health under direct seeded rice lowland condition. *Crop Research*, *50*(1to3), 1-8.

Ranjit, J. D., Rajbhandari, N.K., Bellinder, R., Kataki, P. (1998). Mapping Phalaris minor in the Rice-Wheat Cropping Systems of Different Agro-ecological Regions of Nepal. Nepal Agriculture Research Council, Nepal/ Soil Management Collaborative Research Support Program, Cornell University, USA. 68 p.

Rankova, Z., Moskova, Ts., Neshev, N., Yanev, M. & Dimitrov, G. (2023). Effect of Different Approaches to Soil Surface Maintenance on Weed Infestation and Growth Performance of Young Apricot Plantations. *Journal of Mountain Agriculture on the Balkans*, 26 (3), 238-250.

Reddy, S.R. (2000). Principles of crop production. P. 446-447 Kalyani Publishers, New Delhi, India

Rose, M. T., Cavagnaro, T. R., Scanlan, C. A., Rose, T. J., Vancov, T., Kimber, S., Kennedy. I. R., Kookana, R.S., & Van Zwieten, L. (2016). Impact of herbicides on soil biology and function. *Advances in agronomy*, *136*, 133-220.

Semenov, M. V., Zhelezova, A. D., Ksenofontova, N. A., Ivanova, E. A., Nikitin, D. A., & Semenov, V. M. (2025). Microbiological Indicators for Assessing the Effects of Agricultural Practices on Soil Health: A Review. *Agronomy*, *15*(2), 335.

Semerdjieva, I., Kalinova, S., Yanev, M., & Yankova Tsvetkova, E. (2015). Anatomical changes in tobacco leaf after treatment with isoxaflutole. *IJCRBP*, 2(7), 51–56.

Shopova, N. (2023). Planting time effect on the growth and yield of tomato (Solanum lycopersicum L.). *Scientific Papers. Series B. Horticulture*, 67(2), 391-396.

Shopova, N., & Cholakov, D. (2014). Effect of the age and planting area of tomato (Solanum licopersicum L.) seedlings for late field production on the physiological behavior of plants. *Bulgarian Journal of Agricultural Science*, 20(1), 173–177.

Shopova, N., & Cholakov, D. (2015). Economic efficiency of late tomato field production with seedlings grown in containers of different substrate composition. *Agricultural University – Plovdiv, Scientific Works*, 59(4), 131–136.

Singh, P., Ali, M. (2004). Efficacy of metsulfuron-methyl on weeds in wheat and its residual effects on succeeding soybean crop grown on Vertisol of Rajasthan. *Indian Journal of Weed Science* 36(1&2): 34-37.

Tripathi, S., Srivastava, P., Devi, R. S., & Bhadouria, R. (2020). Influence of synthetic fertilizers and pesticides on soil health and soil microbiology. In *Agrochemicals detection, treatment and remediation*. *Butterworth-Heinemann*, 25-54.

Vasudev Meena, MK Kaushik, Surendra K Meena, Jai Prakash Bhimwal and Bhagwat Singh Chouhan (2017). Influence of pre and post emergence herbicide application on weed growth and nutrient removal in wheat (*Triticum aestivum* L.). *Journal of Pharmacognosy and Phytochemistry*, 6(6): 2413-2418.

Verma, S.K., Singh, S.B., Meena, R.N., Prasad, S.K., Meena, R.S., (2015). A review of weed management in India: the need of new directions for sustainable agriculture. *The Bioscan*, 10:253-263.

Waheed, A., Qureshi, R., Jakhar, G.S., Tareen, H. (2009). Weed community dynamics in wheat crop of district Rahim Yar Khan, Pakistan. *Pak. J. Bot.* 41(1): 247-254.

Walia, U.S., Brar, L.S., Singh, K.J. (1997). Control of Rumex spinosus with sulfonyl urea herbicides in wheat. *Indian Journal of Weed Science* 29(3&4): 103-105.

Yanev, M. & Kalinova, Sht. (2020). Influence of glyphosate on leaf gas exchange and photosynthetic pigments of broomrape-infested tobacco plants. *BJAS*, 26(2), 435–440.

Yanev, M. (2020). Weed Control in Oilseed Rape (Brassica napus L.). *Scientific Papers. Series A. Agronomy*, LXIII(1), 622–631.

Yanev, M. (2021). Possibilities for herbicidal control of mixed weed infestation in maize (Zea mays L.). *Scientific Papers. Series A. Agronomy*, LXIV(1), 620– 631.

Yanev, M. (2022). Herbicidal weed control in winter wheat (Triticum aestivum L.). *Scientific Papers. Series A. Agronomy*, LXV (1), 613–624.

Yanev, M. (2023). Application of herbicides for weed control before germination and in the early vegetation in maize. *Scientific Papers. Series A. Agronomy*, 66(1), 631–642.

Yanev, M. (2024). Application of foliar herbicides to control broadleaf weeds in rye (*Secale cereale* L.). *Scientific Papers. Series A. Agronomy*, *67*(1), 742-750.

Yanev, M., Bozukov, H., & Kalinova, Sht. (2014a). Distribution of *Orobanche ramosa* L. and *Orobanche mutelii* Sch. in the Main Tobacco Producing Regions of Bulgaria. *Plant Science*, LI(1), 114–117.

Yanev, M., Kalinova, Sht., Bozukov, H., & Tahsin, N. (2014b). Technological Indexes of Oriental Tobacco Treated with Glyphosate for the Control of Broomrape. *Turkish Journal of Agricultural and Natural Sciences*, Special Issue, 1. 1025–1029.

Yanev, M. (2015). Study on weed infestation of tobacco fields in South Bulgaria. *Plant Science*, LII(3), 90–95.

Zabaloy, M. C., Zanini, G. P., Bianchinotti, V., Gomez, M. A., & Garland, J. L. (2011). Herbicides in the soil environment: linkage between bioavailability and microbial ecology. *Herbicides, theory and applications*, 161-192.

Zand, E., Baghestani, M.A., Soufizadeh, S., Azar, R.P., Veysi, M., Bagherani, N., Barjasteh, A., Khayami, M.M., & Nezamabadi, N. (2007). Broadleaved weed control in winter wheat (*Triticum aestivum* L.) with post-emergence herbicides in Iran. *Crop Protection*, 26(5), 746-752. doi: 10.1016/j.cropro.2006.06.014.

Zimdahl, R.L. (1993). Fundamentals of Weed Science. *Academic Press*, Inc.A Division of Harcourt Brace & Company London. New York, Boston Toronto.