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Effect of Application Timing and Dosage of Recent Herbicidal Mixtures on Wheat Weeds, Yield and Yield Components and Grain Quality.

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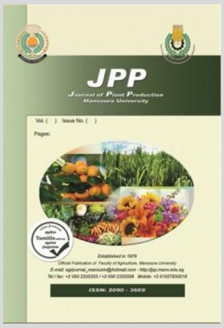

ABSTRACT

Three times of application were randomly distributed in main plots; however, five herbicidal mixtures and control treatments were allocated in sub-plots. *Lolium, Phalaris* as narrow leaf and *Medicago hispida* as broad leaf weeds were dominant in first, second and both seasons, respectively. All studied mixtures under three application timing caused 100% control of broad leaf weeds. Most of herbicide mixtures, especially with Co- formulated at higher dose (0.12 kg/ha) provided suitable control level for *Phalaris* and *Lolium* at first and second application timing compared with third one. So, the optimum time to apply post-emergence herbicide mixtures is at tillering stage "B" of wheat. All herbicide mixtures recorded low indexes of injuries on wheat plants which disappeared completely after 4 weeks from herbicide application, except with third application timing in the first season which gave some phytotoxicity up to 6 weeks because of rain full after two hours from herbicide application. Application herbicide mixtures, generally increased wheat plant growth, grain yield, number of effective tillers/m^2, number of grains /spike^1,100-grain weight, and harvest index in the two seasons, compared with unweeded treatment. Foliar application of the studied herbicides at tillering stage "B" of wheat crop produced the highest growth, grain yield, attributes, grain protein and gluten contents, followed by early application at two leaves "A" growth stage. The best results for wheat growth, yield and grain quality traits resulted from Co-formulated herbicide mixtures application at wheat tillering growth stage.

Keywords: Wheat yield, grain yield, weed control, herbicides, time of application.

INTRODUCTION

Wheat (*Triticum aestivum*, L.) is one the leading cereal crops and took the first rank for both acreage and productivity in the world. It is used for as food and feed crop, where it provides the Egyptian people with 37% of the total calories and 40% protein in the Egyptian diet (Min. Agric. Statistic yearbook, 2000). In Egypt, there is a gap between wheat production and consumption, so a great attention should be paid to overcome or minimize this gab through vertical improvement and horizontal expansion in new reclaimed soils.

The acute problem of both grassy and broad leaf weeds is becoming very common in wheat growing areas of north and south of Egypt, which often results in huge yield losses and makes the weed control more complex. Several herbicides have been used from time to time to control weeds in wheat crop. Continuous use of the same herbicide or herbicides having the same mode of action may result in shift in weed flora, development resistance in weeds (Moss and Rubin, 1993 and Singh *et al*, 2009).

The acetolactate synthase (ALS) inhibiting herbicides are the most effective and widespread method to control broad and grassy weeds in wheat crop. They can control a very wide spectrum of weeds at very low doses measured in grams rather than kilograms per hectare (Sabra *et al*., 2006; Pawan *et al*., 2012; Mahmoud *et al*., 2016; Safina and Absy, 2017; Pacanoski and Mehmeti, 2018; and Sivran *et al*., 2020).

On the other hand, the development of the graminicide of the acetyl CO$^-$ enzyme A Carboxylase (ACCase) inhibiting herbicides such as clodina-fop, diclofop, fenoxa-prop, tralkoxydim and pinoxaden has been investigated in wheat crop to controlling grass weeds by many investigators (Punia *et al.*, 2008; Pawan *et al*., 2012; Mahmoud *et al*., 2016 and Sivran *et al*., 2020).

In most cases, Pre-mix and ready mix of ALS group with ACCase group gives complete control of weeds in wheat crop and broaden control weed spectrum. (Pawan *et al*., 2012; Reddy *et al*., 2013; Abdul Khaliq *et al*., 2014 and Mahmoud *et al*., 2016).

Timing of application and herbicide mixtures dosage played an important role in herbicides efficacy (Auskalnis and Kadzys, 2006).

The aim of this research work was to evaluate the effect of application timing of three herbicidal mixtures Co-formulation (with three dosage), tank mix and ready mix on weed control, growth, yield, yield attributes and grain quality of Wheat crop.

MATERIALS AND METHODS

The present study was carried out at Agriculture Research Station, Faculty of Agriculture, Alexandria University during the two successive winter seasons of 2018/2019 and 2019/2020 to evaluate the effect of application timing and dosage of herbicidal mixtures on weed control, growth, yield, and grain quality of wheat crop.

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Gemmiza II cultivar was drill planted in November 20 in the two-growing seasons at seeding rate of 60 kg/fed.

The experimental design was randomized complete block in split arrangement with four replications. The herbicidal mixtures utilized, common name, material name, form type, rate/ha and application timing are listed in Table (1).

Table 1. Herbicidal mixtures utilized in wheat and common name, material name, form type, rate/ha and application timing and type of formulation.

Treatments	Appl. Code	Appl. Timing	Common name	Material name	Form Type	Rate/ha	Unit	Type of formulation
T_0	-		Untreated	UNTREATED	-	-	-	-
T_1	A B C	BBCH 13-15 BBCH 21-22 BBCH 31-32	Florasulam + Halauxifen-methyl + Pyroxsulam +Surfer (ECOSURF EH9)	GF-3706 GF-2607	WG SL	0.072 0.48	Kg /ha L/ha	Co- formulation
T_2	A B C	BBCH 13-15 BBCH 21-22 BBCH 31-32	Florasulam + Halauxifen-methyl + Pyroxsulam +Surfer (ECOSURF EH9)	GF-3706 GF-2607	WG SL	0.096 0.48	Kg /ha L/ha	Co- formulation
T_3	A B C	BBCH 13-15 BBCH 21-22 BBCH 31-32	Florasulam + Halauxifen-methyl + Pyroxsulam +Surfer (ECOSURF EH9)	GF-3706 GF-2607	WG SL	0.12 0.48	Kg/ha L/ha	Co- formulation
T_4	A B C	BBCH 13-15 BBCH 21-22 BBCH 31-32	Pinoxaden + Pyroxsulam + Halauxifen-methyl	Axial Pallas GF-2353	EC OD SC	0.8 0.222 0.0625	L/ha L/ha L/ha	Tank mix
T_5	A B C	BBCH 13-15 BBCH 21-22 BBCH 31-32	Pyroxsulam + Florasulam + Cloquintocet- methyl +Surfer (ECOSURF EH9)	Broad way star GF-2607	WG SL	0.264 0.48	Kg /ha L/ha	Ready mix

A: Application at four leaf growth stage.
B: Application at the beginning tillering growth stage.
C: Application at internode elongation growth stage.

Three times of application (BBCH 13-15 (Two leaf "A"), BBCH 21-22 (Tillering stage "B") and BBCH 31-32 (Internode elongation "C") according to Zadoks *et al.* (1974) were randomly distributed in main plots, however five herbicidal mixtures, i.e., T_1, T_2, T_3, T_4 and T_5 besides the unwedded check were allocated in the sub-plots. The sub-plot area was 21 m^2 (7 m length ×3 m width).

All herbicide mixtures were applied by a knapsack sprayer with flat- fan nozzle (TK_I) as post-emergence application with three application timing (25,35 and 45 days after sowing). All other agricultural practices were carried out as recommended in Alexandria Governorate.

Data for weeds density (m^2) and wheat growth stage and were recorded for each weed and wheat before herbicidal application using standard procedures. Injury % of wheat crop was visually assessed at 2,4 and 6 weeks after herbicidal application according to the methodology proposed by SBPD, 1995. Fresh weight of weeds was randomly recorded for one square meter after 56 days after treatment using a quadrate of 50 cm × 50 cm in each sub-plot. Fresh weight (gm/ m^2) for each weed species, total weeds and weed control percentages were calculated. Before harvest, grassy seed heads per square meter were recorded.

At harvest of wheat crop, the following measurements were determined as an average of 10 wheat plants randomly taken from each sub- plot. Plant height (cm), Spike length (cm), number of spikelet and grains /spike, 100-grain weight (g) as an average of two samples from each sub-plot, number of fertile tillers/m^2 determined from one square meter taken at random from each sub-plot, grain yield (ton/ha) determined by threshing all the plants in each sub-plot and converted the plot grain yield to (ton /ha) and harvest index (%) calculated as grain yield/biological yield ×100.

Wheat grain protein (%) and dry gluten (g) contents were determined at crop science labs., Faculty of Agriculture, Alexandria University according to the instructions of the manufactures and procedures given in (A.A.C.C, 2000).

Statistical analysis of the experimental data, in each season, was performed according to Gomez and Gomez (1984). Comparison between means of treatments was carried out using the least significant differences method at 0.05 level of probability (L.S.D $_{0.05}$).

RESULTS AND DISCUSSION

Effect of herbicide mixtures on wheat growth and weed control.

1- Weeds, crop stage and density:

Data illustrated in Table (2) indicate the major weeds infesting the experimental plots were: *Medicago hispida*, *Anagallis arvensis*, as broad leaf weeds, and *Phalaris* sp and *Lolium* sp as grassy weeds . Among these, the most dominant weed species was *Lolium* sp (78 and 70.5 plants/m^2) in the first and second seasons, respectively. Similar findings were obtained by El-Metwally and El-Rokiek, 2007; Singh *et al.*, 2008; Saad *et al.*, 2011; El-Rokiek *et al.*, 2012; El-Kholy *et al.*, 2013; Dalgaa *et al.*, 2014; El-Metwally *et al.*, 2015 and Mahmoud *et al.*, 2016.

Percentage of weeds density were increased from 17.5 at first application timing (4 leaf stage of wheat) up to 27.5 in the third application timing (beginning of internode elongation of wheat) in the first season, whereas, from 31.25 up to 35 in second season. Wheat height at first, second and third application timing were 17, 25 and 35 cm, respectively, in the first season: and 16, 24 and 40 cm, respectively, in the second season. All weeds and crop growth stages and density before the three-herbicide application timing are presented in Table (2) and weediness recorded 125 plants/m^2 in the first trial and 162.5 plants/m^2 in the second season. These findings are in conformity with Pacanoski and Mehmeti, 2018.

Table 2. Weeds and crop stages and density before the herbicidal application timing during first and second seasons.

Weeds and crops	Four leaf growth stage.						Beginning of tillering growth stage						Internode elongation stage					
	No. of plants/(m^2)		Plant height (cm)		No. of leaves		No. of plants/(m^2)		Plant height (cm)		No. of leaves or tillers		No. of plants/ (m^2)		Plant height (cm)		No. of leaves or tillers	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
Medicago hispida	8	17	4	5	5	6	7	18	8	12	2 T	3 T	9	16.8	11	*19*	3 T	5 L
Anagallis arvensis	17	51	2	2	4	4	14	49	4	4	6 L	6 L	14	47	5	8	8 L	10 L
Phalaris sp	18	70.5	10	6	3	3	18	65.3	12	11	4 L	4 L	20	62.5	16	22	3 T	4 T
Lolium sp	78	20	9	6	5	3	73.5	21.0	11	12	6 L	6 L	75.5	19.5	18	27	4 T	7 T
Wheat	119	84	17	16	4	4	126	85	25	24	2 T	2 T	130	86	35	40	4 T	5 T
% of weed density	17.5	31.25	17.5	31.25	17.5	31.25	22.5	31.5	22.5	31.5	22.5	31.5	27.5	35	27.5	35	27.5	35

S_1: First season (2018/2019)
S_2: Second season (2019/2020)
L: Number of leaves.
T: Number of tillers.

2- Injury effects of herbicidal mixtures on wheat crop:

The phytotoxicity of wheat crop presented a different response when herbicide mixture treatments were applied. At first application timing, all herbicide mixtures (T_1 up to T_5) caused low wheat injury, which ranged from 5 - 5.75% across post treatments 14 days after application (DAA) Table (3) in the first trial and from 4 – 8.25% in the second trial. The symptoms of phytotoxicity dissipated over time and disappeared completely after 4 WAA for first season and 6 WAA for second season. The same trend was observed with all herbicide mixtures.

Treatments in the second herbicide application timing T_3((Florasulam + Halauxifen-Methyl+ Pyroxsulam), Co-Formulated mixture (0.12 kg/ha) + Ecosurf 0.48L/ha caused the high value of phytotoxicity.

On the other hand, most of herbicide treatments gave high injury effect against wheat crop in the third application timing in the first season only, values of phototoxicity ranged between 10 to 23.25 % after 14 days from herbicide application and from 4.75 to 23.75 % after 28 days from herbicide application, this may be due to rainfall after 2 hours from herbicide application. The highest values were noticed with T_3 and T_5. All herbicide mixtures contain Pyroxsulam as a Co-Formulation (T_1, T_2, T_3), tank mix (T_4) or ready mix (T_5).

Reddy *et al.* (2013) found that Pyroxsulam caused (8 to 13 %) leaf chlorosis two weeks after application. However, injury symptoms disappeared, and Wheat recovered completely with 3 to 4 weeks. Results of this study agree with Reddy *et al.*, (2013). Hoffer *et al.*, (2006) reported that (1- 5 %) average Wheat phytotoxicity after Pinoxaden treatment at the recommended rate. Pyroxsulam caused (5- 10%) Wheat injury 5-14 DAT. However, injury was always transient and not detectable by the end of the season (Geier *et al.*, 2011). These results also agree with finding Mahmoud *et al*., (2016) which found that, symptoms of herbicides injury at beginning of tiller application stage showed injury from most herbicide treatments after one and two weeks from application, these symptoms were recovered after 4 weeks.

Table 3. Percentage of wheat visual injury after 14, 28 and 42 days from the herbicidal applications during the two seasons.

Treatments	14 days						28 days						42 days					
	Four leaf growth stage.		Beginning tillering growth stage		Internode elongation stage		Four leaf growth stage.		Beginning tillering growth stage		Internode elongation stage		Four leaf growth stage.		Beginning tillering growth stage		Internode elongation stage	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
T_0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_1	5.25	4.5	6.0	7.0	18.25	7.0	0	4.5	0	3.0	8.25	2.5	0	0	0	0	2.75	0
T_2	5.25	8.25	5.0	7.25	21.25	8.75	0	6.75	0	5.25	12.5	3.5	0	0	0	0	4.75	0
T_3	5.25	5.5	6.75	9.0	23.25	9.5	0	8.0	0	5.25	15.75	5.25	0	0	0	0	6.0	0
T_4	5.75	5.25	4.5	3.25	10.0	7.0	0	4.0	0	3.50	4.75	3.25	0	0	0	0	0	0
T_5	5.00	4.0	13	10.25	22.5	7.25	0	2.75	9	3.75	23.75	4.75	0	0	5.5	0	11.25	0

S_1: First season (2018/2019). **S_2: Second season (2019/2020).**

3-Weed control efficiency:

A- Weeds fresh weight (gm/m^2).

Major weeds infesting the experimental plots were *Medicago hispid*a, *Anagallis arvensis,* as broad leaf weeds , and *Phalaris* sp and *Lolium* sp , among these the most dominant weed species was *Lolium* spp and the fresh weight accumulated by this weed in unwedded check during first, second and third application timing were 1605 gm/m^2,1665 gm/m^2 and 1715 gm/m^2 in the first year respectively and 1000 gm/m^2 ,1020 gm/m^2 and 1120 gm/m^2 respectively in the second year Table (4)

On the other hand, *Phalaris* spp recorded 405, 435 and 475 gm/m^2 for first, second and third application timing respectively in the first trial and 2555, 2555 and 2725 gm/m^2 respectively in the second trial. So, from the previous results, we can say that *Lolium* is the dominant weed in the first season and *Phalaris* is the dominant in the second season. All herbicide treatments (five treatments) with three application timing caused 100% control of broad leaf weeds compared with weedy check in two different seasons. The high results in controlling of broad leaf due to containing Co-formulated mix under three doses (T_1, T_2, T_3), Tank mix (T_4) and ready mix (T_5) of Florasulam , Halauxifen-Methyl and Pyroxsulam which are effective against broad leaf weeds. The results of five herbicides mixture treatments confirm with Mahmoud *et al.* (2016) and El-Kholy *et al.*

2013.In general there was no difference in the efficacy on weed mass in wheat when the all-herbicide mixtures were applied at the four-leaf stage, at the beginning of tillering and the beginning of internode elongation.

With regarding to grassy weeds, the highest value of controlling *Lolium* spp was obtained with all herbicide mixtures at application timing of tillering stage (BBCH-21-22) compared with 4 leaf stage and beginning of internode elongation in two seasons. Data in Table (4) also presented that T_1, T_2, T_3, T_4 and T_5 gave 85,88.3,91.6,87.7 and 89.2 percent control of *Loluim* sp., respectively in the first season and 71.6, 84.4,92.2,80.1 and 90.7, respectively in second trial. So, the most effective treatment against *Lolium* spp in two seasons was T_3, which recorded percentage 91.6 in first season and 92.2 in the second season compared with unwedded check. All post herbicide mixtures which applied in the beginning of internode elongation stage of Wheat gave lowest controlling of *Lolium* spp, which presented between 66 to 75 % at first trial and between 67 and 82 % in the second season. From these values T_3 gave the highest percentage control in two seasons.

On the other hand, *Phalaris* spp was the dominant weed in the second season and the second weed in the first season. Most of herbicidal mixtures gave excellent control to this weed in application timing one and two and low in the third application timing. With respect of higher values of controlling *Phalaris* spp in the first season in application timing three may be due to selection pressure of dominant weed in this trial (*Lolium* spp). As the dose of 0.072 kg/ha (T_1) which increased to 0.096 kg/ha (T_2) and 0.12 kg/ha (T_3) were improved the controlling of *Phalaris* spp up to 100%. The efficacy of Co-formulated mixture with three doses (T_1, T_2 and T_3), Tank mix (T_4) and ready mix (T_5) in controlling two grassy weeds may be due to containing of all five treatments of Pyroxsulam and in addition to Pinoxaden in (T_4) to minimize risk of wheat injury and maximize of weeds control, the best time to apply post-emergence herbicide mixtures is at the beginning of tillering growth stage of wheat similar finding were obtained by Jack *et al*, (1996).

Table 4. Means of herbicidal mixtures and application timing effects on weeds fresh weight after 56 days from herbicides application during the two seasons.

Treatments	weeds	Means of weeds fresh weight (gm/ m^2)											
		Four leaf growth stage.				Beginning tillering growth stage				Internode elongation stage			
		Weight		% Control		Weight		% Control		Weight		% Control	
		S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
T_0	*Medicago hispida*	245	706	0	0	330	703	0	0	371	785	0	0
	Anagallis arvensis	43	240	0	0	51	265	0	0	68	263	0	0
	Phalaris sp	405	2555	0	0	435	2555	0	0	475	2725	0	0
	Lolium sp	1605	1000	0	0	1665	1020	0	0	1715	1120	0	0
Total	Total	2353	4681	0	0	2546	4785	0	0	2707	5116	0	0
T_1	*Medicago hispida*	0	0	100	100	0	0	100	100	0	0	100	100
	Anagallis arvensis	0	0	100	100	0	0	100	100	0	0	100	100
	Phalaris sp	70	0	82.8	100	65	85	85.1	96.7	20	210	96	92
	Lolium sp	330	343	80.0	66.0	250	290	85.0	71.6	500	380	71	67
Total	Total	400	343	83.1	92.7	315	375	87.7	92.2	520	590	81	88.5
T_2	*Medicago hispida*	0	0	100	100	0	0	100	100	0	0	100	100
	Anagallis arvensis	0	0	100	100	0	0	100	100	0	0	100	100
	Phalaris sp	50	0	87.8	100	60	0	86.3	100	15	115	97	96
	Lolium sp	264	260	84.0	74	195	160	88.3	84.4	443	290	74	74
Total	Total	314	260	86.7	94.5	255	160	90.0	96.7	458	405	83	92.1
T_3	*Medicago hispida*	0	0	100	100	0	0	100	100	0	0	100	100
	Anagallis arvensis	0	0	100	100	0	0	100	100	0	0	100	100
	Phalaris sp	34	0	91.7	100	29	0	93.4	100	5	65	99	98
	Lolium sp	178	168	89.0	83.2	141	80	91.6	92.2	410	200	76	82
Total	Total	212	168	91.0	96.5	169	80	93.4	98.4	415	265	85	94.9
T_4	*Medicago hispida*	0	0	100	100	0	0	100	100	0	0	100	100
	Anagallis arvensis	0	0	100	100	0	0	100	100	0	0	100	100
	Phalaris sp	85	0	80	100	75	54	82.8	97.9	25	185	95	93
	Lolium sp	390	335	75.8	66.5	205	203	87.7	80.1	578	363	66	68
Total	Total	475	335	79.9	92.9	280	257	89.1	94.7	603	548	78	89.3
T_5	*Medicago hispida*	0	0	100	100	0	0	100	100	0	0	100	100
	Anagallis arvensis	0	0	100	100	0	0	100	100	0	0	100	100
	Phalaris sp	83	0	80	100	58	0	86.7	100	10	110	98	96
	Lolium sp	360	258	77.6	74.2	180	95	89.2	90.7	430	233	75	79
Total	Total	443	258	81.2	94.5	238	95	90.7	98.1	440	343	84	93.3

S_1: First season (2018/2019) **S_2: Second season (2019/2020)**

B-Grassy seed heads (numbers/m^2):

Data of Table (5) presented that *Lolium* spp is the dominant weed which recorded 65.1% of weed density in the first season, whereas *Phalaris spp* is the dominant weed in the second season which recorded 67% weed density. This result is the same trend which previously recorded with fresh weigh (gm/m^2). All five herbicide mixtures reduced number of seed heads of two grassy weeds in all herbicide application timing. Maximum control percentage of total grassy weeds was realized by Co-formulated mixture at higher dose (0.12 kg/ha) which are arranged between 86.8 to 90.8% control in the first season and between 94.6 to 95.8

% control in the second season. No different are observed in efficiency against grassy seed heads with first application timing at higher dose of Co- formulated mixture (T_3). The other third application timing had less control than first and second application timing in controlling total grassy seed heads. The same trend was obtained with grassy weeds mass in herbicide mixtures and unwedded check. This result agreed with Mahmoud *et al*, (2016) who reported that Pyroxsulam (which present in all herbicide mixture) provided excellent control for *Phalaris* minor and *Lolium* spp at Alexandria and El-Bahira governorates.

Table 5. Effect of herbicide mixtures on number of grass weeds seed heads before wheat harvest during the two seasons.

Treatments	Appl-code	First season						Second season					
		Phalaris		*Lolium*		Total grass/weeds		*Phalaris*		*Lolium*		Total grass/weeds	
		Mean	%C	Mean	%C	Mean	%C	Mean	%C	Mean	%C	Mean	%C
T_0		113	0	211	0	324	0	221	0	109	0	330	0
T_1	A	18	84.1	45	78.7	63.0	80.6	5	97.8	14	87.2	19	94.3
	B	15	86.8	39	81.6	54.0	83.4	11	95.1	16	85.4	27	91.9
	C	14	87.7	48	77.3	62.0	80.9	14	93.7	27	75.3	41	87.6
T_2	A	14	87.7	35	83.5	49.0	84.9	6	97.3	9	91.8	15	95.5
	B	12	89.4	33	84.4	45.0	86.2	7	96.9	18	83.5	25	92.5
	C	8	93.0	40	81.1	48.0	85.2	8	96.4	20	81.7	28	91.6
T_3	A	10	91.2	21	90.1	31.0	90.5	2	99.1	12	89.0	14	95.8
	B	11	90.3	19	91.0	30.0	90.8	3	98.7	12	89.0	15	95.5
	C	7	93.9	36	83.0	43.0	86.8	7	96.9	11	90.0	18	94.6
T_4	A	15	86.8	47	77.8	62.0	80.9	8	96.4	20	81.7	28	91.6
	B	12	89.4	40	81.1	52.0	84.0	14	93.7	25	77.1	39	88.2
	C	13	88.5	57	73.0	70.0	78.4	13	94.2	17	84.5	30	91.0
T_5	A	12	89.4	37	82.5	49.0	84.9	4	98.2	11	90.0	15	95.5
	B	9	92.1	25	88.2	34.0	89.6	4	98.2	16	85.4	20	94.0
	C	6	94.7	52	75.4	58.0	82.1	6	97.3	13	88.1	19	94.3
% Weed density		34.90		65.10		100		67.00		33.00		100	

A=Four leaf growth stage.
B = Beginning of tillering growth stage
C = Internode elongation stage
%C =percentage of control.

Wheat growth, yield, and yield attributes:

1- Growth characters:

These included plant height, spike length and number of spikletes/spike Table (6). The three studied traits were significantly affected by herbicides, application dates and their interactions in the two studied seasons. Second herbicidal application at tillering stage (B) produced the tallest plants (99.07 and 100.77 cm) without significant differences with earlier application (A)in the two seasons, longest spikes (10.48 and 9.68 cm) and maximum number of spikelets /spike (23.94 and 23.61) in the first and second seasons, respectively. Conversely, late herbicidal application at internode elongation stage (C) produced the shortest plants (92.60 and 93.07 cm), shortest spikes (9.18 ad 8.17 cm) and lowest number of spikelets/spike (22.62 and 22.96) in the two successive seasons. Generally, decreases in the three aforementioned plant growth traits as a result of late chemical weed control mainly due to the competition between plants on growth factors as light and nutritional elements and consequently decrease the photosynthesis and assimilates production and translocation to the growth organs. These findings are in consistent with those reported by Jack *et al*. (1996), Gupta (2004), Zand *et al*. (2007) and Shehzad *et al*. (2012a, b). Regarding herbicides effect, results presented in that table indicated that herbicides application, generally increased wheat plant growth compared with untreated plants (control) in the two studied seasons.

T_3 herbicidal treatment produced the tallest wheat plants (99.23 and 101.31 cm) in the first and second the seasons, respectively. The tallest spikes in the first season (10.50 and 10.68 cm) resulted from T_2 and T_3 foliar application, respectively and all herbicidal treatments in the second season. On the other hand, maximum number spikelets/spike in the second season (24.39) resulted from T_3 application and T_2, T_3 and T_4 (24.52,24.79 and 24.39), respectively in the first season.

Table 6. Means of plant height, spike length and number of spikelets/spikes as affected by application date and herbicidal mixtures in the two seasons.

Factors	Plant height (cm)		Spike length (cm)		Number of spikelets/spikes	
	S_1	S_2	S_1	S_2	S_1	S_2
Time of application						
A	98.82 a	97.03 a	10.06b	9.15b	23.60 a	23.11 b
B	99.07 a	100.77 a	10.48a	9.68a	23.94 a	23.61 a
C	92.60 b	93.07 b	9.18c	8.17c	22.62 b	22.96 b
L.S.D 0.05	2.56	3.82	0.30	0.33	0.54	0.42
Herbicides						
T_0	91.42c	92.70 c	8.06c	7.35b	20.45 c	19.60 c
T_1	95.96 b	95.90 bc	9.96b	9.34a	23.03 b	23.62 b
T_2	96.43 b	96.88 b	10.50a	9.33a	24.52 a	24.33 ab
T_3	99.23 a	101.31 a	10.68a	9.97a	24.79 a	24.39 a
T_4	96.75 b	96.98 b	10.35ab	9.30a	24.39 a	24.17 ab
T_5	97.17 ab	97.93 b	9.91b	9.27a	23.15 ab	23.24 b
L.S.D 0.05	2.07	3.30	0.43	0.29	0.68	0.72
Interactions	*	*	*	*	*	*

followed by the same letter(s) are not significantly different according to L.S.D.$_{0.05}$ values.
***And ** significant at 0.05 and 0.01 levels of probability, respectively.**
N.S: not significant.
A= four leaf growth stage. B = Beginning of tillering growth stage.
C = Means Internode elongation stage
S_1: First season (2018/2019). S_2: Second season (2019/2020)

On the contrast, control treatment produced the shortest plants (91.42 and 92.70 cm), shortest spike (8.06 and 7.35 cm) and least number of spikelets/spike (20.45 and 19.60) in the two successive seasons. That could be due to the efficiency of chemical control for decreasing the competition level of weed population grow accompanied with wheat plants. These results are in line with those obtained by Elattar *et al*. (2018).

Interaction effect of herbicides and time of application Table (9) indicated that T_5 and T_3 applications at tillering stage of wheat (B) produced the tallest wheat plants (101.60 and 103.22 cm), respectively, in the first season, however T_3 application at the same wheat growth stage in the second season gave the tallest plants (108.57 cm). On the contrary, unwedded treatment at the three application times besides T_5 at the three wheat growth stages showed the shortest wheat plants.

Considering spike length, treated wheat with any of the studied herbicides at tillering growth stage (B) produced the tallest spikes in the two seasons, besides T_2, T_3 and T_4 at the two-leaf growth stage in the first season.

Results also indicated that untreated plants with herbicides (control) produced the shortest spikes in both seasons.

The highest number of spikelets /spike (25.13 and 25.03) in the first and second seasons, respectively resulted from T_3 and T_2 application at tillering growth stage (B). However, the least number of spikelets /spike, generally resulted from the control treatment (T_0) at any of the three times of application studied.

2- Grain yield and yield attributes:

Grain yield and its attributes, i.e., number of fertile tillers /m^2, number of grains/spike,100-grain weight, grain yield/ha and harvest index were significantly affected with time of application, herbicidal mixtures and their interactions in the two seasons, expect the interaction effect on harvest index in both seasons as shown in Table (7).

Table 7. Means of wheat grain yield and its components as affected by application date and herbicidal mixtures in the two seasons.

Factors	No.of fertile tillers/m^2		No.of grains/spike		100-grain weight(g)		Grain yield(t/ha)		Harvest index (%)	
	S 1	S 2	S 1	S 2	S 1	S 2	S 1	S 2	S 1	S 2
Time of application										
A	241.42^{b}	223.84^{b}	48.17^{b}	45.42^{b}	4.54^{b}	4.13^{b}	5.315^{b}	4.241^{b}	40.44^{b}	37.54^{b}
B	277.02^{a}	254.75^{a}	50.36^{a}	49.38^{a}	4.78^{a}	4.66^{a}	6.837^{a}	6.058^{a}	44.36^{a}	42.83^{a}
C	202.60^{c}	183.76^{c}	37.98^{b}	35.64^{c}	3.87^{c}	3.54^{c}	2.906^{c}	2.235^{c}	29.13^{c}	28.74^{c}
L.S.D $_{0.05}$	14.65	10.12	1.29	0.79	0.10	0.20	0.658	0.462	0.52	0.46
Herbicides										
T_0	180.24^{b}	172.54^{b}	35.72^{b}	30.85^{c}	3.20^{c}	3.0^{b}	1.986^{b}	1.551^{b}	30.24^{e}	29.56^{f}
T_1	248.23^{a}	228.73^{a}	46.73^{ab}	44.16^{b}	4.59^{ab}	4.33^{a}	5.367^{a}	4.478^{a}	39.20^{c}	35.49^{e}
T_2	254.71^{a}	230.28^{a}	47.80^{ab}	48.01^{a}	4.63^{ab}	4.35^{a}	5.754^{a}	4.896^{a}	39.11^{cd}	38.62^{b}
T_3	256.33^{a}	234.27^{a}	48.80^{a}	47.76^{a}	4.73^{a}	4.39^{a}	5.949^{a}	5.014^{a}	40.64^{a}	39.95^{a}
T_4	254.81^{a}	230.73^{a}	47.84^{ab}	45.92^{ab}	4.65^{ab}	4.33^{a}	5.822^{a}	4.0710^{a}	40.02^{b}	38.10^{c}
T_5	247.90^{a}	228.15^{a}	46.14^{ab}	44.16^{b}	4.54^{b}	4.26^{a}	5.239^{a}	4.417^{a}	38.65^{d}	36.50^{d}
L.S.D $_{0.05}$	12.23	14.56	2.70	3.0	0.16	0.19	0.837	0.605	0.51	0.43
Interactions	**	**	**	**	*	*	**	**	N.S	N.S

Means followed by the same letter(s) are not significantly different according to L.S.D.$_{0.05}$ values.
***And ** significant at 0.05 and 0.01 levels of probability, respectively.**
N.S: not significant.
S_1: First season (2018/2019) S_2: Second season (2019/2020)
A= four leaf growth stage. B = Beginning of tillering growth stage C = Internode elongation stage

Herbicides application at tillering growth stage of wheat (B) produced the highest number of fertile tillers/m^2 (277.02 and 254.75), highest number of grains/spike (50.36 and 49.38), heaviest 100-grain weight (4.78 and 4.66 g), highest grain yield (6.837 and 6.058 t/ha) and highest harvest indices (44.36 and 42.83%) in the first and second seasons, respectively.

In the contrast, later time of application at internode elongation growth stage of wheat crop (C) showed the lowest grain yield (2.906 and 2.235 t/ha) and its components, i.e., number of fertile tillers/m ^{2} (202.60 and 183.76), number of grains/spike (37.98 and 35.64), 100-grain weight (3.87 and 3.54 g) and harvest index (29.13 and 28.74 %) in the first and second seasons, respectively.

It is clear that the second herbicidal application at tillering growth stage (B) was more efficient for weeds control as a result of minimization of weed competition to wheat plants and consequently number of tillers is the most component of grain yield will increase and grow under weed without competition (weed free). That may increase photosynthates production and translocation to flowers (sink) to increase number of grains/spike and grain weight. These results were supported by Jack *et al*. (1996) who reported that weed control using herbicides at tillering growth stage of wheat crop led to minimize risk of wheat plant injury and maximize grain yield.

In the contrast, late application of herbicides was less efficiency for weed control because of new weeds emerged through wheat growing season Wara *et al*. (2020)

Regarding the studied herbicides effect on grain yield and yield components, presented results in Table (7) showed that T_3 herbicidal treatment produced the highest harvest index values (40.64 and 39.95%) in the first and second seasons, respectively, 100-grain weight (4.73 g) in the first season and number of grains/spike (48.80) in the first season and both T_2 and T_3 (48.01 and 47.76), respectively, in the second season. On the other hand, foliar application of any herbicidal treatment studied produced higher wheat grain yield and yielded attributes than unwedded treatment in the two seasons. That might be due to minimize weed competition effect for wheat crop on light, moisture, nutrients and space (Arnon, 1972). These results agreed with those reported by Abdul Khaliq *et al.* (2014) and Elattar *et al.* (2018).

Interaction effect on grain yield and its attributes Table (9) indicated that sprayed wheat pants with any herbicide treatments studied at tillering growth stage produced higher number of fertile tillers/m^2 in the two seasons,100-grain weight and grain yield/ha in the second season compared with other combination between herbicides and time of applications.

On the other hand, maximum number of grains/spike (54.10) in the first season and (53.02 and 52.80) in the second season resulted from T_4, T_2 and T_3 herbicidal application at tillering growth stage of wheat crop.

The heaviest 100-grain weights (5.10,5.13 and 5.08g) resulted from herbicidal application of T_2, T_3 and T_4 treatments at (B) time of application in the first season. However, T_3 and T_4 treatments at the same application time produced the highest grain yield (8.21 and 8.18 t/ha), respectively, in the first season.

The aforementioned results could be due to high herbicidal application efficiency for decreasing weed population in the field during tillering growth stage of wheat plants and consequently accelerate photosynthesis and translocation assimilates from leaves (source) to grains(sink).On the contrary, late weed control (at elongation stage) led to decrease efficiency of the studied herbicidal treatments because of increasing weed tolerance for the herbicides .These findings are in consistent with those reported by Jack *et al*. (1996).

3- Grain quality:

Protein and dry gluten contents were significantly affected by time of application and herbicidal treatments; however, their interactions effect did not reach significance level in the two seasons of the study a shown in Table (8).

Obtained results indicated that herbicidal application at tillering growth stage (B) produced the highest grain protein content (11.68 and 10.74%) and dry gluten contents (6.83 and 6.69g) in the first and second seasons, respectively, followed by late application of herbicides at stem elongation of wheat plants (C) in both seasons.

On the other hand, all studied herbicidal treatments, generally increased wheat grain protein and gluten contents compared with unwedded check treatment in the two seasons. These results were supported by Peltzer and Bowran (1996), Kandil and Ibrahim (2011), El-Metwally *et al.* (2015 a) and Elattar *et al.* (2018).

Table 8. Means of protein and dry gluten contents (%) as affected by application date and herbicidal mixtures in the two seasons.

Treatments	Protein content (%)		Dry gluten content (%)	
Time of application	S_1	S_2	S_1	S_2
A	10.76^c	10.53^c	6.74^b	6.52^c
B	11.68^a	10.74^a	6.83^a	6.69^a
C	11.11^a	10.67^b	6.64^c	6.57^b
L.S.D $_{0.05}$	0.13	0.06	0.02	0.03
Herbicides				
T_0	11.50^a	10.42^c	6.43^d	6.43^d
T_1	10.86^a	10.86^b	6.74^c	6.63^c
T_2	10.28^a	10.25^d	6.73^c	6.29^e
T_3	11.07^a	10.28^d	6.37^e	6.26^e
T_4	11.10^a	10.91^b	6.97^b	6.86^b
T_5	10.28^a	11.16^a	7.20^a	7.10^a
L.S.D $_{0.05}$	N.S	0.06	0.03	0.06
Interactions	N.S	N.S	N.S	N.S

Means followed by the same letter(s) are not significantly different according to L.S.D.$_{0.05}$ values.
***And ** significant at 0.05 and 0.01 levels of probability, respectively.**
N.S: not significant.
A= four leaf growth stage. B = Beginning of tillering growth stage C = Internode elongation stage
S_1: First season (2018/2019) S_2: Second season (2019/2020)

Table 9. Means of wheat growth and yield traits as affected by application date × herbicidal mixtures interaction in the two seasons.

Time of application	Herbicides	Plant height (cm)		Spike length(cm)		No.of fertile tillers/m^2		No.of spikelets/spike		No.of grains/spike		100-grain weight (g)		Grain yield(ton/ha)	
		S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
A	T_0	92.54^{cd}	93.34^d	7.98^d	7.43^d	178.23^d	171.26^c	21.52^d	19.87^c	39.22^c	30.17^e	3.29^d	3.00^{de}	2.21^e	1.41^d
	T_1	96.11^{cd}	96.11^{cd}	9.89^{bc}	9.57^b	250.17^b	235.07^b	22.89^c	23.79^b	50.21^b	48.00^b	4.80^b	4.31^b	5.99^{bc}	4.68^b
	T_2	97.0^{bc}	97.67^c	10.98^a	9.47^b	258.94^b	234.20^b	24.56^{ab}	24.00^{ab}	51.09^{ab}	50.00^{ab}	4.79^b	4.34^b	6.09^{bc}	4.97^b
	T_3	99.13^b	99.86^{bc}	11.02^a	9.62^b	256.38^b	238.13^b	25.00^{ab}	24.13^{ab}	50.27^b	49.63^{ab}	4.96^{ab}	4.42^b	6.17^{bc}	5.13^b
	T_4	97.84^{bc}	97.00^{cd}	10.59^a	9.51^b	255.17^b	233.41^b	24.49^{ab}	23.78^b	49.18^b	47.13^b	4.82^b	4.38^b	5.96^{bc}	4.67^b
	T_5	98.30^{bc}	98.17^{bc}	9.91^{bc}	9.50^b	249.66^b	230.99^b	23.15^{bc}	23.12^b	48.98^b	47.60^b	4.62^b	4.33^b	5.47^c	4.594^b
B	T_0	92.17^d	94.06^c	8.12^d	7.67^d	181.96^d	173.55^c	20.16^e	20.07^c	41.13^{cd}	38.52^{cd}	3.44^d	3.19^d	2.46^d	2.12^{cd}
	T_1	99.17^b	100.30^{bc}	10.92^a	10.05^a	290.19^a	266.36^a	24.12^{ab}	23.53^b	49.88^b	50.20^{ab}	4.98^{ab}	4.90^a	7.02^b	6.49^a
	T_2	99.15^b	99.80^{bc}	11.00^a	10.11^a	296.87^a	271.42^a	25.00^{ab}	25.03^a	52.34^{ab}	53.02^a	5.10^a	4.96^a	7.92^{ab}	7.06^a
	T_3	103.22^a	108.57^a	11.07^a	10.23^a	302.17^a	276.34^a	25.13^a	25.00^{ab}	53.62^{ab}	52.80^a	5.13^a	5.02^a	8.21^a	7.17^a
	T_4	99.08^b	99.47^{bc}	10.98^a	10.02^a	300.07^a	272.50^a	24.96^{ab}	24.88^{ab}	54.10^a	51.98^{ab}	5.08^a	5.00^a	8.18^a	7.02^a
	T_5	101.60^{ab}	102.40^b	10.84^a	10.04^a	291.22^a	268.33^a	24.32^{ab}	23.15^b	51.13^{ab}	49.76^{ab}	5.00^{ab}	4.89^a	7.23^{ab}	6.48^a
C	T_0	89.57^d	90.72^d	8.09^d	6.95^f	180.54^d	172.83^c	19.68^e	18.89^c	26.72^e	23.87^f	2.89^e	2.81^e	1.29^e	1.13^d
	T_1	92.60^{cd}	91.31^d	9.07^c	8.42^c	204.34^c	184.76^c	22.09^d	23.55^b	40.10^{cd}	34.29^d	4.00^c	3.78^c	3.09^d	2.26^{cd}
	T_2	93.15^{cd}	93.18^d	9.53^{bc}	8.43^c	208.32^c	185.22^c	24.00^b	23.98^{ab}	39.98^{cd}	41.03^c	4.13^c	3.75^c	3.25^d	2.66^c
	T_3	95.36^c	95.52^{cd}	9.96^{bc}	8.56^c	210.44^c	188.36^c	24.26^{ab}	24.06^{ab}	42.53^c	40.87^c	4.11^c	3.73^c	3.46^d	2.75^c
	T_4	93.34^{cd}	94.47^{cd}	9.48^c	8.39^c	209.19^c	186.29^c	23.74^b	23.86^{ab}	40.26^{cd}	38.65^{cd}	4.07^c	3.62^c	3.32^d	2.45^c
	T_5	91.60^d	93.22^d	9.00^c	8.28^c	202.82^c	185.14	22.00^c	23.47^b	38.33^d	35.13^d	4.02^c	3.56^c	3.02^d	2.18^{cd}
L.S.D $_{0.05}$		3.14	4.30	0.54	0.40	20.36	20.87	1.02	1.24	3.56	4.18	0.24	0.31	1.062	0.973

A= Four leaf growth stage. B = Beginning of tillering growth stage C = Internode elongation stage
S_1: First season (2018/2019) S_2: Second season (2019/2020)
Means followed by the same letter(s) are not significantly different according to L.S.D.$_{0.05}$ values.
***And ** significant at 0.05 and 0.01 levels of probability, respectively**

CONCLUSION

The study results have demonstrated that, Co-formulated herbicide mixtures of florasulam + halauxifen-methyl+ pyroxsulam under three doses with three application timing gave excellent control (100%) against broad leaf weeds. Fresh weight and good control for grassy fresh weight and seed head weeds (*Phalaris* spp and *Lolium* spp) in wheat crop compared with tank mix of pinoxaden +pyroxsulam +halauxifen -methyl and ready mix of pyroxsulam + florasulam + clonquintocet-methyl. Combination of herbicides were significant value to increase yield attributed wheat in realize to the unwedded check treatment. Among the alternative application mixtures of Co-formulated of florasulam + halauxifen-methyl+pyroxsulam at the rate of 0.120 kg/ha is effective to increase growth yield, grain and its components besides grain quality of wheat especially at tillering growth stage of crop followed by other doses of Co-formulated and ready and tank mixes compared with the other two application time.

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تأثيرموعد ومعدل اضافة خلائط مبيدات الحشائش على الحشائش و المحصول ومكوناته وجودة حبوب محصول القمح

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أجريت هذه الدراسة بمحطة البحوث الزراعية بكلية الزراعة جامعة الإسكندرية بمنطقة أبيس، خلال موسمي الشتاء المتتاليين 2019/2018 و 2020/2019 . وكان الهدف من هذا الدراسة هو تقييم تأثير موعد و معدل اضافة خلائط مبيدات الحشائش علي مكافحة الحشائش ، النمو ، المحصول ، صفات المحصول وجودة الحبوب لمحصول القمح.وتم توزيع ثلاثة مواعيد من البرنامج عشوائيا في قطع الأراضي الرئيسية، و تم تخصيص خمسة مخاليط من مبيدات الحشائش ومعاملة الكنترول في قطع الأراضي الفرعية. وكان من اهم النتائج : سيادة نباتات *Medicago hispida* كحشائش عريضة الاوراق و *Lolium* , *Phalaris* كحشائش ضيقة الاوراق في الموسم الأول والثاني وكلا الموسمين على التوالي. جميع المخاليط المدروسة تحت ثلاث مواعيد البرنامج تسببت في السيطرة بنسبة 100٪ على الحشائش عريضة الأوراق. معظم مخاليط مبيدات الحشائش ، خاصةً التركيبية ذات الجرعة العالية (0.12 كجم / هكتار) ،اعطت مستوي تحكم مناسب ل*Lolium , Phalaris* في توقيت التطبيق الاول والثاني مقارنة بالثالث. لذلك ، فإن الوقت الأمثل لتطبيق مخاليط مبيدات الحشائش اللاحقة الظهور هو خلال مرحلة النمو (ب) في محصول القمح. سجلت جميع مخاليط مبيدات الحشائش مؤشرات منخفضة للإصابات على نباتات محصول القمح التي اختفت تمامًا بعد 4 أسابيع من استخدام مبيدات الحشائش ، باستثناء موعد الاستخدام الثالث في الموسم الأول مما أعطى بعض السمية النباتية حتى 6 أسابيع بسبب هطول الأمطار الكاملة بعد ساعتين من استخدام مبيدات الحشائش.ادي استخدام مخاليط مبيدات الحشائش بشكل عام الي زيادة نمو نبات القمح ،محصول الحبوب ، عدد الخلفات الفعالة / م 2 ، عدد الحبوب / السنبلة ، وزن 100 حبة ، ومعامل الحصاد في الموسمين ، مقارنة بمعاملة الكنترول. أعطى التطبيق الورقي لمبيدات الحشائش المدروسة في مرحلة النمو (ب) لمحصول القمح أعلى نمو ، محصول حبوب ،صفاته، بروتين الحبوب ومحتويات الغلوتين ، يليه التطبيق المبكر في مرحلة النمو (أ). نتجت أفضل النتائج لنمو القمح والمحصول وخصائص جودة الحبوب عن استخدام خليط مبيدات الحشائش التركيبية في مرحلة نمو خلفات القمح.