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CHEMICAL CONTROL OF GRASSY WEEDS IN DRILL-SEEDED RICE *(ORYZA SATIVA* L.*)*

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ABSTRACT: Weeds are the main obstruction under drill-seeded rice system so that two field experiments were conducted at the experimental farm of Rice Research & Training Center, Sakha Agricultural Research Station, Kafrelsheikh, Egypt in the summer seasons of 2020 and 2021 to reset the best chemical control program against grassy weeds in drill-seeded rice (Giza 179 cv.). Randomized Complete Block Design (RCBD) with three replications was used during both seasons of study. Ten chemical weed control were applied; (1) pendimethalin 50% EC (2.023 kg ai ha^{-1}) at 4 DAS as pre-emergence herbicide, (2) pendimethalin as per-emergence followed by (fb) penoxsulam 2.5% OD (0.0238 kg ai ha^{-1}) at 15 DAS as post-emergence herbicide, (3) pendimethalin as per-emergence fb bispyribac-sodium 2% SL (0.0381 kg ai ha^{-1}) at 25 DAS, (4) pendimethalin as pre-emergence fb ready mix of cyhalofop-butyl 7% + quinclorac 10% OD (0.238+0.1667 Kg ai ha^{-1}) at 20 DAS, (5) pendimethalin as pre-emergence fb fenoxaprop-ethyl 7.5% EW (0.0625 kg ai ha^{-1}) at 40 DAS, (6) thiobencarb 50% EC (3.57 kg ai ha^{-1}) at 4 DAS as pre-emergence herbicide fb bispyribac-sodium, (7) penoxsulam fb bispyribac-sodium, (8) penoxsulam at 15 DAS fb ready mix of cyhalofop-butyl 7% + quinclorac 10% OD at 25 DAS, (9) penoxsulam at 15 DAS fb fenoxaprop-ethyl and (10) tank mix of penoxsulam (0.0119 kg ai ha^{-1}) + fenoxaprop-ethyl (0.0357 kg ai ha^{-1}) at 35 DAS as compared to un-treated plots (weedy check) and weed free. The obtained results showed that, sequential application of pendimethalin 50% at 4 DAS pre-emergence herbicide followed by fenoxaprop-ethyl 7.5% at 40 DAS or ready mix of cyhalofop-butyl 7%+quinclorac 10% at 20 DAS recorded the lowest density and biomass of grasses and highest weed control efficiency, highest rice vegetative growth, grain yield and its attributes and reduced yield losses to 3.2 and 3.9%, respectively as compared to weed free during both studing seasons. Based on the obtained data, it could be concluded that sequential application of pre-emergence fb post-emergence herbicides was the best in grassy weed management and improved rice grain yield (87.1% and 9.203 t ha^{-1}), while sequential application of early post-emergence fb late post-emergence herbicides ranked second (83.2% and 8.011 t ha^{-1}) and exceeded single application of pre-emergence herbicide (40.3% and 4.317 t ha^{-1}) and post-emergence herbicide tank mix (72.6% and 7.351 t ha^{-1}) under dill-seeded rice conditions.

Key words: Rice, Weeds, Drill seeded rice, Herbicides, Pre-emergence, Post-emergence, Application, Yield, Losses, Efficiency

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the main cereal crops which ensure food security not only in Egypt but also around the world especially after the crisis of wheat shortage. Most of people resorted to feeding on rice as a main dish rich by carbohydrates, nutrients and minerals. In Egypt, the total production of paddy rice was 4,893,507 tons produced from 554205 hectares (FAOSTAT, 2020). The new Egyptian strategy for rice production during the latest few years is depending on maximize water productivity by releasing new rice cultivars have a short duration, high yielding ability and high quality, in addition to increasing the area cultivated with direct seeded rice (DSR) as dry seeds in dry soil to decrease applied irrigation water for rice by far irrigation intervals with economic yield. Drill-seeded rice conserve aerobic condition and good root system for rice plants by irrigation on wide intervals save production cost and reduce rice duration by about seven days less than

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transplanted rice. Tabbal *et al*., 2002 found that DSR saved about 11-18.5% of applied irrigation water as compared to transplanted rice.

Weeds is the limitation factor in rice production under DSR system, it compete versus rice plants on water absorption, sun light for photosynthesis, place in the field (Kumar *et al*. 2016) which reduce rice tillering ability and deplete macro and micro elements from the soil, moreover is main host for insects and pathogens which attack rice plants along growing season. Grassy weeds is the dominant weeds in DSR, such aerobic conditions enhance seeds of grasses to rapidly germinate and grow and become more stronger as C_4 photosynthetic grass than rice, in addition to appearing grassy weeds in successive generations during growing season of rice. Ranjit, 1997 cited that weeds caused yield losses determined by 14-93 % in direct seeded rice and 17- 47 % in transplanted rice. *E. colona* is grassy weed belongs to family Poaceae, it has rapid germination, high tillering ability moreover the secondary tillers can be independent plants when arrive to soil surface and produce secondary roots have ability to absorb water and nutrients. Jungle rice is C_4 grass has high growth rate and produce a huge number of seeds which shatter into the soil before rice harvest and increase soil seed bank and help the weed on germination the next season in sequence generation along summer growing season in Egypt (Hassan *et al*, 2001). *Dinebra retroflexa* is an obstinate C_4 grass belongs to family Poaceae, it germinate and seedlings emergence is 7 DAS then start flowering at 36 DAS in the field, every plant produce about 5.3 tillers and thousand seed weight is very light about 0.136 g (Jayakumar *et al*., 2020).

Chemical weed control is the key and the last defense line against aggressive weeds to improve grain yield of rice under direct seeding system. Herbicide as selective chemical substances which prevent seed germination or kill weed with no harmful effect on the crop must be added by sequential application to keep rice field free of weeds during critical period of weed-rice competition (eight weeks after rice seeding) in DSR to help rice plants on optimum vegetative growth, high tillering, dry matter accumulation, more panicles and maximize grain yield of rice (Chauhan *et al*., 2015). Abd El-Naby *et al*., 2018 concluded that the highest rice grain yield and best weed management were achieved by spraying pendimethalin 50% EC as pre-emergence herbicide at 4 DAS fb penoxsulam 2.5% OD or bispyribac-sodium 2% SL or fenoxaprop-ethyl 7.5% EW mixed with halosulfuron 75% WG at recommended doses as post-emergence herbicides at 15, 22 and 35 DAS, respectively. Current study aimed to reset effective program of chemical control against grassy weeds in drill-seeded rice and improve rice productivity.

MATERIALS AND METHODS

A field experiments was conducted at the experimental farm of Rice Research and Training Center (RRTC), Sakha, Kafrelsheikh, Egypt, during summer seasons of 2020 and 2021 to reset an effective chemical control program against grassy weeds in drill-seeded rice (Giza 179 cv). A randomized Complete Block Design (RCBD) with three replications was used, plot area was 15 m^2 (2.5 x 6 m). Other rice agricultural practices were applied as recommended for drill-seeded rice according to RRTC, 2019.

Weed control treatments were suggested as follow (Table 1)

1- Stomp 50% EC (pendimethalin) at 2.023 kg ai ha^{-1} at 4 days after seeding (DAS).

2- Stomp 50% EC (2.023 kg ai ha^{-1}) at 4 DAS fb Rainbow 2.5% OD (penoxsulam) at 0.0238 kg ai ha^{-1} at 20 DAS.

3- Stomp 50% EC (2.023 kg ai ha^{-1}) at 4 DAS fb Nominee 2% SL (bispyribac-sodium) at rate of 0.0381 kg ai ha^{-1} at 25 DAS.

4- Stomp 50% EC (2.023 kg ai ha^{-1}) at 4 DAS fb Thanos 17% OD (cyhalofop-butyl 7% + quinclorac 10%) at rate of 0.167 + 0.238 kg ai ha^{-1} at 25 DAS.

5- Stomp 50% EC at 4 DAS fb Whip-super 7.5% EW (fenoxaprop-ethyl) at rate of 0.0625 kg ai ha^{-1} at 40 DAS.

6- Saturn 50% EC (thiobencarb 3.57 kg ai ha^{-1}) at 4 DAS fb Nominee 2% SL (bispyribac-sodium) at rate of 0.0381 kg ai ha^{-1} at 25 DAS.

7- Rainbow 2.5% OD (penoxsulam) at 15 DAS fb Nominee 2% (bispyribac-sodium) at rate of 0.0381 kg ai ha^{-1} at 25 DAS.

8- Rainbow 2.5% OD (penoxsulam 0.0238 kg ai ha^{-1}) at 15 DAS fb Thanos 17% OD (cyhalofop-butyl 7% + quinclorac 10%) at rate of 0.167 + 0.238 kg ai ha^{-1} at 25 DAS.

9- Rainbow 2.5% OD (penoxsulam 0.0238 kg ai ha^{-1}) at 15 DAS fb Whip-super 7.5% EW (fenoxaprop-ethyl) at rate of 0.0625 kg ai ha^{-1} at 40 DAS.

10- Rainbow 2.5% OD + Whip-super 7.5% EW at rate of 0.0238+0.0357 kg ai ha^{-1} at 35 DAS.

11- Weedy check (untreated).

12- Weed free (weeds were removed hand each two weeks until end season).

All herbicidal treatments were sprayed in 300 liter water per hectare on moisted land by using Knapsack sprayer then the soil was irrigated after 24 hours from herbicidal application

Studied characteristics:
A-Weed traits:

The dominant grasses were *Echinochloa colona*, *Echinochloa crus-galli* and *Dinebra retroflexa*. At 80 days after seeding, weeds were sampled by area of 50 x 50 cm quadrate replicated four times for each plot, weeds were classified, cleaned then counted, air dried then oven dried at 70 °C for 48 hours or to stable weight then dry weight as g m^{-2} for every weed species was recorded during the two seasons. Studied traits were determined as follow:

1- Number of tiller m^{-2} for *E. colona*, *E. crus-galli*, *D. retroflexa* and total grassy weeds.

2- Dry weight $g.m^{-2}$ for *E. colona*, *E. crus-galli*, *D. retroflexa* and total grassy weeds.

3- Weed control efficiency percentage (WCE %) according to Drost and Moody, 1982.

Table 1: Studied herbicides trade name, active ingredient, chemical group, mode of action, target weeds, rate Kg ai ha^{-1} and rate per feddan.

Herbicide Character	Herbicide trade name					
	Stomp 50% EC	**Rainbow 2.5% OD**	**Nominee 2% SL**	**Thanos 17% OD**	**Whip-super 7.5% EW**	**Saturn 50% EC**
Active ingredient	pendimethalin	penoxsulam	bispyribac-sodium	Cyhalofop-butyl	fenoxaprop-ethyl	thiobencarb
Chemical group	Dinitroaniline	Triazolopyrimidine	Pyrimidinyloxybenzoic acid	Aryloxy phenoxy propionate	Aryloxyphenoxypropionic	Thiocarbamate
Mode of action	Systemic - photosynthesis inhibitors	Systemic – ALS inhibitors	Systemic- ALS inhibitors	Systemic – ACCase inhibition	Systemic – ACCase inhibition	Systemic – photosynthesis inhibitors
Target weeds	Grasses + sedges	Grassy + broad leaves + sedges	Grassy + sedges	Grasses	Grasses	Grassy + sedges
Rate (Kg ai ha^{-1})	2.023	0.0238	0.0381	0.1667	0.0625	3.57

Lit.= litter, ha= hectare (10000m^2), g= gram, ALS= aceto lactate synthase, ACCase= acetyl-Coenzyme A carboxylase

B- Rice characteristics:

1- Dry weight of rice (g m^{-2}): At 80 DAS, area of 50 x 50 cm quadrate replicated four times from each plot were randomly sampled to determine dry weight, the samples were air dried for two days then oven dried at 70 °C for 48 hours or up to stable weight. Then samples were weighed as g m^{-2}.

2- Number of panicles m^{-2}: before harvest, rice panicles were counted by area of 50 x 50 cm quadrate replicated four times then the main was calculated and attributed to number of panicles m^{-2}.

3- Panicle weight (g): at harvest ten rice panicles were sampled to determine panicle weight as average.

4-Thousand grain weight (g): 1000-grains were taken from samples of the yield of each plots.

5- Number of filled grains per panicle: estimated from 5 panicles from each plots.

6-Grain yield (t ha^{-1}): at harvest the central four square meters from each plot were harvested and grain yield was estimated at 14% moisture content and converted to (t ha^{-1}).

7- Yield losses percentage: were calculated by the following formula:

Yield losses (%) =

$$\frac{Y_{\text{weed free}} - Y_{\text{treatment}}}{Y_{\text{weed free}}} \times 100$$

Statistical analysis

Weed data were subjected the collected data were subjected to proper statistical analysis of variance according to Snedecor and Cochran (1971). Weed data were statistically analyzed by MSTATC program after transformed according to square-root transformation ($\sqrt{[x + 0.5]}$), while rice collected data were directly analyzed by MSTATC program then the means of both weeds and rice characters were compared by using Duncan´s Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

A- Weeds traits

The target weeds in this study were grassy weeds included *Echinochloa colona* (jungle rice), *Echinochloa crus-galli* (barnyard grass) and *Dinebra retroflexa* (Viper grass) during the two seasons of study. Number of tillers m^{-2}, dry weight g m^{-2} and weed control efficiency percent for individual weeds as well as total weeds were determined. Weed free plots were kept free of weeds during whole season, the discussion of the data will be discussed as follow:

A-1: Effect of weed control treatments on *Echinochloa colona* studied traits

Data presented in Table 2 showed that all chemical weed control treatments significantly reduced weed density and dry weight than weedy check plots in both seasons of study. The application of Stomp 50% EC (pendimethalin) as pre-emergence herbicide applied at 4 DAS fb Whip-super 7.5% EW (fenoxaprop-ethyl) at 40 DAS by recommended dose recorded the lowest number of tillers per square meter and dry weights as well as highest WCE (%) during both seasons of study with no significant differences between Stomp 50% EC applied at 4 DAS fb ready mix herbicide of Thanos 17% (cyhalofop-butyl + quinclorac) at 25 DAS in 2020 and 2021 seasons. While the application of Rainbow 2.5% OD (penoxsulam) at 15 DAS as post-emergence herbicide fb Whip-super 7.5% EW at 40 DAS by recommended doses ranked second in this respect. On the opposite, un-treated plots gave the highest number of tillers m^{-2} and dry weight g m^{-2} of *E. colona* during both seasons of study. These results may be due to the high performance of pre-emergence herbicide in preventing or delaying weed seeds germination for at least 15-20 days which donate rice plants good conditions for germination and growth without weed competition during this period, moreover gave a relative advantage for post-emergence herbicide to kill germinated weeds based on age selectivity without toxicity on rice crop. Khaliq and Matloob, 2012 found that *E. colona* density significantly reduced when butachlor or pendimethalin were applied as pre-emergence herbicides. similar results were obtained by Valverde and Gressel, 2005 and Abd El-Naby *et al.*, 2018.

Table 2: Number of tillers m^{-2}, dry weight (g m^{-2}) of *Echinochloa colona* and weed control efficiency (%) as affected by weed control treatments during 2020 and 2021 seasons.

Treatment	*Echinochloa colona*					
	Number of tillers m^{-2}		Dry weight (g m^{-2})		Weed control efficiency (%)	
	2020	2021	2020	2021	2020	2021
Pendimethalin 50% EC	624.0 (24.9 b)	485.3 (22.0 b)	746.7 (27.33 b)	560.6 (23.67 b)	20.74	32.49
Pendimethalin *fb* penoxsulam 2.5% SC	128.0 (11.32 e)	112.0 (10.6 de)	185.2 (13.62 e)	146.2 (12.10 d)	80.34	82.39
Pendimethalin *fb* bispyribac-sodium 2%SL	106.7 (10.5 f)	96.0 (9.8 e)	122.1 (11.05 e)	111.7 (10.59 e)	87.03	86.55
Pendimethalin *fb* ready mix (cyhalofop-buty l7%+quinclorac 10%)	85.3 (9.3 gh)	64.0 (7.9 f)	66.9 (8.19 hi)	23.4 (4.84 h)	92.89	97.18
Pendimethalin *fb* fenoxaprop-ethyl	74.7 (8.6 h)	58.7 (7.7 f)	60.4 (7.80 i)	21.3 (4.61 h)	93.56	97.43
Thiobencarb 50% EC *fb* bispyribac-sodium	138.7 (11.8 e)	106.7 (10.4 e)	134.4 (11.61 f)	74.7 (8.66 f)	85.73	91.0
Penoxsulam *fb* bispyribac-sodium	288.0 (16.9 c)	186.7 (13.6 c)	404.4 (20.10 c)	257.7 (16.02 c)	57.07	68.97
Penoxsulam *fb* ready mix (cyhalofop-butyl + quinclorac)	117.3 (10.9 ef)	112.0 (10.6 de)	95.6 (9.80 g)	62.9 (7.94 fg)	89.85	92.42
Penoxsulam *fb* fenoxaprop-ethyl	101.3 (10.8 fg)	96.0 (9.8 e)	81.9 (9.06 gh)	49.6 (7.05 g)	91.30	94.02
Penoxsulam + fenoxaprop-ethyl	240.0 (15.5 d)	144.0 (12.0 d)	322.7 (17.97 d)	166.9 (12.93 d)	65.74	79.9
Weedy check	762.7 (27.6 a)	709.3 (26.6 a)	942.1 (30.69 a)	830.5 (28.83 a)	-	-
Weed free	0.0 (0.7 i)	0.0 (0.7 g)	0.00 (0.71 g)	0.00 (0.71 i)	100.00	100.00

Transformed values are shown in parentheses; means of transformed data followed by the same letter are not significantly different at 5% level, using Duncan's Multiple Range Test.

Based on data presented in Table 2, it could be extracted that the best weed control technique in DSR is the sequential application of pre-emergence herbicide fb post-emergence herbicide which recorded 89.4% of WCE, while the sequential application of early post-emergence herbicide at 15 DAS followed by late post-emergence herbicide recorded 82.3% of WCE as average of treatments of this category. Individual application by post-emergence herbicide as herbicides mixture achieved 72.8% of WCE against Jungle rice. The lowest WCE (26.6%) was recorded by the application of pre-emergence herbicide alone along growing season.

A-2- Effect of weed control treatments on *Echinochloa crus-galli* studied traits.

As shown from data in Table 3, chemical control treatments significantly reduced weed density and biomass as compared to weedy check plots in the two seasons of study. The lowest number of tillers per unit area and dry weight g m^{-2} of barnyard grass were recorded by the application of pendimethalin at 4 DAS fb fenoxaprop-ethyl at 40 DAS or ready mix (cyhalofop-butyl+quinclorac) at 25 DAS in 2020 and 2021 seasons. While sequential application of penoxsulam at 15 DAS fb fenoxaprop-ethyl at 40 DAS by recommended doses ranked second in both seasons of study. The highest tillers number of barnyard grass per square meter and dry weight g m^{-2} were recorded by un-treated plots (weedy check) through both seasons of study. These results are similar to those found by Singh *et al*., 2016 and Kumar *et al*., 2020.

For weed control efficiency (%), the application of pendimethalin 50% at 4 DAS fb fenoxaprop-ethyl 7.5% at 40 DAS recorded the highest WCE percent (94.7), while pendimethalin 50% at 4 DAS fb Thanos 17% at 25 DAS recorded 94.6% of WCE as an average for 2020 and 2021 seasons. The application of pre-emergence herbicide only (Stomp 50% EC) scored 58.3% of WCE against barnyard grass. On the other hand herbicide mixture of penoxsulam + fenoxaprop-ethyl (0.0238+0.0357 kg ai ha^{-1}) at 35 DAS achieved 82.6% of WCE against *E. crus-galli*. It means that for better weed control against barnyard grass, it must be used sequential application technique by applying one of such applications (1) pre-emergence herbicide (Stomp 50% at 4 DAS) followed by whip-super 7.5% at 40 DAS or Thanos 17% at 25 DAS by recommended doses. (2) Post-emergence herbicide (Rainbow 2.5% at 15 DAS) fb whip-super 7.5% at 40 DAS or Thanos 17% at 25 DAS by recommended rates. While single applications of pre-emergence herbicide or post-emergence herbicide are useless in controlling barnyard grass in heavy infested fields of DSR. Sen *et al*., 2020 concluded that sequential application of pendimethalin as pre-emergence herbicide fb ready mix of penoxsulam + cyhalofop-butyl recorded 87% weed control efficiency in DSR.

Table 3: Number of tillers m^{-2}, dry weight (g m^{-2}) of *Echinochloa curs-galli* and weed control efficiency (%) as affected by weed control treatments during 2020 and 2021 seasons.

Treatment	*Echinochloa crus-galli*					
	Number of tillers m^{-2}		Dry weight (g m^{-2})		Weed control efficiency (%)	
	2020	2021	2020	2021	2020	2021
Pendimethalin 50% EC	368.0 (19.2 b)	186.7 (13.7 b)	463.6 (21.53 b)	232.3 (15.21 b)	50.60	65.95
Pendimethalin ***fb*** penoxsulam 2.5% SC	160.0 (12.7 d)	80.0 (8.9 cd)	114.1 (10.70 ef)	91.9 (9.61 cd)	87.84	86.53
Pendimethalin ***fb*** bispyribac-sodium 2%SL	96.0 (9.8 ef)	53.3 (7.3 de)	102.5 (10.11 ef)	61.4 (7.68 def)	89.07	91.00
Pendimethalin *fb* ready mix (cyhalofop-butyl7%+quinclorac 10%)	64.0 (7.9 gh)	21.3 (4.6 f)	53.1 (7.32 h)	34.6 (5.92 f)	94.34	94.92
Pendimethalin *fb* fenoxaprop-ethyl	48.0 (6.9 h)	16.0 (4.1 f)	54.7 (7.43 h)	32.6 (5.74 f)	94.17	95.22
Thiobencarb 50% EC ***fb*** bispyribac-sodium	112.0 (10.6 e)	69.3 (8.3 cd)	120.4 (10.98 e)	78.7 (8.82 de)	87.17	88.46
Penoxsulam ***fb*** bispyribac-sodium	224.0 (14.9 c)	90.7 (9.5 c)	201.3 (14.15 c)	127.2 (11.20 c)	78.55	81.35
Penoxsulam ***fb*** ready mix (cyhalofop-butyl + quinclorac)	106.7 (10.3 e)	48.0 (6.9 de)	87.3 (9.34 fg)	45.8 (6.74 ef)	90.69	93.28
Penoxsulam ***fb*** fenoxaprop-ethyl	80.0 (8.9 fg)	37.3 (5.9 ef)	73.3 (8.56 gh)	39.8 (6.30 f)	92.18	94.16
Penoxsulam + fenoxaprop-ethyl	144.0 (12.0 d)	101.3 (9.9 c)	156.3 (12.50 d)	123.8 (11.04 c)	83.34	81.85
Weedy check	682.7 (26.1a)	565.3 (23.8 a)	938.5 (30.64 a)	682.4 (26.08 a)	-	-
Weed free	0.0 (0.7 i)	0.0 (0.7 g)	0.00 (0.71 i)	0.00 (0.71 g)	100	100

Transformed values are shown in parentheses ; means of transformed data followed by the same letter are not significantly different at 5% level, using Duncan's Multiple Range Test.

A-3- Effect of weed control treatments on *Dinebra retroflexa* studied traits.

Data allocated in Table 4 showed that *D. retroflexa* has a tolerance against most of grassy weeds herbicides used in drill-seeded rice. Out of ten tested chemical control treatments only two treatments performed good management against viper weed in DSR, sequential application of pendimethalin 50% EC as pre-emergence herbicide applied at 4 DAS fb fenoxaprop-ethyl 7.5% EW at 40 DAS at recommended doses recorded the lowest number of tillers per m^2 and dry biomass g m^{-2} in the two seasons of study without significant differences between Stomp 50% EC applied at 4 DAS fb Thanos 17% OD at 25 DAS in both seasons. These results are in harmony with those obtained by Ghosh *et al.*, 2016 and Kumar *et al*., 2018.

For WCE (%), the data in Table 4 summarized that for Stomp 50% EC (pendimethalin) sprayed at 4 DAS fb Whip-super 7.5% EW (fenoxaprop-ethyl) applied at 40 DAS recorded 91.95% control efficiency against D. retroflexa as an average for both study seasons, Stomp 50% EC at 4 DAS fb ready mix of Thanos 17% OD (cyhalofop-butyl+quinclorac) at 25 DAS ranked second in this respect and scored 89.96% of WCE. On the other hand, the highest viper grass density and biomass were recorded by weedy check (un-treated) plots in 2020 and 2021 seasons.

Table 4: Number of tillers m^{-2}, dry weight (g m^{-2}) of *Dinebra retroflexa* and weed control efficiency (%) as affected by weed control treatments during 2020 and 2021 seasons.

Treatment	***Dinebra retroflexa***					
	Number of tillers m^{-2}		**Dry weight (g m^{-2})**		**Weed control efficiency (%)**	
	2020	**2021**	**2020**	**2021**	**2020**	**2021**
Pendimethalin 50% EC	240.0 (15.5 b)	138.7 (11.6 b)	261.8 (16.19 b)	165.5 (12.88 b)	26.27	40.72
Pendimethalin ***fb*** penoxsulam 2.5% SC	160.0 (12.7 c)	101.3 (10.1 b)	171.9 (13.13 c)	135.4 (11.66 bcd)	51.59	51.50
Pendimethalin ***fb*** bispyribac-sodium 2%SL	128.0 (11.3 c)	90.7 (9.5 b)	137.2 (11.72 c)	105.5 (10.30 b)	61.36	62.21
Pendimethalin ***fb*** ready mix (cyhalofop-butyl7%+quinclorac 10%)	51.3 (7.2 e)	32.0 (5.6 cd)	36.7 (6.01 ef)	27.2 (5.19 fg)	89.66	90.25
Pendimethalin ***fb*** fenoxaprop-ethyl	21.3 (4.6 f)	16.0 (4.1 d)	28.9 (5.41 f)	22.2 (4.74 g)	91.86	92.04
Thiobencarb 50% EC ***fb*** bispyribac-sodium	133.3 (11.6 c)	106.7 (10.5 b)	145.5 (12.06 c)	122.7 (11.10 cd)	59.02	56.05
Penoxsulam ***fb*** bispyribac-sodium	160.0 (12.6 c)	117.3 (10.9 b)	172.4 (13.12 c)	150.6 (11.87 bc)	51.45	46.06
Penoxsulam ***fb*** ready mix (cyhalofop-butyl + quinclorac)	80.0 (8.9 d)	53.3 (7.3 c)	61.3 (7.84 d)	53.6 (7.34 e)	82.73	80.80
Penoxsulam ***fb*** fenoxaprop-ethyl	58.7 (7.7 de)	42.7 (6.5 c)	54.9 (7.41 de)	40.3 (6.36 ef)	84.53	85.56
Penoxsulam + fenoxaprop-ethyl	138.7 (11.8 c)	117.3 (10.9 b)	146.3 (12.05 c)	153.7 (12.41 bc)	58.80	44.94
Weedy check	330.7 (18.2 a)	256.0 (15.9 a)	355.1 (18.82 a)	279.2 (16.62 a)	-	-
Weed free	0.0 (0.7 g)	0.0 (0.7 e)	0.00 (0.71 g)	0.00 (0.71 h)	100.00	100.00

Transformed values are shown in parentheses; means of transformed data followed by the same letter are not significantly different at 5% level, using Duncan's Multiple Range Test.

A-4- Effect of weed control treatments on total grassy weeds during 2020 and 2021 seasons.

In current study organized comparison among four techniques of chemical weed control against grassy weeds in drill-seeded rice the techniques were; (1) Pre-emergence herbicide alone. (2) Pre-emergence herbicide followed by post-emergence herbicide. (3) Early post-emergence herbicide followed by late post-emergence herbicide. (4) Herbicide mixture as post-emergence herbicides, all compared to un-treated (weedy check) plots and weed free once in drill-seeded rice.

Data in Table 5 revealed that all chemical control treatments significantly reduced weeds density and biomass as well as increased WCE percentage as compared to weedy check plots in the two seasons of study. Sequential application of Stomp 50% EC at 4 DAS fb Whip-super 7.5% EW at 40 DAS recorded the lowest number of tillers m^{-2} and dry weights g m^{-2} for total weeds achieved the best weed control efficiency (94.66%) during two seasons of study with the same significance degree with application of Stomp 50% EC at 4 DAS fb Thanos 17% OD at 25 DAS which recorded 94.12% WCE as average in 2020 and 2021 seasons. The combination of Rainbow 2.5% + Whip-super 7.5% at 35 DAS as a single post-emergence application achieved low weed control efficiency (72.6%) against grassy weeds as average for both seasons of study. While spraying Stomp 50% EC at 4 DAS alone as pre-emergence herbicide appeared lowest grassy weeds control efficiency (40.3%). On the opposite, the highest values of grassy weeds density per square meter and biomass g m^{-2} were obtained by weedy check (un-treated) plots during both seasons of study. Singh *et al.*, 2016 reported that sequential application of pendimethalin or oxadiagryl as pre-emergence herbicides followed by bispyribac-sodium or azimsulfuron as post-emergence herbicides exceeded single application of pre or post-emergence herbicides in weed control.

Table 5: Number of tillers m^{-2}, dry weight (g m^{-2}) of total weeds and weed control efficiency (%) as affected by weed control treatments during 2020 and 2021 seasons.

Treatment	Total grassy weeds					
	Number of tillers m^{-2}		Dry weight (g m^{-2})		Weed control efficiency (%)	
	2020	2021	2020	2021	2020	2021
Pendimethalin 50% EC	1232.0 (35.1 b)	810.7 (28.5 b)	1472.2 (38.38 b)	958.3 (30.96 b)	3.15	46.53
Pendimethalin ***fb*** penoxsulam 2.5% SC	448.0 (21.2 e)	293.3 (17.1 d)	471.2 (21.72 e)	373.5 (19.34 e)	78.93	79.16
Pendimethalin ***fb*** bispyribac-sodium 2%SL	330.7 (18.2 g)	240.0 (15.5 de)	361.7 (19.01 f)	278.7 (16.69 f)	83.82	84.45
Pendimethalin *fb* ready mix (cyhalofop-butyl7%+quinclorac 10%)	200.7 (14.2 i)	117.3 (10.8 g)	156.8 (12.53 i)	85.2 (9.21h)	92.99	95.25
Pendimethalin ***fb*** fenoxaprop-ethyl	144.0 (11.9 j)	90.7 (9.5 g)	144.0 (12.02 i)	76.1 (8.75 h)	93.56	95.75
Thiobencarb 50% EC ***fb*** bispyribac-sodium	384.0 (19.6 f)	282.7 (16.8 d)	400.3 (20.02 f)	276.1 (16.61 f)	82.10	84.60
Penoxsulam ***fb*** bispyribac-sodium	672.0 (25.9 c)	394.7 (19.8 c)	778.1 (27.90 c)	525.5 (22.89 c)	65.20	70.68
Penoxsulam ***fb*** ready mix (cyhalofop-butyl + quinclorac)	304.0 (17.4 g)	213.3 (14.6 ef)	244.3 (15.62 g)	162.3 (12.75 g)	89.07	90.94
Penoxsulam ***fb*** fenoxaprop-ethyl	240.0 (15.5 h)	176.0 (13.3 f)	210.1 (14.50 h)	129.7 (11.38 g)	90.60	92.76
Penoxsulam + fenoxaprop-ethyl	522.7 (22.9 d)	362.7 (19.0 c)	625.4 (25.02 d)	444.5 (21.09 d)	70.03	75.20
Weedy check	1776.0 (42.2 a)	1530.7 (39.1 a)	2235.7 (47.28 a)	1792.2 (42.31 a)	-	-
Weed free	0.0 (0.7 k)	0.0 (0.7 h)	0.00 (0.71 j)	0.00 (0.71 i)	100	100

Transformed values are shown in parentheses ; means of transformed data followed by the same letter are not significantly different at 5% level, using Duncan's Multiple Range Test.

B- Effect of weed control treatments on rice dry weight, yield and its attributes and yield losses

Rice dry weight (g m^{-2}), number of panicles per m^2, panicle weight (g), thousand-grain weight (g), number of filled grains per panicle and grain yield (t ha^{-1}) were determined for rice, in addition to estimating yield losses (%) depending on weed free plots to reflect the effect of tested weed control treatments on rice growth and yield. Results will be presented as follow:

Data presented in Tables 6 and 7 showed that all studied characteristics of Giza 179 rice cultivar were significantly influenced by weed control treatments in both seasons of study. For dry weight, the highest values were obtained by the application of Stomp 50% EC (pendimethalin) at 4 DAS fb Whip-super 7.5% EW (fenoxaprop-ethyl) at 40 DAS with no significant differences among Stomp 50% EC (pendimethalin) at 4 DAS fb pre-mixed herbicide Thanos 17% OD (cyhalofop-butyl 7% + quinclorac 10%) at 25 DAS and weed free plots in 2020 and 2021 seasons. While the lowest dry matter of rice was recorded by weedy check (un-treated) plots in both seasons of study. Chauhan and Johnson, 2011 and Kumar *et al*., 2018 found that adding pendimethalin as pre-emergence herbicide kept DSR fields free of weeds at least for 15 days or more from seeding.

For grain yield and its attributes, pendimethalin 50% at 4 DAS fb fenoxaprop-ethyl 7.5% at 40 DAS or ready mix of cyhalofop-butyl 7% + quinclorac 10% at 25 DAS recorded the highest values of panicles per square meter, panicle weight, 1000-grain weight and filled grains per panicle as well as highest grain yield (10.082 and 9.951 t ha^{-1}), respectively as an average for study seasons with no significant differences between weed free plots which yielded 10.358 t ha^{-1} (Table 6 and 7). Weedy check plots produced the lowest values of yield attributes during both seasons consequently produced grain yield less than one ton per hectare (0.734 ton) as an average for two seasons. These results may be due to the high efficiency of sequential application of pre-emergence herbicide (which inhibited or delayed weed seeds germination for at least 15-20 days) fb post-emergence herbicide contain one active ingredient or ready mix of two active ingredients (which killed the young seedlings of weeds without any toxicity on rice plants) in managing grassy weeds and kept the field free of weeds during critical period of weed-rice competition (8-10 weeks after seeding in DSR as mentioned by Zimdahl, 1988) lead to maximize rice ability absorb macro and micro elements, water uptake, receive more sun light and increasing photosynthesis process and produce more tillers to quickly covering soil surface and prevent germination of more weeds, then increase dry matter accumulation and produce more panicles per unit area and panicle weight which increase grain yield of rice. Kumar *et al*., 2018 cited that sequential application of pre-emergence herbicide followed by post-emergence herbicide and single application of herbicide mixture as post-emergence herbicide exceeded applying pre-emergence herbicide only by 83 and 67% for rice grain yield.

For yield losses percentage (as shown in Table 7), weedy check plots (full season weed competition) caused 93% yield losses as an average for two seasons. While lowest yield losses (%) were recorded by the application of Stomp (pendimethalin) at 4 DAS fb Whip-super (fenoxaprop-ethyl) at 40 DAS and Stomp (pendimethalin) at 4 DAS fb pre-mixed herbicide Thanos (cyhalofop-butyl 7% + quinclorac 10%) at 25 DAS (2.7 and 3.9%, respectively). While sequential application of Rainbow (penoxsulam) at 15 DAS followed by Whip-super (fenoxaprop-ethyl) at 40 DAS or pre-mixed herbicide Thanos recorded 9.35 and 10.2%, respectively as average of 2020 and 2021 seasons. McCauley *et al*., 2005 reported that without post-emergence herbicides application, rice yield losses were 9-60%. Farooq *et al*., 2011 cited that pendimethalin as pre-emergence herbicide could not be able to prevent germination of grassy weeds for a large period of growing season.

Table 6: Dry weight (g m^{-2}), number of panicles $m^{-2}$and panicle weight (g) of rice as affected by weed control treatments during 2020 and 2021 seasons.

Treatment	Dry weight (g m^{-2})		Number of panicles (m^{-2})		Panicle weight (g)	
	2020	2021	2020	2021	2020	2021
Pendimethalin 50% EC	336.4 g	377.6 e	314.7 e	325.3 f	1.54 e	1.69 d
Pendimethalin ***fb*** penoxsulam 2.5% SC	742.6 de	827.9 c	432.0 c	464.0 d	1.95 cd	2.03 bc
Pendimethalin ***fb*** bispyribac-sodium 2%SL	875.7 cd	969.1 b	469.3 bc	485.3 d	2.01bcd	2.10 b
Pendimethalin *fb* ready mix (cyhalofop -butyl7% +quinclorac 10%)	1038.4 ab	1185.9 a	554.7 a	576.0 ab	2.34 a	2.40 a
Pendimethalin *fb* fenoxaprop-ethyl	1039.4 ab	1199.5 a	554.7 a	581.3 ab	2.33 a	2.41 a
Thiobencarb 50% EC ***fb*** bispyribac-sodium	846.9 cd	964.3 b	469.3 bc	485.3 d	2.01bcd	2.09 b
Penoxsulam ***fb*** bispyribac-sodium	566.8 f	667.2 d	336.0 e	362.7 f	1.62 e	1.86 cd
Penoxsulam ***fb*** ready mix (cyhalofop-butyl + quinclorac)	873.1 cd	999.1 b	496.0 b	506.7 cd	2.08 bc	2.12 b
Penoxsulam ***fb*** fenoxaprop-ethyl	918.1 bc	1051.8 b	506.7 b	538.7 bc	2.12 b	2.18 b
Penoxsulam + fenoxaprop-ethyl	619.9 ef	768.3 cd	389.3 d	410.7 e	1.90 d	2.08 b
Weedy check	72.9 h	88.1 f	58.7 f	80.0 g	0.70 f	0.99 e
Weed free	1128.0 a	1259.8 a	586.7 a	608.0 a	2.45 a	2.58 a

In a column, means followed by the same letter are not significantly different at 5% level, using Duncan's Multiple Range Test.

Table 7: Thousand-grain weight (g), number of filed grain $panicle^{-1}$ and grain yield (t ha^{-1}) of rice as affected by weed control treatments during 2020 and 2021 seasons

Treatment	1000-grian weight (g)		Number of filled grains per panicle		Grain yield (t ha^{-1})		Yield losses (%)	
	2020	2021	2020	2021	2020	2021	2020	2021
Pendimethalin 50% EC	16.67 e	19.33 e	74.3 e	77.0 D	4.084 g	4.549 g	59.8	56.9
Pendimethalin ***fb*** penoxsulam 2.5% SC	21.33 cd	22.67 cd	92.7 cd	100.0 Bc	7.830 d	8.477 c	23.0	19.7
Pendimethalin ***fb*** bispyribac-sodium 2%SL	22.33 bcd	23.00 bcd	100.0 bc	103.3 Bc	8.940 bc	9.081 cd	12.0	13.9
Pendimethalin *fb* ready mix (cyhalofop - butyl7%+quinclorac 10%)	23.67 ab	25.13 abc	103.3abc	109.0 Ab	9.784 a	10.119 ab	3.7	4.1
Pendimethalin *fb* fenoxaprop-ethyl	24.00 ab	25.77 ab	104.3 ab	111.0 Ab	9.903 a	10.261 a	2.6	2.8
Thiobencarb 50% EC ***fb*** bispyribac-sodium	22.00 bcd	22.67 cd	97.67 bc	102.3 Bc	8.647 c	8.988 cdc	14.9	14.8
Penoxsulam ***fb*** bispyribac-sodium	20.67 d	21.33 de	85.3 d	92.3 C	4.855 f	5.858 f	52.2	44.5
Penoxsulam ***fb*** ready mix (cyhalofop-butyl + quinclorac)	23.04 bc	23.37 bcd	97.0 bc	100.7 C	9.165 bc	9.429 c	9.8	10.6
Penoxsulam ***fb*** fenoxaprop-ethyl	23.14 bc	23.53 bcd	99.0 bc	102.7 Bc	9.234 bc	9.522 bc	9.2	9.5
Penoxsulam + fenoxaprop-ethyl	20.33 d	21.67 de	85.3 d	93.0 C	6.871 e	7.831 e	32.4	25.8
Weedy check	11.00 f	15.00 f	46.7 f	61.7 E	0.550 h	0.917 h	94.6	91.3
Weed free	25.40 a	26.33 a	112.0 a	118.0 A	10.164 a	10.552 a	--	--

In a column, means followed by the same letter are not significantly different at 5% level, using Duncan's Multiple Range Test.

Conclusion

Based on the obtained results under drill-seeded rice system, it can be concluded that grassy weeds are aggressive and reduced rice grain yield by 93%, moreover single application of pre-emergence herbicides was less effective in controlling weeds and cause 58.4% yield losses. While sequential application of pendimethalin as pre-emergence herbicide at 4 DAS fb fenoxaprop-ethyl or ready mix of quinclorac + cyhalofop-butyl as post-emergence herbicides applied at 40 and 25 DAS reduced grassy weeds density and biomass and achieved 94.66 and 94.12 of WCE, respectively and produced 10.082 and 9.951 t ha^{-1} grain yield of Giza 179 cv.

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المكافحة الكيماوية للحشائش النجيلية في الأرز التسطير

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الملخص العربي

تعتبر الحشائش هي العائق الرئيسي للإنتاج تحت ظروف الأرز المنزرع بطريقة التسطير لذلك أجريت تجربتان حقليتان بالمزرعة البحثية لمركز البحوث والتدريب في الأرز، محطة البحوث الزراعية بسخا- كفرالشيخ- جمهورية مصر العربية في الموسم الصيفي لعامي ٢٠٢٠ و ٢٠٢١ لوضع أفضل برنامج للمكافحة الكيماوية ضد الحشائش النجيلية في صنف الأرز جيزة ١٧٩ المنزرع بطريقة التسطير. وكان التصميم الإحصائي المستخدم هو القطاعات كاملة العشوائية في ثلاث مكررات خلال موسمي الدراسة. اختبرت عشرة معاملات كيماوية لمكافحة الحشائش النجيلية هي: (١) مبيد بنديميثالين ٥٠٪ بمعدل ٢,٠٢٣ كجم مادة فعالة للهكتار قبل الانبثاق منفرداً رشاً بعد ٤ أيام من الزراعة. (٢) مبيد بنديميثالين قبل الانبثاق يليه بينوكسولام ٢,٥٪ بمعدل ٠,٠٢٣٨ كجم للهكتار بعد ١٥ يوم من الزراعة. (٣) مبيد بنديميثالين قبل الانبثاق يليه بيسبيرباك صوديوم ٢٪ بمعدل ٠,٠٣٨١ كجم مادة فعالة للهكتار بعد ٢٥ يوم من الزراعة. (٤) مبيد بنديميثالين قبل الانبثاق يليه مخلوط جاهز من مادتي سيهالوفوب- بيوتيل ٧٪ + كوينكلوراك ١٠٪ بمعدل ٠,٢٣٨ + ٠,١٦٦٧ كجم مادة فعالة للهكتار بعد ٢٠ يوم من الزراعة. (٥) مبيد بنداميثيللين قبل الانبثاق يليه فينوكسابروب إيثيل ٧,٥٪ بمعدل٠,٠٦٢٥ كجم مادة فعالة للهكتار. (٦) مبيد ثيوبينكارب ٥٠٪ بمعدل ٣,٥٧ كجم مادة فعالة للهكتار كمبيد قبل الإنبثاق بعد ٤ أيام من الزراعة يليه بيسبيرباك صوديوم. (٧) مبيد بينوكسولام يليه بيسبيرباك صوديوم. (٨) مبيد بينوكسولام يليه مبيد مخلوط جاهز من مادتي سيهالوفوب- بيوتيل ٧٪ + كوينكلوراك ١٠٪. (٩) مبيد بينوكسولام يليه فينوكسابروب إيثيل. (١٠) مخلوط من مبيدي بينوكسولام ٢,٥٪ + فينوكسابروب إيثيل ٧,٥٪ بمعدل ٠,٠١١٩ + ٠,٠٣٥٧ كجم مادة فعالة للهكتار. مقارنة بالقطع التجريبية غير المعاملة بمبيد الحشائش والقطع التجريبية الخالية من الحشائش طول موسم نمو الأرز.

أوضحت النتائج المتحصل عليها أن إضافة مبيد بنديميثالين بعد الزراعة بـ ٤ أيام كمبيد قبل الانبثاق متبوعاً بمبيد فينوكسابروب إيثيل ٧,٥٪ بعد ٤٠ يوم من الزراعة أو مخلوط جاهز من مادتي سيهالوفوب- بيوتيل ٧٪ + كوينكلوراك ١٠٪ بعد ٢٠ يوم من الزراعة قد سجلت أقل عدد أفرع ووزن جاف للحشائش النجيلية المدروسة وكذلك أعلى نسبة مئوية لكفاءة مكافحة الحشائش بالإضافة إلى أعلى مادة جافة وصفات المحصول ومكوناته للأرز التسطير خلال موسمي الزراعة كما خفضت الفقد في المحصول بنسبة ٣,٢ و ٣,٩٪ على الترتيب مقارنة بالقطع التجريبية الخالية من الحشائش خلال موسمي الدراسة. وبناءً على النتائج المتحصل عليها تحت ظروف الأرز التسطير يمكن التوصية بأن المعاملة المتعاقبة من مبيد قبل الانبثاق يليه مبيد بعد الانبثاق قد حققت أفضل مكافحة للحشائش النجيلية بنسبة ٨٧,١٪ وكذلك أعطت محصول حبوب للأرز ٩,٢٠٣ طن للهكتار. بينما المعاملة بمبيد قبل الانبثاق مبكراً يليه مبيد بعد الانبثاق متأخراً جاءت في المرتبة الثانية وحققت ٨٣,٢٪ كفاءة مكافحة الحشائش واعطت ٨,٠١١ طن للهكتار من محصول حبوب الأرز متفوقة على المعاملة المنفردة بمبيد الحشائش سواء كان قبل الانبثاق التي حققت ٤٠,٣٪ كفاءة مكافحة الحشائش واعطت ٤,٣١٧ طن للهكتار من محصول حبوب الأرز أو مخلوط من مبيد يضاف بعد الانبثاق الذي حقق ٧٢,٦٪ كفاءة مكافحة الحشائش واعطت ٧,٣٥١ طن للهكتار من محصول حبوب الأرز.