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Combination of Halauxifen - Methyl + Florasulamwith Other Grassy Herbicides Against Complex Weed Flora in Wheat (*Triticumaestivum*)

Mahmoud, S. M. [1]; F. S. Soliman[2] and M. Elsheik[3]

[1,2]Department of Pesticide Chemistry and Technology, Faculty of Agriculture, Alexandria University, Alex., Egypt.

[3] Department of crop production.Faculty of Agriculture, Alexandria University, Alex., Egypt.

***Corresponding author's email: ms_kassem2@yahoo.com**

ABSTRACT

Two field experiments were carried out in Alexandria and El-Beheira governorates in Egypt to evaluate the biological efficacy of a ready mix herbicide Paradigm (Halauxifen-methyl + Florasulam) with application rate 21 gm/fed combined with Pyroxsulam (160 ml/fed), Pinoxaden (550 ml/fed), Clodinafop-propargyl (140 gm/fed) and Diclofop-methyl (1000 ml/fed) compared to Pyroxsulam (Pallas), Atlantis (Iodosulfuran + Mesosulfuron) and unweededcheck on winter wheat in 2014, herbicides were applied at tillering stage in both regions. Paradigm with its combinations with grassy weed herbicides showed excellent control on*Medicagohispida, Beta vulgaris, Malvaprviflora, Anagallisarvensis, Coronopussquamatus, Sonchusoleraceus*and *Brassica nigra* .On the other hand, the best efficacy on grassy weed mass, visual weed estimation and percentage of grassy seed heads were obtained from Paradigm combinations with Pyroxsulam and Pinoxaden only at tillering stage in Alexandria region, while its combination with Clodinafop-propargyl and Diclofop-methyl did not improve grassy herbicidal activity in both trials compared to standard herbicides, Generally the combinations showed good control for broad weed leaves in both locations, while in grassy leaves it showed better control in Alexandria than in El-Beheira governorate.

INTRODUCTION

Wheat is the one of the most produced crop on Earth, Wheat provides a large fraction of the dietary protein and total food supply, and is grown all throughout the world in a wide variety of climates. Wheat is a staple crop, grown as a primary food product and for other uses as well.

The global science and agricultural development landscapes are changing in substantive ways, with important implications for the funding, conduct and institutional arrangements affecting research for food and agriculture. Wheat improvement research is part of this broader agricultural innovation landscape (Pardey, 2011).

Among the food crops, wheat is one of the most abundant sources of energy and proteins for the world population and its increased production is essential for food security (Chhokar*et al*., 2006).

Yield of wheat can be increased by two ways, either by bringing more land area under cultivation or by increasing its yield per unit area. Currently, it is not possible to increase area under wheat due to other competitive rabi crops. The only alternative is to obtain higher yield per unit area by growing new high yielding varieties and better crop management, (Musaddique*et al.*, 2000).

The presence of weeds in a crop can adversely affect production in a number of ways. Weeds compete with crop plants for light, moisture, nutrients and space. Weeds also increase harvesting costs, reduce quality of product, and increase fire hazards (Arnon, 1972). In order to increase wheat yields it is important to manage weeds, which resulted higher yield in wheat crop (Khan *et al.*, 2003).Chemicals and hand weeding have often been used as a weed control in wheat. Ahmad *et al*.,(1993)observed that herbicides application and hand weeding decreased dry weight of weeds significantly compared to dry weight in non-treated plots. Chemical weed control in wheat was best in producing higher grain yield than hand weeding, also it was found that application of grassy and broad leaf herbicides increased grain yield and yield components. (Akhtar *et al.*,1991).

In view to the importance of weed problems in wheat crops, the acute problem of both grassy and broad leaf weeds are becoming very common in wheat growing areas in North Egypt, which often results in huge yield losses and makes weed control more complex. High weed infestation may cause complete crop failure, Tanner and Giref(1991) mentioned that the presence of weeds in wheat crops caused yield reduction up to 70%.

Acetolactate synthase (ALS) - inhibiting herbicides are primary herbicides for broad leaf weeds control in winter wheat since more than three decades and for winter annual grasses since nearly two decades. ALS-inhibiting herbicides are widely used because of their low doses, low mammalian toxicity and high efficacy (Yu *et al*, 2003). Chlorosulfuron, metsulfuron, thifensulfuron, triasulfuron and tribenuron methyl are registered for weed control in wheat, these herbicides provide good control for broad leaf weeds but have little or no activity on grassy weeds,also sufolsulfuron, propoxycarbazone-Na, pyroxsulam and atlantis are selective for controlling both grassy and broad leaf weeds in wheat(Geier*et al*, 2011).

The development of graminicides inhibiting acetyl coenzyme A (ACCase) such as clodinafop-propargyl, diclifop-methyl, fenoxaprop-ethyl, tralkoxydim and pinoxaden has been studiedby many researchers in wheat crops for controlling grassy weeds(Kodayari et al., 1983; El-deeb, et al., 1986; Khan and Rashid, 1994; Lemerle and verbeek, 1995; Stranchan, 1995; Soliman, 1995; Koscelny and Peeper, 1996; sabra et al., 1999; Hoffer et al., 2006; Punia et al., 2008 and Pawan et al., 2012). The mixtures of ALS herbicide groups with graminicide gives in most cases complete control of weeds in wheat crops and broaden the control of weed spectrum.

The aim of this research is to assess Paradigm (new ready mix broad leaf weeds herbicide) combinations with other graminicides with different mode of action on bothbroad and narrow leaf weeds affecting wheat crops in Egyptin order to overcome the resistance of some weeds and to reduce the number of herbicides spraying.

MATERIALS AND METHODS

Two field experiments were performed at Faculty of Agriculture station, Alexandria governorate and the other atAlhagger, El-Beheira governorate in North Egypt to evaluate the efficacy of Paradigm (Halauxifen-methyl + florasulam) combinations with grass killers to control all weeds in wheat crops during winter season 2012.

The trials layout was randomized complete block design with four replicates. Experimental plot size was 21 m^2. Winter wheat (Sakha 93) was grown with a rate 60kg seeds/feddan. All herbicide treatments were applied by a knapsack sprayer with flat-fan nozzle with a rate 200 liter water/ feddan as a post emergence application at beginning of tillering.All cultural practices like fertilization and irrigation (floating) were applied as usual in wheat plantation.

Four herbicide tank mix combinations between Halauxifen-methyl +florasulam (Paradigm) and grassy herbicides, in addition to pallas 45 OD (pyroxsulam) which is widely used in Egypt and atlantis OD (iodosulfuron-methyl + mesosulfuron) as standard treatments were used.

(Halauxifen methyl + Florasulam) was assessed alone on broad leaf weeds, also all used graminicides were assessed on narrow weed leaves to compare their effects with tested mixtures.

All herbicide treatments, common names, trade names, time and rate of applications are illustrated in Table (1).

Table (1): Common, trade names, formulation, rate/feddan, application time and manufacturer of herbicidal treatments

Common name	Trade name	formulation	Rate/feddan	Application time	Manufacturer
(Halauxifen-methyl20%+Florasulam20%) + Pyroxsulam	Paradigm + Pallas	WG+ OD	21g + 160ml	post-emergence	Dow Agrosciences
(Halauxifen-methyl+Florasulam) + pinoxaden	Paradigm + Axial	WG+ EC	21g + 550ml		Dow Agrosciences + Syngenta
(Halauxifen-methyl+Florasulam) + clodinafop-propargyl	Paradigm + Topik	WG+ WP	21g + 140g		Dow Agrosciences + Syngenta
(Halauxifen-methyl+Florasulam) + diclofop-methyl	Paradigm +illoxan	WG+ EC	21g + 1000ml		Dow Agrosciences + Bayer
Iodosulfuron + mesosulfuron	Atlantis	WG	400ml		Bayer
pyroxsulam	Pallas	OD	160ml		Dow Agrosciences
Unweeded check	Control				

Evaluation of wheat injury was estimated after 1, 2 and 4 weeks from herbicide application according to European Weed Research council (EWRC). Assessment of total grassy weeds control was recorded according to a visual rating system (Frans and Talbert, 1977 and Roberts, 1982) after eight weeks from herbicides application. Evaluation of tested compounds efficacy was carried out after eight weeks from application by collecting all weeds grown in 1m2 from each plot, weeds were sorted and weighted then percentage of weed reduction was calculated. Methods for assessment of seed production have been developed most extensively for annual grass weeds, grassy seed heads were count according to Robert's method (1982) at harvesting stage and percentage of control values of herbicide treatments were calculated.

Statistical analysis of data was carried out by AssistatSoftware version beta (Silva and Azevedo, 2009).

RESULTS AND DISCUSSION

Wheat field trials were infested with both grassy and broad leaf weeds. The dominantgrassy weeds were *Phlaris minor* and *Loliumprenne* in Alexandria region with a percentage of infestation 20.32 and 18.68 %, respectively and *Phlaris minor* in Elbeheira with infestation percentage 76.61 %, while the dominant broad leaf weed was*Medicagohispida*in Alexandria region with infestation percentage 44.30 %and*Sonchusoleraceus*in El-Beheira region with infestation percentage 12.53 % (Tables 3, 4 and 5).

From the visual estimation (Table 2), it was obvious that all treatments showed excellent control on total weeds after 14 days from treatment in both districts, but during the second and third estimation after 28 and 56 days, the combination of (Halauxifen-methyl + florasulam) with pyroxsulam and pinoxaden together with standards showed very high control percentage in Alexandria district, while standard treatments (Iodosulfuron + mesosulfuronand pyroxsulam) were the best in El-Beheira district.

Table (2): Visual estimation control percentage of all weeds by herbicidal treatments in Alexandria and El-Beheira governorates compared with unweeded check

Treatments (Rate/Hectare)	Alexandria			El-Beheira		
	14 days	28 days	56 days	14 days	28 days	56 days
(Halauxifen-methyl+Florasulam) + Pyroxsulam	99.13	98	98.65	100	41.25	70.63
(Halauxifen-methyl+Florasulam) + pinoxaden	99.08	96.5	97.95	100	47.5	73.75
(Halauxifen-methyl+Florasulam) + clodinafop-propargyl	93.49	62.5	86.5	100	48.75	74.38
(Halauxifen-methyl+Florasulam) + diclofop-methyl	97.75	50	80.25	99.38	30	76
Iodosulfuron + mesosulfuron	98.83	97.75	98.4	100	85	96.86
pyroxsulam	97.73	95.63	96.75	99.38	75	93.75
Unweeded check	100	100	100	100	100	100

Table (3): Effect of herbicidal treatments on wheat broad leaf weeds (fresh weight, g/m^2) in Alexandria governorate

Treatments (Rate/Hectare)	*Medicagohispida*	*Beta vulgaris*	*Malvaparviflora*	*Anagallisarvensis*	*Coronopussquamatus*	Total broad	% reduction
(Halauxifen-methyl+Florasulam) + Pyroxsulam	0	10	0	22	0	32	99.01
(Halauxifen-methyl+Florasulam) + pinoxaden	0	0	5	13	0	18	99.44
(Halauxifen-methyl+Florasulam) + clodinafop-propargyl	0	0	0	0	0	0	100.00
(Halauxifen-methyl+Florasulam) + diclofop-methyl	0	0	0	10	0	10	99.69
Iodosulfuron + mesosulfuron	0	3	7	12	0	22	99.32
pyroxsulam	0	0	3	10	2	15	99.54
Unweeded check	2355	567	125	103	93	3243	0
% infestation	44.30	10.67	2.35	1.94	1.75	61.00	

Symptoms of herbicides injury at the tiller application stage in Alexandria region showed significant injury from most herbicide treatments after one and two weeks from application, these symptoms were recovered after four weeks, on the other hand most herbicides applied in El-Beheira region caused slight injury on wheat crop after one and two weeks only from herbicide applications.

Halauxifen-methyl + florasulam (paradigm) gave 100% reduction in fresh weight of broad leaf weeds in both locations, all herbicide treatments were superior compared to weedy check in reducing the fresh weight of broad leaf weeds at 56 days from herbicide application (Tables 3 and 4),Halauxifen-methyl + florasulamwith its tank mixed combinations with pyroxsulam, pinoxaden, clodinafop-propargyl and diclofop-methyl in addition to atlantisOD andpallas as standard herbicide treatments showed excellent control against all broad leaf weeds (nearly 100%) in both locations. At Alexandria governorate, Paradigm with pyroxsulam or pinoxaden as well as standard herbicides provided excellent control for *Phlaris minor* and *Loliumprenne*. This result agreed with(Chhokar*et al*, 2006; Yadav *et al*, 2009; Praptae*t al*, 2009 and Pawan*et al*, 2012) who studied the activity of pyroxsulam and pinoxaden against *Phlaris spp*. The herbicide which gave least control for grassy weeds in Alexandria and El-Beheira locations was ((Halauxifen-methyl + Florasulam) +diclofop-methyl (27.4% and 38.18%) reduction percentage, respectively(Table 5) as well as 0.65 and 42.18% reduction for grassy seed heads, respectively (Table 7).

Table (4): Effect of herbicidal treatments on wheat broad leaf weeds (fresh weight, g/m^2) in El-Beheira governorate

Treatments (Rate/Hectare)	*Sonchusoleraceus*	*Beta vulgaris*	*Brassica nigra*	*Anagallisarvensis*	Total
(Halauxifen-methyl+Florasulam) + Pyroxsulam	0	0	0	0	0
(Halauxifen-methyl+Florasulam) + pinoxaden	0	0	0	0	0
(Halauxifen-methyl+Florasulam) + clodinafop-propargyl	0	0	0	0	0
(Halauxifen-methyl+Florasulam) + diclofop-methyl	0	0	0	0	0
Iodosulfuron + mesosulfuron	0	0	0	0	0
pyroxsulam	0	0	0	0	0
Unweeded check	675	115	410	60	1260
% infestation	12.53	2.13	7.61	1.11	23.39

Concerning with El-Beheira results(Table 5), most of Paradigm combinations with graminicides except diclofop-methyl had moderately effect against grassy weeds, this may be due to severeinfestation of *Phlaris minor*. Paradigm with clodinafop-propargyl was not so effective for controlling *Phlaris minor* and *Loliumprenne* in both locations. This result agreed with Puni*a et al*(2008) who found that UPH 206 (clodinafoppropargyl 15% + metsulfuron 1%) was not effective in controlling grassy weeds.

These results showed similar control to graminicideswhen applied alone (pinoxaden, clodinafop-propargyl and diclofop-methyl) as they gave 87.94, 64.79 and 31.02% reduction) for total narrow leaf weeds in Alexandria and (60.03, 58.58 and 40.41% reduction) in El-Beheira, respectively and (64.52, 25.81 and 8.06% reduction) for grassy seed heads in Alexandria and (73.17, 65.14 and 39.51 % reduction) in El-Beheira governorate, which indicates the absence of antagonistic effect between their mixture with the main herbicide (Halauxifen-methyl + Florasulam).

Atlantis OD was the only herbicide treatment which gave good control for grassy weeds (95.49% fresh weight reduction) and good seed head (88.45% control) in El-Beheira district (Tables5 and 7).

The data in Tables(3and 5)revealed that (Halauxifen-methyl + florasulam) with pyroxsulam and pinoxaden treatments in addition to atlantis OD and pallus(standard treatments)were the most herbicide treatments in controlling both broad and grassy weeds as well as total weeds (Table 6) in Alexandria region without any toxicity problems on wheat, whereas in El-beheira region(Tables 4,5 and 6), standard treatments were more powerful in controlling both broad leaf and grassy weeds, the addition of Halauxifen-methyl + florasulam to pallus reduced its efficacy on controlling *Phlaris minor* which was the dominant weed in this district with very high infestation (76.6%), these results agreed with Mukherjee *et al*(2014) who mentioned that the mixture of halausifen-methyl 10.4% + Florasulam 10% did not leave any residue in wheat and suggested that this mixture will not cause any toxicity problems when applied at recommended dose.

Table (5): Effect of herbicidal treatments on wheat narrow leaf weeds (fresh weight, g/m^2) in Alexandria and El-Beheira governorates

Treatments (Rate/Hectare)	Alexandria				El-Beheira	
	Phlaris minor	*Loliumprenne*	Total grassy	% Reduction	*Phlaris minor*	% Reduction
(Halauxifen-methyl+Florasulam) + Pyroxsulam	3	0	3	99.86	2330	43.56
(Halauxifen-methyl+Florasulam) + pinoxaden	85	100	185	91.08	1870	54.70
(Halauxifen-methyl+Florasulam) + clodinafop-propargyl	300	470	770	62.86	1540	62.69
(Halauxifen-methyl+Florasulam) + diclofop-methyl	1150	355	1505	27.40	2552	38.18
Iodosulfuron + mesosulfuron	65	0	65	96.86	186	95.49
pyroxsulam	115	91	206	90.06	695	83.16
Unweeded check	1080	993	2073	0	4128	0.00
% infestation	20.32	18.68	39.00		76.61	
LSD 0.05			152.40		260.21	

Table (6): Effect of herbicidal treatments on total wheat broad and narrow leaf weeds (fresh weight, g/m^2) in Alexandria and El-Beheira governorates

Treatments (Rate/Hectare)	Alexandria		El-Beheira	
	Total	%Reduction	Total	%Reduction
(Halauxifen-methyl+Florasulam) + Pyroxsulam	35	99.34	2330	56.76
(Halauxifen-methyl+Florasulam) + pinoxaden	203	96.18	1870	65.29
(Halauxifen-methyl+Florasulam) + clodinafop-propargyl	770	85.52	1540	71.42
(Halauxifen-methyl+Florasulam) + diclofop-methyl	1515	71.50	2552	52.64
Iodosulfuron + mesosulfuron	87	98.36	186	96.55
pyroxsulam	221	95.84	695	87.10
Unweeded check	5316	0	5388	0

Table (7): Effect of herbicidal treatments on grassy seed heads in Alexandria and El-Beheira governorates

Treatments (Rate/Hectare)	Alexandria		El-Beheira	
	Mean	%Reduction	Mean	%Reduction
(Halauxifen-methyl+Florasulam) + Pyroxsulam	3	99.03	374.5	46.27
(Halauxifen-methyl+Florasulam) + pinoxaden	84.5	72.74	219.75	68.47
(Halauxifen-methyl+Florasulam) + clodinafop-propargyl	210	32.26	216.5	68.94
(Halauxifen-methyl+Florasulam) + diclofop-methyl	308	0.65	403	42.18
Iodosulfuron + mesosulfuron	19	93.87	80.5	88.45
pyroxsulam	88	71.61	243	65.14
Unweeded check	310		697	
LSD 0.05	35.02		62.19	

From these results, we conclude that (Halauxifen-methyl + florasulam) combination with pyroxsulam and pinoxaden succeeded to control both broad and grassy weed with moderate infestation without antagonistic effect between them, these combinationsshowed almost similar results to standard treatments but withdifferentmode of actions to avoid weed resistance to certain herbicide group, also reduced the number and cost of spraying.

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خليط مبيد هلوكسيفين ميثيل + فلوراسيولام مع مبيدات حشائش رفيعة الأوراق لمكافحة حشائش القمح

محمود شحاتة محمود[1]، فؤاد شعبان سليمان[2] و محمد الشيخ[3]

١،٢ قسم كيمياء و تقنية المبيدات- كلية الزراعة- جامعة الاسكندرية

٣ قسم انتاج المحاصيل- كلية الزراعة- جامعة الاسكندرية

تم إجراء تجربتان حقليتان فى محافظتى الاسكندرية و البحيرة لتقييم كفاءة مبيد الحشائش هلوكسيفين ميثيل + فلوراسيولام (باراديجم) بمعدل ٢١ جم/فدان مخلوط بايروكسيولام (١٦٠ مل/فدان)، بينوكسادين (٥٥٠ مل/فدان)، كلودينافوب بروبارجيل (١٤٠ جم/فدان) و دايكلوفوب ميثيل (١٠٠٠ مل/فدان) و مقارنتهم مع بايروكسيولام (بالاس) و ايودوسلفيورون + ميزوسلفيورون (اتلانتس) و ذلك فى محصول القمح الشتوى عام ٢٠١٤. تم تطبيق المبيدات عند بداية تفريع المحصول. اظهرت النتائج ان مبيد الباراديجم عندما تم خلطه مع مبيدات الحشائش رفيعة الاوراق أعطى مكافحة ممتازة ضد حشائش النفل، السلق، الخبيزة، الزغلنت، الرشاد البرى، الجعضيض و الكبر. من ناحية أخرى أعطى تطبيق الباراديجم مع كلا من بايروكسيولام و بينوكسادين أفضل مكافحة للحشائش رفيعة الأوراق على عكس تطبيقة مع كلودينافوب بروبارجيل و دايكلوفوب ميثيل و الذى لم يظهر أى تحسن. عامة أظهرت الخلائط نتائج ممتازة فى مكافحة الحشائش عريضة الاوراق فى كلا المنطقتين، أما بالنسبة للحشائش رفيعة الأوراق فكانت نتائج الخلائط فى منطقة الاسكندرية أفضل من البحيرة.