Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 22, Issue 4, 2022
PRINT ISSN 2284-7995, E-ISSN 2285-3952

EFFICACITY EVALUATION OF SOME ANTI-DRIFT AGENTS IN THE CONDITIONS OF CARACAL PLAIN, ROMANIA

Gheorghe MATEI, Cătălin Viorel POPESCU, Mirela PARASCHIVU, Călin SĂLCEANU, Elena ROȘCULETE

University of Craiova, Faculty of Agronomy, 19 Libertății Street, Craiova, Dolj County, Romania, Phone: +400251418475, +40723509520; Mobile: +40773818957; +40744825227; + 40745577355; +40729589490, Emails: matei.gheorghe@gmail.com, catalin.popescu@gmail.com, paraschivumirela@yahoo.com, calin.salceanu@yahoo.com, rosculeta200@yahoo.com

Corresponding author: catalin.popescu@gmail.com

Abstract

The increasing use of pesticides in modern agriculture has led to increased concerns about the risk of pollution of surface waters, soil and its agro-productive properties. The application of large doses of pesticides using outdated technologies and non-performing agricultural equipments, with poor application in terms of distribution uniformity and the lack of farmers' knowledge and measures to prevent the drift phenomenon leads to their spread outside the targeted areas and implicitly to the increase of environmental pollution. In the present study, three anti-drift agents: EM260 (dodecilbenzensulfonat of calcium 50%, and butanol 18%), SC (heptametiltrisiloxan polietilenglicol) and respectively SO (surfactant non – ionic) have been tested according to ISO 22866, in the field conditions of Agricultural Research Development Station (ARDS) Caracal, Romania. The obtained results emphasized that the most valuable, among all variants, was EM260 (dodecilbenzensulfonat of calcium 50%, and butanol 18%) with smaller drift effect recorded at 1 meter distance (6.4%), followed by the second point, at 3 meters (3.1%) and at 5 meters with a calculated value of 2.1%. Also, at this variant the affected plants percent was smallest from the entire tested assortment, of 35.2%.

Key words**:** *drift, anti-drift agents, droplet size, crop protection, affected plants*

INTRODUCTION

The drift phenomenon refers to the floating in the atmosphere and the random movement (carried by the wind) of microparticles of the solution outside the target area when applying different pesticides. It can affect the effectiveness of the treatment itself, due to the fact that a smaller amount of solution reaches the target than the recommended dose, the health of people and animals, due to the penetration of toxic chemicals into inhabited areas near agricultural lands, in the habitat of wild animals, it can affect bees, surface waters and aquatic animals and also it can destroy neighboring crops in the field. By understanding the effects of drift and the factors that influence it, necessary measures can be taken to reduce it.

Spray drift is an inescapable consequence of agricultural plant protection operation, which has always been one of the major concerns in the spray application industry. Spray drift evaluation is essential to provide a basis for the rational selection of spray technique and working surroundings [13].

The reduction of drift is a concern both for environmental organizations and local communities as well, also for industry and agriculture. That is the reason why many specialists in these fields are engaged in a research work to find solutions in order to minimize its effects.

In the obvious climate changes the main issue worldwide proves to be the ability to provide food for billions of people using the resources from agriculture across the planet, ensuring health of plants, animals and people [9][14][16]. The new climate conditions, with higher temperatures and unevenly distributed rains, often outside the period of plant growth and fruiting, or with extreme weather events leads to reconsider the crops technologies, to create new genotypes with higher traits for pests and diseases resistance [3].

In the literature there are lots of studies related to the factors which can influence the drift phenomenon. The majority refers, with higher frequency, to: nozzle type, hole size, nozzle orientation during spraying, viscosity of the emulsion, pression in equipment, temperature and wind speed. Also, it can be mentioned the interactions between equipment, application methods, and spray mixtures, which is fundamental to optimize the application of pesticides. The determination of the best combination of these factors can reduce the drift during the application of treatment solutions [8]. The use of surfactant adjuvant must be carried out carefully, according to the nozzle model, working pressure, and spray mixture. The conventional single fan jet nozzle is more sensitive to increased working pressure and has a high potential to cause drift compared with the models with air induction [8].

The control of droplet spectrum can ensure a successful application of the agrochemical's solutions for various crops. In order to obtain a percentage of the volume of droplets smaller than 100 μm it is recommended the use of spray nozzle with the diameter of the favorable volumetric median for the solutions application leading to a safety anti-drift effect and to more homogeneous droplet spectrum. Adding adjuvants has lower risk of drift, and the increased concentration of adjuvants increase the homogeneity of the droplet spectrum [12, 4].

In the last years, on international market new drift control adjuvants were selected for drift studies in aerial applications. For those conditions, the deposition, droplet size, droplet coverage, and total drops were highly correlated to the drift distance and treatments or adjuvants [10].

The viscosity of emulsions is influenced by the ratio of water/oil. In case of rotary atomizers used for aerial applications, such as forest pest spraying and mosquito control sprays a higher viscosity of emulsion is needed. These types of atomizers have a rotating fan at speeds of 2,000 to 10,000 revolutions per minute (rpm) through which a spray is emitted and atomized. Many applicators routinely add spray adjuvants to change the droplet size, to reduce drift potential, or to reduce evaporative effects of a particular spray solution. For applicators working under hot, dry conditions where evaporation is a concern, choosing an oil-based adjuvant to help get better coverage by creating smaller droplets that do not evaporate, would be recommended [8].

MATERIALS AND METHODS

In order to evaluate the behavior of three anti-drift agents and direct drift of the pesticides on the field crops, a trial has been established in the experimental field at Agricultural Research Development Station (ARDS) Caracal from the University of Craiova. The tests were applied at wheat crop and included four variants using glyphosate herbicide solutions alone as well as in combination with anti-drift agents. Following the compatibility and stability tests carried out in the laboratory, three of the five identified agents - EM260 (dodecilbenzensulfonat of calcium 50%, butanol 18%), SC (heptametiltrisiloxan polietilenglicol) and respectively SO (surfactant non – ionic) were selected and retained for the field tests. Each of the tested variants consisted of a treatment zone and a measuring zone, adjacent to the treatment zone. According to ISO 22866, the area sprayed directly must be at least 20 m wide from the edge of the application area and the length of the spray track must be at least twice as long as the sampling distance in the transverse direction of the wind and must be symmetrical about the axis of the measuring area. Therefore, each test was performed over a spray distance of 40 m to treat an area of 800 m^2 (40 × 20 m) (Figures 1 and 2).

All variants were treated with glyphosate solution (dose of 3 l/ha) in 200 liters of water, in which the anti-drift agents EM260, SC and SO were added. The control variant (APG) was established without any anti-drift agent. Three repetitions were performed for each of the variants. The location of the measuring points was determined starting with half the space between the nozzles compared to the last nozzle of the application installation.

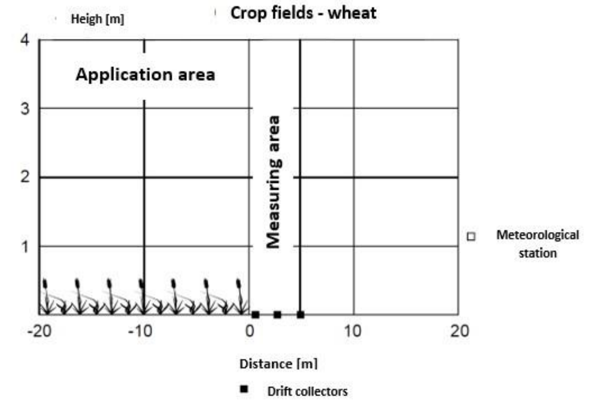

Fig. 1. Application and measuring areas scheme
Source: own experimental design.

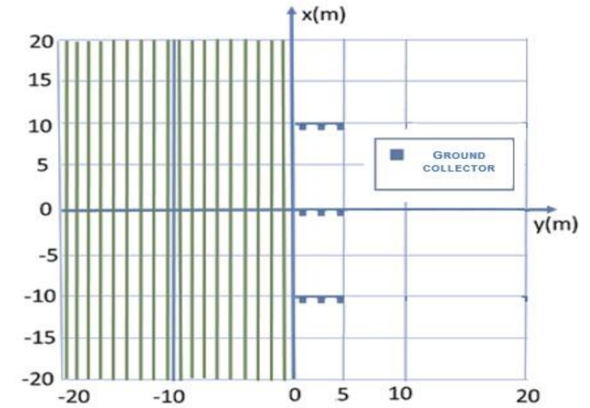

Fig. 2. Ground collectors' positions
Source: own experimental design.

In this study, to assess the risk of field drift, only one type of Lechler ST 110-04 flatbed nozzle was tested at a pressure of 3.0 bar at a flow rate of 1.6 l/minute (Figure 3).

Fig. 3. Lechler ST 110-04 flatbed nozzle
Source: https://www.lechler.com [11].

In order to ensure the application of 200 l/ha, the movement was made with a speed of 10 km/h.
The reference/control application APG was established as the application with the horizontal ramp spray system with flat nozzles with flattened jets standard ISO 04, without air support/induction, with a spray ramp height and nozzle distance of 0.50 m, at a pressure of 3.0 bar and a speed of 10 km/h, resulting an application dose of 200 l/ha. This control application was used for a comparative assessment of the different applications with anti-drift agents. The measurements were performed according to ISO 28666 (2005).
Many studies focused on the efficacy of different types of nozzles pressure on the total reduction potential of drift PRD were made and some obtained data were presented in Table 1.

Table 1. Efficacy of various nozzle types

Nozzle	ISO nozzle size	DRP_t (%) average	SD
F	02	-136.5	*83.3*
F^S	03	0	*0*
F	04	33.9	*20.8*
F	06	29.5	*6.0*
LD	02	-3.6	*56.2*
LD	03	38.4	*11.9*
LD	04	54.9	*15.4*
Injet	02	67.2	*9.7*
Injet	03	89.8	*3.8*
Injet	04	77.7	*4.3*

Reference spray application; DRPt, Total drift reduction potential
Source: Nuyttens et al. (2008) [15].

During the tests, the following data were recorded (in the area behind the test area, 2 meters above the ground): wind direction (one measured value per second); wind speed (one measured value per second); air temperature (one value measured per displacement); relative humidity (one value measured on the move). The recordings were made with Habotest HT625B digital multimeter meter and correlated with the data obtained from the weather station from experimental fields of ARDS Caracal.
For this research, in each test variant, were evaluated the drops deposited on collectors placed horizontally on the ground at different distances from the edge of the application surface, respectively 1; 3; 5 m were measured. The experiments were arranged for three repetitions for each variant. The collectors consisted of pieces of wood on which were placed water-sensitive papers measuring 52 x 76 mm (an area of 39.5 square cm).
Water-sensitive paper is a special paper, of different sizes, treated with a substance that changes color in contact with liquids. It is used to assess the degree of products coverage of the target surface when carrying out phytosanitary treatments. Special papers

were subsequently scanned and processed using the DepositScan/ImageJ program.
In order to determine the negative impact of the drift on crop plants, measurements of the number of plants affected by glyphosate were performed using the metric frame.

RESULTS AND DISCUSSIONS

Spray drift to unintended areas is more of a concern as applications of nonselective herbicides associated with herbicide-resistant crops and the proximity of residential land to agricultural land increase [19]. Without the use of anti-drift agents, the application of foliar fertilizers, herbicides and pesticides would generally be ineffective, firstly because of the inadequate treatment of the crops and secondly because of the unwanted effects on other collateral crops, on the soil and waters. The tests carried out indicated that, in some cases, the anti-drift agents determined the reduction of the drift effect with values between 50-80%. [2][5][20].
Spraying disperses the liquid into droplets of small diameter, the average diameter of the resulting droplets can be very different, from a few microns (μm) to 2-3 mm [10]. Depending on the average droplet size, the following forms (categories) of spraying liquid dispersion are distinguished: atomization, fine spraying, sprinkling and (artificial) rain (Figure 4).

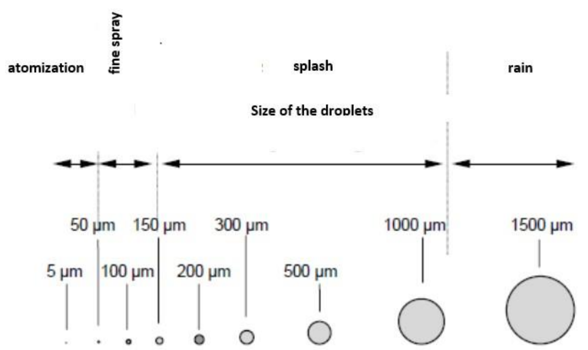

Fig. 4. Classification of forms of spraying (dispersion) of the sprayed liquid according to the size of the drops
Source: Stahli W. & Bungescu T.S. (2006) [18].

Current spraying machines produce drops with diameters between 50 μm and 1.5-2 mm. The size of the drops used depends on the treatment applied and the product sprayed. Thus, for the works to combat cryptogamic diseases, drops with a small diameter are mainly used, and the application of fungicides is usually done by fine spraying. For the rest of the control products and depending on the toxicity of the product for the environment, it is recommended to spray with drops with diameters between 150 and 600 μm. [5][6][17].
In the agricultural sprays more importance is generally given to the pesticide and less to the application technique, though the losses can overpass 70%. The high temperature and the low relative humidity of the air have important effects on the spraying of pesticides, causing faster evaporation of the drops [1].
In the present experiment, the data from table 1 show that the main climatic conditions recorded on 10 repetitions during the test, the wind ranged between 3.57 m/s at variant APG+SC to 4.60 m/s at variant APG (Table 2). Also, the temperature raises from 10.5°C when the control variant (APG) was tested to 13.5°C at variant APG+SO.

Table 2. Climatic conditions during the test in the experimental fields

Sample/test	Number of records	Wind Speed (m/s)	Temp. (°C)	Relative humidity (%)	Dominant wind direction
APG	10	4.60	10.5	84.2	E/NE
APG+EM260	10	3.97	11.0	82.8	E/NE
APG+SC	10	3.57	13.3	71.4	NE
APG+SO	10	3.92	13.5	70.0	NE

Source: own records.

An inverse relationship is observed between temperature and relative humidity of the air. At the beginning of tests, the air humidity was 84.2% (APG variant) and at the end of tests the recorded value was 70.0% in the conditions of increase of the temperature (APG+SO).
It was taken into consideration the dominant wind directions during the tests and the main values shows us that the E/NE was dominant when we applied APG and APG+EM260 and NE direction when we tested the other two variants: APG+SC and APG+SO.
In accordance with the testing procedure, the collectors on the ground – with sensitive

papers samples - were positioned at different distances from the edge of the application surface, respectively 1; 3; 5 m.

After the herbicide application, the sensitive papers were collected and analyzed in order to establish the drift effect by the surface covered by droplets related to the entire surface of the paper sample (Figures 5, 6, 7 and 8).

At the first variant (APG) the dispersion of the droplets (Figure 5) was obvious different was different at the three distances tested. The larger droplets were recorded at 1 meter distance, followed by medium large and medium size on second distance of 3 meter and those with smaller size on the third distance of 5 meter. The calculated values for drift percentage, as average on the three repetitions, were 14.2% at 1 meter, 7.9% for 3 meters distance and 5.2% in case of the 5 meters distance (Table 3).

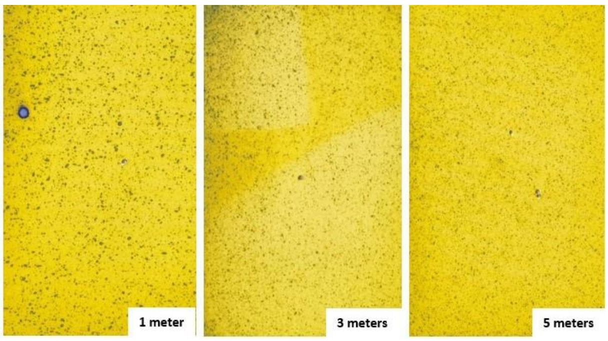

Fig. 5. Images of the water sensitive papers with drop deposits when herbicide glyphosate is applied (APG)
Source: own records.

At the second variant (APG+EM260) we obtained the most valuable results which put us in the position to considerate the EM260 anti-drift agent as the best of the tested assortment. The combination of APG with dodecilbenzensulfonat of calcium 50% and butanol 18% conduct to modified droplet sizes, those with larger size (which represent a large percent of total droplets) were observed on the sensitive paper of ground collector placed at 1 meter from application area (Figure 6). For this point we calculated a value of drift phenomenon of 6.4% (Table 3). On the other two point placed at 3 and respectively 5 meters the values of drift were 2.9% and 1.8%.

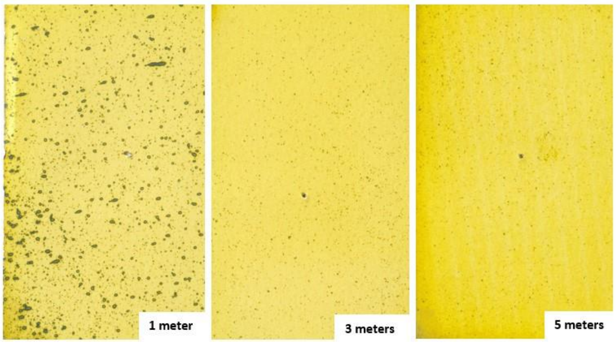

Fig. 6. Images of the water sensitive papers with drop deposits when herbicide is applied with EM260 agent (APG+EM260)
Source: own records.

In case of the third variant (APG+SC), the combination of glyphosate with heptamethyltrisiloxane, polietilenglicol had a favorable influence in order to reduce the drift phenomenon. The uniformity of the distribution of the drops is higher (Figure 7), and the amplitudes between of the values of distances of point recorded in Table 3 certify this.

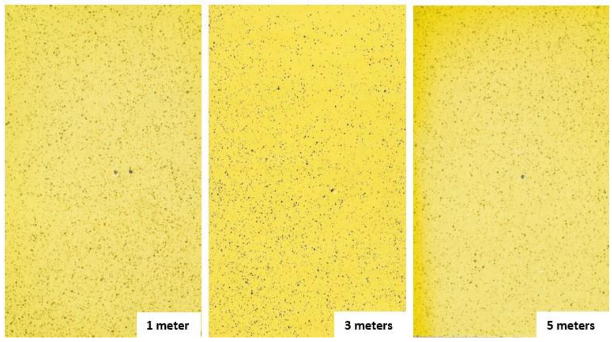

Fig. 7. Images of the water sensitive papers with drop deposits when herbicide is applied with SC agent (APG+SC)
Source: own records.

At 1 meter point, the calculated drift was of 7.6%. For the second point, at 3 meters, we were determinate a drift of 4.3%. On the last point, at 5 meters from the application area, the value of the calculated drift was of 3.1%. This variant, due the results obtained, was appreciated as worst of all in order to reduce de drift phenomenon.

The last tested variant, APG+SO (Figure 9) had almost a similar behavior as previous one, but the values of drift were smaller that the precedent one (Table 3).

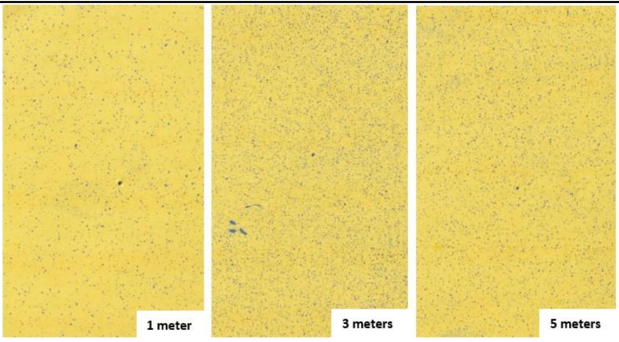

Fig. 8. Images of the water sensitive papers with drop deposits when herbicide is applied with SO agent (APG+SO)
Source: own records.

The non – ionic surfactant used as anti-drift agent prove to be a good solution for decreasing the risks of the uncontrolled spread of pesticide in agricultural practices. Droplet spectrum is also with small differences between ground points of observation. The higher value of drift was recorded at 1 meter distance, with 6.4%, followed by the second point, at 3 meters, with 3.1% and last of the positions, at 5 meters, with a calculated value of 2.1%.

Table 3. The percentage of drift registered on water sensitive papers at tested variants (%)

Number/ anti-drift agent	Distance	Number of plants/sqm	Number of affected plants	Percentage of affected plants (%)
APG	1 m	327.0	277.0	85.0
	3 m	363.0	288.0	79.0
	5 m	389.0	281.0	73.0
APG + EM260	1 m	425.7	232.7	54.5
	3 m	424.7	206.0	48.7
	5 m	449.0	158.7	35.2
APG + SC	1 m	410.0	248.7	60.7
	3 m	460.3	260.7	56.9
	5 m	418.7	200.7	48.2
APG + SO	1 m	462.7	260.7	56.3
	3 m	456.7	230.0	50.3
	5 m	402.0	163.3	40.6

Source: own calculations.

Not only the technical aspect of the experiment was important, but also the practical one. For this reason, we made some field determinations in order to evaluate the percent of the affected plants after the tests were done. All the observation were made at 15 days after application using the square meter frame (Photo 1).

There were determined the number of plants/square meter in the application area, the number of affected plants due the drift phenomenon and based on those values was calculated the percentage of the affected plants (Table 4).

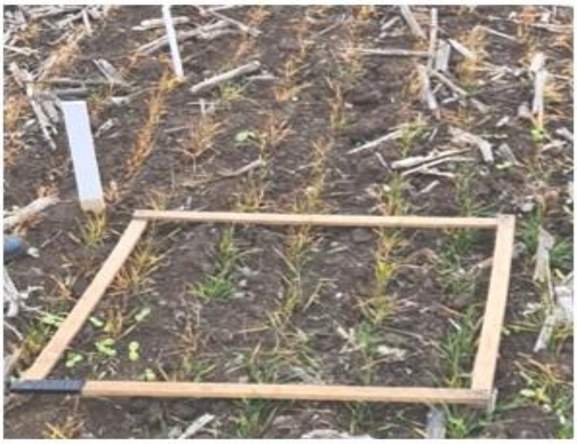

Photo 1. Fields aspect from the determinations of affected plants by experimented variants
Source: own records.

Table 4. Comparative drift measurements using the metric frame by determining the number of the herbicide affected plants with glyphosate alone and with anti-drift agents

Type / Distance		R1 % Drops	R2 % Drops	R3 % Drops	Average
APG	1m	14.3	13.4	15.0	14.2
	3m	8.6	7.1	8.0	7.9
	5m	7.5	4.6	3.5	5.2
APG + EM 260	1m	8.5	4.6	6.2	6.4
	3m	4.0	2.1	2.8	2.9
	5m	2.0	1.6	1.7	1.8
APG + SC	1m	7.8	7.3	7.8	7.6
	3m	4.3	4.1	4.5	4.3
	5m	3.8	2.7	2.9	3.1
APG + SC	1m	6.4	6.6	6.3	6.4
	3m	3.0	3.3	2.9	3.1
	5m	2.2	1.5	2.8	2.1

Source: own calculations.

As it can be observed, the damage caused by the direct action of glyphosate herbicide drift had different values due the treatment/variant tested. The highest percentage of the affected plants has been recorded at variant APG where the glyphosate was applied alone. The percent varied starting 85% at 1 meter point to 79% at the second recorded point at distance of 3 meter and the last values of 73% has been calculated at the point placed at 5 meters distance.

The trend line of decreasing values from first point (1meter) to last point (5 meters) has been registered also to the other variants, but the calculated values were smaller that the control. Thus, on the second variant, where we applied glyphosate with EM260 anti-drift agent, the percent of affected plants was the smallest from the entire experiment and varied between 54.5% at distance of 1 meter to 35.2% at 5 meters distance. In comparison with the control variant the decrease is more than 30% in case of the distance of 1 meter ground collector and 24.3% in case of the 5 meters distance. This aspect can be observed also in Figure 9 where all the tested variants were compared between them selves.

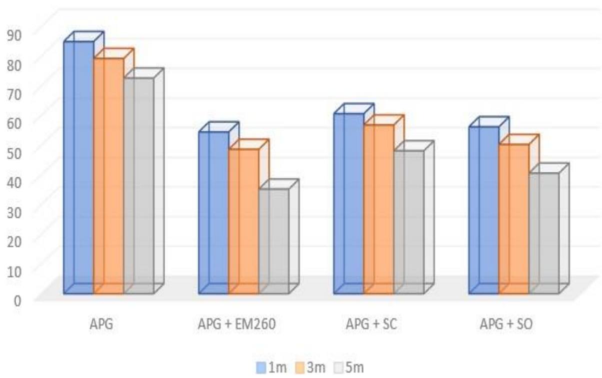

Fig. 9. Drift evaluation of herbicide treatments with anti-drift agents
Source: own calculations.

The last two variants, APG+SC and APG+SO, had closer values of the affected plants, range between 60.7% and 40.2% in case of APG+SC and 56.3% and 40.6% for the APG+SO variant.

CONCLUSIONS

All over the world there is a large interest about the prevention of drift generated by the application of pesticides to protect the environment. Mitigation of risk arising from spray drift in Europe is achieved mostly by implementation of no-spray buffer zones and the use of approved drift-reducing techniques. Developed country, such Belgium, adopted their own strategy for drift mitigation. In their legislation there is a mainly consists of a classification list of spray nozzles, air assistance and shielded systems are also considered. Also, in Germany, England, the Netherlands and Sweden were adopted specific measures in order to reduce the pollution of surface waters by spray drift in field crops and orchards.

It is all known that the physicochemical properties of spray solutions have a powerful influence to spray drift and they are not yet incorporated into regulatory risk assessments at the European level. The most common solutions to combat the phenomenon of drift remain the use of anti-drift agents or the use of specific nozzles.

Related the tested anti-drift agents in the present experiment it was highlighted the combination of APG+EM260 applied with type of Lechler ST 110-04 flatbed nozzle at a pressure of 3.0 bar and at a flow rate of 1.6 l/minute which had the most valuable results regarding the smallest drift percent and the lowest percent of affected plants. Good practical results were recorded also in combination of APG+SO, variant which have surfactant non – ionic as anti-drift agent.

ACKNOWLEDGEMENTS

This work was supported by a grant of the Romanian Ministry of Education and Research, CCCDI-UEFISCDI, Project number PN III – P3-3.5-EUK-2019-0220, within PNCDI III.

REFERENCES

[1]Balan, M.G., Abi-Saab, O.J.G., da Silva, C.G., do Rio, A., 2008, Deposition of the spraying suspension for three spray nozzles under different meteorological conditions, Semina-Ciencias Agrarias, Vol. 29 (2): 293-298.

[2]Chen, Y., Hou, C., Tang, Y., Zhuang, J., Lin, J., Luo, S., 2019, An effective spray drift-reducing method for a plant-protection unmanned aerial vehicle. International Journal of Agricultural and Biological Engineering, 12(5):14-20.

[3]Cotuna, O., Paraschivu, M., Bulai, A., Toma, I., Sărăţeanu,V., Horablaga, N.M., Buzna, C., 2021, Behaviour of some oat lines to the attack of the fungus Blumeria graminis (D. C.) f. sp. avenae EM. Marchal. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 21 (4):161-170.

[4]De Lima Lopes, L., dos Reis, E.F., 2020, Espectro de gotas de caldas de pulverização com diferentes pontas e adjuvantes (Spectrum of spray droplets with different nozzles and adjuvants), Revista Brasileira De Ciencias Agrarias-Agraria, Vol. 15 (2). e6552, DOI:10.5039/agraria.v15i2a6552

[5]Heidary, Al., M., Douzals, J.P., Sinfort, C., Vallet, A., 2014, Influence of spray characteristics on potential spray drift of fi eld crop sprayers: a literature review. Crop Prot., 63:120-130.

[6]Hilz, E., Vermeer, A.W.P.P., 2013, Spray drift review: the extent to which a formulation can contribute to spray drift reduction. Crop Prot 44: 75–83.

[7]Hoffmann, W.C., Fritz, B.K., Yang, C.H., 2016, Effects of Spray Adjuvants on Spray Droplet Size from a Rotary Atomizer, Pesticide formulation and delivery systems: 35th volume, pesticide formulations, adjuvants, and spray characterization in 2014. Book Series American Society for Testing and Materials Selected Technical Papers Vol. 1587: 52-60.

[8]Godinho, J.D., Vieira, L.C., Ruas, R.A.A., Carvalho, A., Faria, V.R., God, P.I.V.G ., 2020, Spray nozzles, working pressures and use of adjuvant in reduction of 2,4-D herbicide spray drift. PLANTA DANINHA. Volume: 38.WOS:000584464000001

[9]Kilian, B., Dempewolf, H., Guarino, L., Werner, P., Coyne, C., Warburton, M.L., 2021. Crop Science special issue: Adapting agriculture to climate change: A walk on the wild side. Crop Science, Vol:61:32–36.

[10]Lan, Y., Hoffmann, W.C., Fritz, B.K., Martin, D.E., Lopez, J.D., 2008, Spray drift mitigation with spray mix adjuvants., Applied engineering in agriculture, Vol. 24 (1): 5-10.

[11]Lechler.com, 2022, Standard flat spray nozzles ST -Lechler, https://www.lechler.com/de-en/products-nozzles-spray-technology-systems/product-range/agriculture/nozzles-for-broadcast-spraying/st, Accessed on Sept. 10, 2022.

[12]Lewis, R.W., Evans, R.A., Malic, N., Saito, K., Cameron, N.R., 2016, Polymeric drift control adjuvants for agricultural spraying. Macromol. Chem. Phys., 217(20), 2223-2242.

[13]Li, L.,, Zhang, R.., Chen, L., Liu, B., Zhang, L., Tang, Q., Ding, C., Zhang, Z., Hewitt, A.J., 2022, Spray drift evaluation with point clouds data of 3D LiDAR as a potential alternative to the sampling method. Frontiers in plant science. Vol. 13. https://doi.org/10.3389/fpls.2022.939733

[14]Matei, Gh., 2016, Study on yield features of sweet sorghum hybrids grown in South West of Romania, International Multidisciplinary Scientific GeoConference: SGEM, Issue 1: 783-790.

[15]Nuyttens, D., De Schampheleire, M., Baetens, K., Sonck, B., 2008, Comparison of different drift risk assessment means. Aspects of Applied Biology, Vol. 84. International Advances in Pesticide Application.

[16]Păunescu, G., Paraschivu, M., Păunescu, R.A., Roșculete, C.A., 2022, The relationship between yield and pathogens attack on the advanced breeding winter wheat lines assessed for adult plant resistance. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 22 (1): 493-501.

[17]Popescu, C.V., Paraschivu, M., Matei, Gh., Sălceanu, C., Roșculete, E., 2022, Anti-drift technology: market, formulation, applying methods, Scientific Papers, Series Management, Economic Engineering in Agriculture and Rural Development, Vol 22 (3).

[18]Stahli W., Bungescu T.S., 2006, Appliances, Equipment and Machines for plant protection (Aparate, echipamente și mașini pentru protecția plantelor). Agroprint Publishing House, Timișoara, p. 86.

[19]Vangessel, M.J., Johnson, Q.R., 2005, Evaluating drift control agents to reduce short distance movement and effect on herbicide performance, Weed Technology, Vol. 19 (1), 78-85.

[20]Wang, X., He, X., Song, J., Wang, Z., Wang, C., Wang, S., Meng, Y., 2018, Drift potential of UAV with adjuvants in aerial applications. International Journal of Agricultural and Biological Engineering, 11(5):54-58.