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Physicochemical and Phytotoxic Studies of Arena 7% OD Herbicide on Some Morphological Parameters of Common Wheat (*Triticum aestivum* L.)

Ramadan F. Hamaad[(1)], Zakia K. Elkhiat[(2)], Nasser A. Ibrahim[(2)#]
[(1)]Phytotoxicity Department, Central Agricultural Pesticide Laboratory, Agricultural Research Centre (ARC), Giza, Egypt; [(2)]Pesticide Formulation Department, Central Agricultural Pesticide Laboratory, Agricultural Research Centre (ARC), Giza, Egypt.

PHYSICOCHEMICAL characterization of arena 7% OD herbicide formulation and spray tank solutions, as well as its phytotoxic effects, were studied to investigate the problems caused by its application to manage weeds on common wheat plants. Cultivators recorded that application of the herbicide in 2020 destroyed about 20% of common wheat in some governorates in Egypt. A ready-made sample of the herbicide was used in the study. Three different concentrations of the herbicide were applied which include half recommended, recommended and double recommended doses. Phytotoxic action on the common wheat plant was studied under laboratory and outdoor conditions. Morphological parameters measured under laboratory conditions are relative root length (%), relative shoot length (%) and relative germination ratio (%). Phytotoxic parameters measured in outdoor experiments include biomass (g), plant length (cm), spike weight (g), grain weight (g), stem and root lengths (cm) and weights (g). The results obtained revealed that both pesticide formulation and its spray solutions pass successfully the required tests according to the standard organizations. Arena 7% OD has phytotoxic effects on seed germination (%) and seedling growth especially the double recommended dose. The outdoor experiment indicated that the tested herbicide is non phytotoxic to wheat. Both half and full recommended (600 $ml.ha^{-1}$ and 1200 $ml.ha^{-1}$) doses non–significantly increased the common wheat yield components as plant length and plant biomass. Based on the obtained data, it turns out that away from the quality of arena formulation there are other factors caused its undesirable effects on common wheat in Egypt.

Keywords: Arena 7% OD herbicide, Common wheat (*Triticum aestivum* L.), Physicochemical properties, Phytotoxicity.

Introduction

The common wheat (*Triticum aestivum* L.) is one of the most important cereal crops in the world, where it is used as food for one-third of the world's population (Laila et al., 2014). It is ranked by global production as the second cereal crop after rice (*Oryza sativa*) and as the number one in terms of the total area under cultivation (FAO, 2018; OECD–FAO, 2018). About 95% of the wheat produced consists of *Triticum aestivum* L., which is called common or bread or soft wheat (Mayer et al., 2014). In Egypt, common wheat is the most important cereal crop. It represents almost 10% of the total value of agricultural production and about 20% of all agricultural imports (McGil et al., 2015). Increasing the productivity of wheat is one of the main goals of the Egyptian agricultural policy, to face the rapid increase in human populations (Hoda et al., 2018).

Weeds competition with wheat is a key point in yield reduction of wheat (Zand et al., 2007; Waheed et al., 2009). As a result, weed management is a very important component of management practices recommended to increase crop production.

#Corresponding author email: naaibrahim@yahoo.com
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Herbicides are the most important and effective tool for weed management to improve crop yield and quality (Safina & Absy, 2017). Arena7% OD is the trade name of a herbicide mixture registered newly in Egypt (Reg. No. 2706) and recommended to control narrow and wide weeds in wheat fields at a rate of 1200 ml.ha^{-1}. It is an oil dispersion (OD) formulation that contains clodinafop–propargyl (6.5%), florasulam (0.5%) as active ingredients and mefenpyr–diethyl (3.0%) as a safener (Rosenhauer et al., 2016).

Geminiani et al. (2008) observed no yield reduction in various cultivars of soft wheat after application of some post-emergence herbicides and their combinations including iodosulfuron, fenoxaprop–P–ethyl, mefenpyr–diethyl, metsulfuron-methyl, tribenuron–methyl, clodinafop–propargyl, cloquintocet–mexyl, and florasulam. On the other hand, some negative effects of using herbicides on cereal crops were recorded. Kong et al. (2009) found that grain yield was reduced due to mesosulfuron application without safener by 2.7–10.1% for varieties of hard winter wheat and by 1.6–6.6% for soft winter wheat. Sikkema et al. (2007) reported a visible injury to wheat crop as much as 5% when evaluated 42 days after treatment by herbicide combination of dicamba, MCPA, and mecoprop. In 2020 many farmers from different governorates in Egypt submitted complaints to the agricultural pesticides committee due to destroying about 20% of their crops by applying arena 7% OD herbicide on wheat. The herbicide is recommended to be used as a post-emergence herbicide in wheat (Safina & Absy, 2017). The aim of this study is to study the physicochemical properties and phytotoxic effects of arena 7% OD herbicide hoping to find out reasons for the undesirable effects of such herbicide.

Materials and Methods

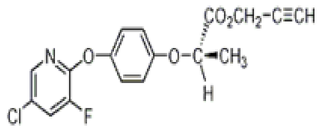
Chemicals used

Pesticide used

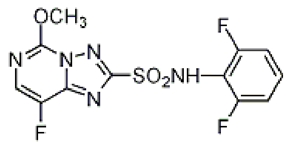
Arena 7 % OD is a herbicide mixture contains florasulam 0.5% + clodinafop–propargyl 6.5% (as active ingredient) + mefenpyr–diethyl 3.0% (as herbicide safener). It is manufactured by Qingdao Nongguan pesticide Co, Ltd– China and imported by Starchem Industrial Chemicals, Egypt. The herbicide sample used in the study was obtained from Pesticide Analysis Dept., Central Agricultural Pesticide Laboratory (CAPL), Agricultural Research Center (ARC), Egypt.

Chemical names and structures

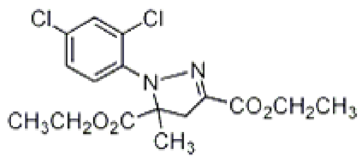
Florasulam: IUPAC name :2′,6′,8–trifluoro–5–methoxy[1,2,4] triazolo [1,5–c] pyrimidine–2–sulfonanilide



Clodinafop–propargyl: IUPAC name: prop–2–ynyl (R)–2–[4– (5–chloro–3–fluoropyridin–2–yloxy)phenoxy] propionate.



Mefenpyr–diethyl: IUPAC name: diethyl (RS)–1–(2,4–dichloro–phenyl)–5–methyl–2–pyrazoline–3,5–dicarboxylate.



Spray tank solutions

The spray solutions used in the study are WHO standard soft and hard water. Hard water was prepared by dissolving 0.304g of calcium chloride (anhydrous) and 0.139g of magnesium chloride hexahydrate in distilled water and made up to one liter. This provides total hardness equivalent to 342 ppm of calcium carbonate. Soft water was prepared by mixing one volume of the previous hard water with five volumes of distilled water to provide water hardness of 57ppm (WHO, 1979).

Determination of the active ingredient contents of the studied herbicide.

High-performance liquid chromatography (HPLC) equipment (Agilent technologies 1260 Infinity with UV detector) was used. The column is Eslips plus C18. The mobile phase used is a mixture of acetonitrile: methanol (90:10) for clodinafop –propargyl and acetonitrile: methanol (30:70) for mefenpyr–diethyl. The wavelength for florasulam is 235nm, the column temperature is 30ºC, the flow rate is 3mL/ min and the injection volume used was 5µL. Data obtained are illustrated in Table 1.

Determination of the physicochemical properties of the formulation and its spray solutions at different *storage conditions*

Physical and chemical characteristics were investigated for the formulation and its spray tank solutions to determine the stability and the quality of the formulation before and after both accelerated cold and hot storage processes. The accelerated hot storage process was executed by placing the sample (100 ml) in a capped bottle in an oven at 54 ± 2°C for 14 days CIPAC MT 46.3 (1999). For the stability test at low temperature (0°C), 100mL of a sample was transferred to a glass tube and kept in the refrigerator at 0±1°C for 7 days. At the end of day 7, the tubes were removed from the refrigerator and allowed to remain undisturbed at room temperature for 3 hours. The volume of any separated material at the bottom of the tubes was subsequently recorded CIPAC MT 39.3 (1999). The following physicochemical properties of both formulation and its spray solutions were carried out to justify the formulation storage stability tests where data obtained are illustrated in Tables 2 and 3.

Persistent foam

Persistent foam is a measure of the amount of foam present in a spray tank after dilution with water. Five ml of the formulation was added to 95 ml hard water and 95 ml soft water in two separated measuring cylinders and made up them to the mark. The cylinders were Stoppard and inverted 30 times and left on the bench for 5 min. The volume of foam was recorded according to CIPAC MT 47.1 (1995).

Dispersion stability

The effect of dispersions stability of oil dispersion formulations was measured according to CIPAC MT 180 (1997). Ten mL of formulation sample was pipetted (dropwise) into 250mL graduated cylinders filled with 240mL hard water at room temperature (23±2°C) and the cylinder was inverted 30 times. The same steps were repeated using 240mL of soft water. The dispersion characteristics (amount of cream, free oil and sediment) were observed after 0.5h in two cylinders.

Electrical conductivity

It was measured for spray solutions only using Thermo Orion Conductivity, Salinity and TDS meter "model 115A$^+$, USA" for 1.0% v/v spray solution of the three spray solutions. It was carried out at 25±2°C following CIPAC MT 32 (1995). One (g) of the formulation was weighed and added to 100mL distilled water in a beaker then completely mixed. The electrode of the instrument was immersed into the mixture and left for 1–2min during the measurement at room temperature (25±2°C) to allow the conductivity value to stabilize.

Viscosity

It was measured for formulation and spray solutions using ″Brookfield DV II+ PRO″ digital Viscometer (Brookfield, USA). According to the requirements of ASTM–D2196–15 (2015). The temperature was kept at 25°C during all measurements using of water bath TC–502, USA.

Surface tension

It was estimated for formulation and spray solutions using Force Tensiomate Sigma 700 USA by Whilmy plate method to satisfy the test procedure ASTM–D1331–14 (2014).

Density and specific gravity

Density and specific gravity of formulation only were measured using the autosampler Rudolph Densitometer (2910–the USA) according to the test method ASTM–D4052–11 (2011).

pH value

PH values of both formulation and its spray solutions were measured using Jenway pH meter (3510 – UK) supported by HANNA pH electrode following the requirements of CIPAC MT 75.3 (1999) test method.

Free acidity or alkalinity

They were measured using electrometric endpoint according to CIPAC MT 191 (2005) for formulation**.** About 10g of the sample were weighed then added to100mL deionized water and stirred well to homogenize. The sample was titrated electrometrically to pH= 7 at ambient temperature (25±2°C). Either a sodium hydroxide solution (t mL) or hydrochloric acid solutions (s mL) were used depending on the pH of the solution

Acidity calculated as $H_2SO_4 = \frac{4.904\ x\ t\ x\ C_1}{w}$

Alkalinity calculated as NaOH = $\frac{4.001\ x\ s\ x\ C_2}{w}$

where: C_1= Conc. of sodium hydroxide solution (mol/L), C_2= Conc. of hydrochloric acid solution (mol/L), W= Weight of the sample.

Wet sieve test

The wet sieve test of the formulation was determined according to CIPAC MT 185 (2003). Ten grams of the sample with 100mL tap water were mixed in a 250mL beaker. The beaker was allowed to stand for 60sec, then stirred with a magnetic stirrer for an additional 5min. The slurry was then transferred to the sieve (diameter 75µm mesh size) then rinsed sample on the sieve with tap water for 10min. The residue was dried then weighed and calculated as a percentage of the sample weight.

Laboratory bioassay

Petri dish bioassay was carried out according to Pannacci et al. (2013, 2015) and Yang & Watts (2005). Ten evenly sized seeds of wheat (*Triticum aestivum* cv. Gemezza 11) were pre-sterilized with 2% sodium hypochlorite for 5min then rinsed three times with distilled water. The seeds were placed in Petri dishes (10mm) containing one layer of Whatman No.1 filter paper. Five mL of each herbicide concentration (half recommended, full recommended and double recommended doses) was added separately per Petri–dish. The control dishes were moistened with 5 ml of distilled water. The treatments were replicated four times according to a completely randomized design. All Petri dishes were placed in a dark chamber at 20/10°C (day/night temperatures). Distilled water was added to all Petri dishes as needed. Germination (%), shoot and root lengths (cm) per petri–dish was determined 10 days after incubation. Relative root elongation %, relative shoot elongation % and relative germination % were calculated as follows and listed in Table 4:

Relative germination %= (Seeds germinated in tested sample/ seeds germinated in control) × 100

Relative root length %= (Mean root length in tested sample/ mean root length in control) × 100

Relative shoot length %= (Mean shoot length in tested sample/ mean shoot length in control) × 100

Outdoor pots experiment

The outdoor pot experiment was conducted at the experimental field of the Central Agricultural Pesticide Laboratory (CAPL), Dokki, Giza governorate, Egypt, during the 2019–2020 season. Plastic pots (30cm diameter x 30cm high) were filled with an equal volume of field clay soil. Ten equalized healthy seeds of wheat (*Triticum aestivum* L. cv. Gemezza 11) were planted in November 2019. The seedlings were thinned to five uniformly sized seedlings per pot ten days after germination. The pots were irrigated and fertilized as needed according to the Egyptian Ministry of Agriculture Recommendations. The experiment was designed as randomized blocks with six replications. Arena 7% OD herbicide was applied at the stage of 2–4 leaves of common wheat plants using a 2–L hand sprayer equipped with a flat fan nozzle delivering a spray volume of 20mL.m^{-2} (480 l.ha^{-1}). The herbicide was applied at three doses; half recommended dose (600mL.ha^{-1}), recommended dose (1200mL.ha^{-1}) and double recommended dose (2400mL.ha^{-1}) in addition to the untreated control. The plants were allowed to grow to seed maturity. At harvest, to obtain almost complete roots, the roots were gently washed with tap water and air-dried. Finally, the plants were cut into roots and shoots then air-dried in shadow for one month. Dry biomass weight (whole plant weight) (g), root weight (g), stem weight (g), spike weight (g), and grain weight (g) in addition to whole plant length (cm), stem height (cm) and root length (cm) were determined (Soliman et al., 2011**)** and listed in Table (5). Weight reduction was calculated as a percentage of the untreated control as follows:

Dry weight reduction (%)= (DWc−DWt)/DWc X 100

where, Wc is the average weight of untreated plants and Wt is the average weight of treated plants.

Statistical analysis

One-way ANOVA followed by the least significant differences (LSD) was subjected to IPM_SPSS Ver. 20 statistical software to find out among the treatment effects. The results were presented as mean ± SD (standard deviation). Statistical significance was accepted when the probability of the result assuming the null hypothesis (P) is less than 0.05.

Results and Discussion

Investigation of the quality of the studied herbicide.

Effect of storage conditions on the chemical and physical properties of arena formulation.

The chemical and physical characteristics of pesticides greatly affect their biological and environmental behaviors. The characteristics can determine the pesticide dosage, method of application, mode of action and the subsequent environmental chemodynamics (Emara & Abd Elattif, 2020). As a result, laboratory investigations for pesticides quality are a major routine work in pesticides research and industry. The main objective is the verification of properties, performance and toxicity of pesticides in pre and post-registration. Data in Table 1 show the active ingredient contents of arena 7% OD herbicide at different storage conditions as detected by HPLC chromatography. There is no evidence to indicate that a product has a satisfactory shelf life, of at least 2 years, in different temperature zones. Accelerated cold and hot storage tests give a piece of good evidence for the validity of formulations on the markets for about 2 years under different storage conditions (El–Sayed & Mohammad, 2014). Clodinafop–propargyl contents before and after accelerated hot and cold storage conditions are (6.91, 6.71 and 6.74%) respectively. The percentages of florasulam before and after hot and cold storage are recorded as (0.505, 0.497 and 0.502%) respectively. On the same sequence, the percentages of safener before and after storage were found to be (2.84, 2.84 and 2.83%). The obtained results showed no significant changes in the active components of the herbicide and all obtained values are in the acceptable range of tolerance of ± 15% of florasulam (a.i), ± 10% for both clodinafop–propargyl (a.i) and mefenpyr–diethyl (safener) Manual on the development and use of FAO and WHO specifications (2016).

Physicochemical parameters of arena 7% OD formulation were measured according to the specifications of WHO (1979), JMPSa (2002) and JMPSb (2010) recommendations. They include viscosity, surface tension, pH, dispersion stability and conductivity before and after accelerated storage conditions. Data in Table 2 show such parameters. It is clear that the values of each parameter are close and no significant differences between values in the three checked conditions (fresh and after accelerated storage conditions). The most affected parameter is the wet sieve test after the cold storage process where such storage conditions reduced the test value from 0.33% to 20%. Although the change is significant the value remains in the acceptable range. FAO and WHO (2016), stated that the acceptable limit of the wet sieve is 0.5% w/w from the weight of the sample retained on 75µm test sieve. Mostly, there were no valuable changes in the physicochemical properties of arena formulation which indicates its stability and resistance to the stress of both cold and hot storage processes.

Physical properties of spray solutions of arena 7% OD formulation

The most important tests that determine the quality of OD formulation are dispersion stability, persistent foam, surface tension, viscosity, conductivity and pH value. Dispersion stability test measures the amount of separated oily layer or sedimentation of the formulation in the spray tank solution. According to APVMA (2020) and JMPSb (2010), the acceptable limit of the test is the separation of 2mL oil layer as a maximum. The importance of measuring the pH value or acidity level of pesticide spray solution is in measuring the rate of hydrolysis of pesticides. It was recorded that the rate becomes faster as the pH value becomes more alkaline, especially if the pH value is 8 or greater. Consequently, it is preferred to lower the pH of water in the spray mixture within the acidic range (EL–AW, 2008). Slavica et al. (2012) mentioned that the variation in pH values ranged from 4.6 to 6.0 when persistent foam changed from 0 to 6.0mL. Data in Table 3 show that all spray solutions of arena 7% OD are acidic and the two storage processes slightly change the pH values. Data also indicate that persistent foam reduced significantly after cold and hot storage while, surface tension changed non significantly after storage. Mostly, arena formulation meets the required specifications and storage conditions change such specifications non–significantly.

TABLE 1. Effect of storage conditions on the active ingredient contents for arena 7% OD

Arena 7 % OD	Before storage	After accelerated storage	
		Hot	Cold
Clodinafop-propargyl 6.5 % (a.i)	6.91	6.71	6.74
Florasulam 0.5 % (a.i)	0.505	0.497	0.502
Mefenpyr-diethyl 3.0 % (safener)	2.84	2.84	2.83

TABLE 2. Physicochemical properties of Arena 7% (OD) formulation

Physical properties	Arena 7% OD formulation		
	Before storage (fresh)	After storage	
		Hot	Cold
Surface tension (dyne/ cm)	31.17	29.77	32.32
pH value	4.20	3.99	4.15
Acidity (as % H_2SO_4)	0.54	0.51	0.49
Density (gm/cm^3)	0.971	0.961	0.982
Specific gravity	0.973	0.965	0.985
Viscosity (cP)	135.69	129.22	138.60
Wet sieve test	0.33%	0.28%	0.20%

O.D= Oil Dispersion

TABLE 3. Physicochemical properties of arena 7% OD spray solutions

Physical properties	Before storage		After accelerated storage			
			Hot		Cold	
	S. W	H. W	S. W	H. W	S. W	H. W
Dispersion stability (mL)	1.0	1.0	0.5	1.0	1.0	1.5
Persistent foam (mL)	3.0	3.0	2.5	3.0	1.5	2.0
pH value	4.09	6.56	4.01	6.46	4.61	5.31
Surface Tension (dyne/cm)	29.85	30.08	27.76	28.00	31.34	31.67
Viscosity (cp)	1.83	1.92	1.82	1.90	1.85	1.66
Conductivity (µs)	155.4	420.0	146.3	410.4	127.6	385.0

S.W = Soft water H.W = Hard water

Phytotoxicity studies.

Laboratory bioassay

Data in Table 4 illustrate the results of the petri–dish experiment carried out in the laboratory. Arena herbicide has strong phytotoxic effects on seed germination and seedling growth of common wheat (*Triticum aestivum* L.), especially the double recommended dose (2400mL.ha^{-1}). Compared with the untreated control (relative germination % is 100), the relative germination percentages are 87.5%, 82.5% and 20.0% for half recommended, recommended, and double recommended doses respectively. Double recommended dose inhibited the relative germination strongly while half and full recommended doses reduced it moderately. Root and shoot lengths were significantly inhibited by all three applied doses. The measured root lengths are 54.00, 2.85, 1.85, and 0.40cm/dish for untreated control, treated with half recommended, recommended and double recommended doses respectively. Such values show high significant difference between the untreated control and the other three treatments and also a significant difference between every two treatments.

Also, the measured shoot lengths are 116.10, 16.72, 12.10, and 2.10cm/dish, respectively. The lowest phytotoxic effect toward wheat seedling growth was observed with the half-recommended dose while the highest was with the double recommended dose. No significant differences in shoot length parameters were observed between half recommended and double recommended dose treatments. Significant reduction in growth parameters in all studied doses, compared with the untreated control, can be explained by the fact that arena herbicide is a post-emergence herbicide. Post-emergent herbicides are products used to eradicate weeds and other non–desirable vegetation that has already been emergent from the soil while pre-emergent herbicides kill weeds before emergence from the soil (Kumar Naik et al., 2016; Safina & Absy, 2017).

TABLE 4. Phytotoxic effects of different doses of Arena 7.0% OD herbicide on seed germination and seedling growth (root and shoot length) of common wheat (*Triticum aestivum* L.)

Application rate ($mL.ha^{-1}$)	Relative germ. (%)	Root length ($cm\ dish^{-1}$)	Relative root length (%)	Shoot length ($cm\ dish^{-1}$)	Relative shoot length (%)
Untreated control ($0.0mL.ha^{-1}$)	100.00	54.00 ± 0.81^{a}	100.00	116.10 ± 8.05a	100.00
Half recommended dose ($600mL.ha^{-1}$)	87.50	2.85 ± 0.52^{b}	5.20	16.72 ± 3.32^{b}	14.40
Recommended dose ($1200mL.ha^{-1}$)	82.50]	1.85 ± 0.54^{c}	3.42	12.10 ± 0.31^{bc}	10.42
Double recommended dose ($2400mL.ha^{-1}$)	20.00	0.40 ± 0.46^{d}	0.70	2.10 ± 2.45^{d}	1.80

- Values are means of three replicates of each parameter ± S.D.
- Means within each column followed by the same letter are not significantly at P> 0.05.

Effect of arena herbicide on wheat yield components.

Results presented in Table 5 show that half and full recommended doses of arena herbicide increase the whole plant weight or plant biomass (g) in non–significant manner compared with the untreated control. The highest plant biomass value (43.93± 4.17g) was obtained with the application of the recommended dose. The double recommended dose of arena herbicide does not affect plant biomass. Plant length (cm) was increased with the application of both half recommended and full recommended doses in a non–significant manner too. The shortest plant length (79.00± 1.78cm) was obtained in the application of the double recommended dose. These results are in agreement with that obtained by Marwat et al. (2005), Arif et al. (2011), and Shehzad et al. (2012), who reported that application of post-emergence herbicides has no significant effect on plant height. Data also show that both half and full recommended doses increase the stem weight (g) significantly while double recommended dose increases it non–significantly. In addition, half and full recommended doses non–significantly increase the stem length (cm) and double recommended dose reduces it non–significantly. The maximum stem elongation (69.5± 1.37cm) was recorded by applying the half-recommended dose.

Root weight and root length are also non–significantly affected by the application of all doses. The lowest root weight and root length values (5.20± 0.60g and 11.16± 1.16cm) were recorded in treatment with the double recommended dose. Both half and full recommended doses cause a non–significant increase in the root weight and a decrease in the root length values. Data also show that spike and grain weight values affected non–significantly by applying the three treatments. The double recommended dose gave a slight reduction (21.23± 3.08g and 13.74± 2.38g) in phytotoxic parameters spike weight and grain weight respectively as compared with the untreated control. Recommended dose non–significantly increases the spike weight (22.92± 3.48g) with no effect on grain weight. We can say that the application of herbicide with the recommended dose increases the spike weight by 4.4% with no effects on the grain weight while applying the double recommended dose reduces the spike weight by 3.3% and grain weight by 4.4%. The obtained results are in agreement with that obtained by Elattar et al. (2018) which evaluated the phytotoxicity of some post-emergence herbicides (florasulam is one of their active ingredients) on wheat. They found no visible phytotoxicity, an increase in plant height and yield attributes (spike length, biological and grain yields). Data obtained by application of the recommended dose are in contrast to that obtained by Hamouz et al. (2015) who stated that yield losses reached 5.3% and 4.3% in treatments with herbicides applied with and without urea–ammonium nitrate fertilizer solution (UAN), respectively. Application of double recommended dose of arena herbicide gave a reduction in yield near to that reported by Hamouz et al. (2015) as mentioned before.

TABLE 5. Effect of different doses of Arena 7.0% OD on the morphological parameters of common wheat (*Triticum aestivum* L.).

Application rate ($mL.ha^{-1}$)	Biomass or plant weight (g)	Plant length (cm)	Stem weight (g)	Stem length (cm)	Root weight (g)	Root length (cm)	Spike weight (g)	Grain weight (g)
Untreated control ($0.0mL.ha^{-1}$)	40.68± 2.49^{a}	79.16± 2.04^{a}	13.48± 0.86^{a}	67.16± 2.13^{ab}	5.23± 0.1^{a}	12.00± 1.09^{a}	21.96± 1.40^{a}	14.37± 1.25^{a}
Half recommended dose ($600mL.ha^{-1}$)	42.71± 5.92^{a}	80.66± 1.63^{a}	14.33± 1.96a^{b}	69.50± 1.37^{a}	5.92± 1.52^{a}	11.33± 0.81^{a}	22.38± 2.83^{a}	14.01± 1.58^{a}
Recommended dose ($1200mL.\ ha^{-1}$)	43.93± 4.17^{a}	80.83± 1.72^{a}	15.22± 1.18^{b}	69.00± 1.78^{ab}	5.78± 1.4^{a}	11.83± 1.47^{a}	22.92± 3.48^{a}	14.37± 2.30^{a}
Double recommended dose ($2400mL.ha^{-1}$)	40.41± 4.09^{a}	79.00± 1.78^{a}	13.65± 1.26^{ab}	66.66± 2.33^{b}	5.20± 0.60^{a}	11.16± 1.16^{a}	21.23± 3.08^{a}	13.74± 2.38a

- Data presented as the means of six replicates ± S.D.
- Different letters refer to significant difference (P≤ 0.05).

In general, both half and full recommended doses increased most of the tested wheat yield components non–significantly, while the double recommended dose reduced the stem weight significantly and the other parameters non–significantly. The stimulation effect of the half recommended and full recommended doses may be due to the hormesis phenomenon. Some substances, although toxic at higher doses, can be stimulatory or even beneficial at low doses. The stimulatory effect of a low dose of such toxicants is called hormesis. They coined this term using the Greek word "hormo" which means to excite. The same root is used in the word hormone (Duke et al., 2006). Hormesis has been found within all groups of organisms, from bacteria and fungi to higher plants and animals (Calabrese, 2005). When applied in low doses, herbicides may even have a stimulatory effect on the crop (Cedergreen, 2008; Belz et al., 2011). A survey of hormesis caused by herbicides in crop and aquatic plants demonstrated that hormesis can range from a few percentages up to a 100% increase in the measured parameter, but with an average of 20–30% stimulation compared to the control (Cedergreen et al., 2005).

Conclusion

To search for the reasons upon which arena 7% OD herbicide caused some destructive effects to the wheat crop in Egypt in 2020, the current study was conducted. The reasons were postulated to be due to formulation corruption or phytotoxicity. Laboratory and semi-field experiments were carried out to investigate the chemical, physical and phytotoxic parameters of the herbicide. The herbicide sample used in the study was supplied from Pesticide Analysis Department, Central Agricultural Pesticide Laboratory (CAPL), Egypt. The chemical and physical properties of the herbicide were studied under different storage conditions. A phytotoxicity study was carried out using three application rates (half recommended, recommended and double recommended doses). Data obtained revealed that arena herbicide verifies the specifications needed for registration and trading of pesticides in Egypt according to the standard organizations. Accelerated cold and hot storage processes non–significantly affect the physicochemical properties of the herbicide. As a post-emergence herbicide, arena showed no phytotoxic effects using the recommended dose. Both half and full recommended doses increased non–significantly most of the phytotoxic parameters of wheat as a nontarget plant. Consequently, problems caused by arena herbicide that destroyed about 20% of the common wheat crop may be due to the wrong application of herbicide, application by untrained applicants, using expired samples, using cheated packages (with no safener), using obsolete samples, or using illegally manufactured arena herbicide.

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دراسات فيزيائية و كيميائية و السمية النباتية لمبيد Arena 7% OD على بعض الخواص المورفولوجية لنبات القمح (*Triticum aestivum* L.)

رمضان فرغلى حماد، زكية كمال الخياط، ناصر عبدالمنعم ابراهيم
المعمل المركزى للمبيدات – مركز البحوث الزراعية – الجيزة – مصر.

فى هذا البحث تم دراسة الخصائص الفيزيائية والكيميائية لمبيد الحشائش 7٪ Arena OD ومحاليل الرش له بالإضافة إلى تأثيرات المبيد السامة للنباتات وذلك لدراسة المشكلات التي سببها تطبيق المبيد عند مكافحة الحشائش الحولية المصاحبة لنبات القمح فى مصر، حيث رصد المزارعون تدمير ما يقرب من 20٪ من محصول القمح في بعض المحافظات عند تطبيق المبيد في عام 2020. فى الدراسة تم استخدام عينة جاهزة (Ready made) من المبيد تم أحضارها من قسم التحليل بالمعمل المركزى للمبيدات. تم تطبيق ثلاث تراكيز مختلفة من المبيد والتي تشمل نصف الجرعة الموصي بها والجرعة الموصي بها وضعف الجرعة الموصى بها على نبات القمح، حيث تم دراسة التأثير السام للمبيد على نبات القمح في الظروف المختبرية والحقلية. العوامل المورفولوجية التي تم قياسها تحت الظروف المعملية هي الطول النسبي للجذر، الطول النسبي للسيقان ونسبة الإنبات. عوامل سمية المبيد للنبات والتي تم قياسها في التجربة الخارجية هى الكتلة الحيوية، وطول النبات، ووزن السنبلة، ووزن الحبوب، وأطوال وأوزان الساق والجذر. أظهرت النتائج التي تم الحصول عليها أن كلاً من الخواص الفيزيائية والكيميائية للمبيد ومحاليل الرش الخاصة به اجتازت بنجاح الاختبارات المطلوبة وفقًا للمنظمات القياسية الدولية وأن مبيد Arena 7٪ OD له تأثيرات سامة على إنبات البذور ونمو شتلات نبات القمح خاصة عند المعاملة بضعف الجرعة الموصى بها على نبات القمح. أشارت نتائج التجربة االنصف حقلية أن المبيد المختبر لم يظهر تأثيراً سام معنوى على نبات القمح ولم تؤدي الجرعات النصفية والكاملة الموصى بها إلى زيادة معنوية في مكونات محصول القمح. بناء على البيانات والنتائج التى تم الحصول عليها فى الدراسة يتضح أن هناك عوامل أخرى غير مواصفات وجودة مركب الأرينا هى التى أدت إلى مشاكل فى محصول القمح فى مصر عند أستخدام المبيد لمحاربة الحشائش عريضة وضيقة الأوراق على نبات القمح.