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Effect of Water Regime and Weed Control Treatments on Weeds, Growth and Yields in Hybrid Rice

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ABSTRACT

Two field experiments were conducted at Rice Research and Training Center, Sakha, Kafr El-Sheikh, Egypt during 2015 and 2016 seasons to detect the effect of water regime and weed control treatments on weeds, growth and yields of hybrid rice (Sk2034H). Water regime (4-days on and 6-days off, saturation and continuous flooding) were allocated in main plots while weed control treatments were Thiobencarb 50% EC at three rates; 1.8 , 2.4 and 3.6 kg ai ha^{-1} in addition to weedy check were distributed in sub-plots. Weed species and hybrid rice yields were greatly influenced by water regime and weed control treatments. *Echinochloa crus-galli* and total weeds dry weights were significantly reduced under flooded or saturated plots than under shortage of water (4-days on + 6-days off). In different response, *Cyperus difformis* considerably reduced under the water shortage than saturated or flooded plots. The highest values of panicles per hill and grain yield of hybrid rice were recorded under flooding conditions followed by saturated soil. The application of Thiobencarb 50% EC at the high rate (3.6 kg ai h^{-1}) resulted in the best weed control and highest grain yield followed by the application of 2.4 kg ai ha^{-1} from the same compound, while weedy check plots recorded the highest in weed presence and the lowest in rice yields. For the interaction, the lowest dry weights of *Echinochloa crus-galli*, *Cyperus difformis* and total weeds, also the largest weed control efficiency (%), number of panicles per hill and the highest rice grain yields were obtained under flooded plots treated with Thiobencarb at both rates of 2.4 and 3.6 kg ai ha^{-1}. This trend was true under all treatments even the weedy check plots except for *Cyperus difformis* which increased significantly by soil saturation or flooding in un-treated plots.

Keywords: Water regime, Weed control, *Echinochloa crus-galli,* Rice grain yield and Hybrid rice

INTRODUCTION

Rice (*Oryza sativa* L) is on of the most important grain crops not only in Egypt but also over the world. Hybrid rice technology is one such innovative break through that can further increase rice production leading to food security in Egypt. Hybrid rice varieties can out-yield conventional modern varieties by 19% even at the same input levels (Lin, 1994).

In Egypt, rice grown under flooding and accused as a water-consuming crop. Abo- Soliman *et al.* (1990), found that irrigation every 4 days or at saturation maintain good rice stand as well as good grain yield and water use efficiency compared with irrigation at field capacity.

Water management is a major component of weed control strategy in rice. The type of weeds association with rice is closely related to moisture content of the soil and depth of water. *Echinochloa crus-galli* (barnyard grass) is the most common grass weed in rice. Barnyard grass and other weeds must be controlled soon after emergence to prevent yield losses. Once a permanent flooding is established, these grassy weeds usually will not emerge. The effect of water management, rice population on weed growth and transplanted rice grain yield were investigated by Hassan (1996).

In chemical weed control, chemicals called herbicides are used to kill certain plants or inhibit their germination and growth. Chemical weed control is an option in integrated weed management that refers to the integrated use of cultural, manual, mechanical and/or chemical control methods. Herbicides are effective against weed species, but most of them are specific and are effective against narrow range of weed species (Mukherjee and Singh, 2005).

Weed management can be defined as the manipulation of an agroecological environment to create a situation favorable for crop growth but unfavorable for weed survival (Moody, 1996). *Cyperus difformis* is erect, smooth tufted annual sedge that can grow as tall as 75 cm. This weed is normally propagated by seeds and adapted by moist soils, it is a heavy seed producer and complete one life cycle in about 30 days. Through high seed production and short life cycle, this weed can spread rapidly to become a dominant weed in a rice field (kim and Park, 1996).

The main target of the current work is to study the effect of water regime and different rates of Thiobencarb 50% EC to achieve the best weed control and the highest grain yield of hybrid rice.

MATERIALS AND METHODS

Two field experiments were carried out in 2015 and 2016 seasons at the experimental farm of Rice Research and Training Center, Sakha, Kafer EL-Sheikh, Egypt to study the influence of water regime and weed control treatments on weeds, growth and yield of hybrid rice (Egyptian hybrid 1). A split-plot design with four replicates was used. Three water treatments (4-days on and 6-days off, saturation and continuous flooding) were assigned to the main plats. Four weed control treatments (Thiobencarb 50 % EC at rates of 1.8, 2.4 and 3.6 kg ai ha^{-1} in addition to weedy check) were distributed in sub plots. Weed control treatments were applied at 4 days after transplanting (DAT) during the two seasons of study. Plot size was 15 m^2 (3 m x 5 m). Thirty-days old seedlings of the hybrid rice EH1 (Sk2034 H) was used.

Sampling and Data recorded:

Weed samples were collected using 0.5 m^2 quadrate at 50 DAT, and dried for 24 hour at 70 $^{\circ}$C in an oven and dry weigh for weeds was recorded.

Weed control efficiency (WCE %): WCE was calculated with the following formula:

$$WCE\ (\%) = \frac{DMC - DMT}{DMC} \times 100$$

Where: **DMC = Weed dry matter in un-weeded treatment.**
DMT = Weed dry matter in weed control treatment.

Number of rice panicles per hill was recorded at maturity. At harvest, rice grain yield was recorded from the central 10 m^2 and was adjusted to 14% moisture. All recorded data were subjected to statistical analysis of variance according to Snedecor and Cochran (1971). The recorded data were statistically analyzed by MSTATC program and Duncan Multiple Range Test (Duncan, 1955) was used at 5% level of significance for comparing averages for treatments.

RESULTS AND DISCUSSION

The ubiquitous dominant weeds in the experiment in both years were *Echinochloa crus-galli* and *Cyperus difformis*. The effect of water regime, weed control treatments and their interaction on weeds, rice panicles per hill and rice yield are presented in tables (1 - 6).

A- Effect of water regime on weeds and rice:

As shown in table (1), dry weight (g. m^{-2}) for *Echinochloa crus-galli*, *Cyperus difformis*, total weeds, number of panicles $hill^{-1}$ and grain yield of rice (ton ha^{-1}) were greatly influenced by water regime during 2015 and 2016 seasons. Continuous flooding was the best water regime whereas recorded the lowest values of dry weight for *E. crus-galli* and total weeds, the highest number of rice panicles per hill and the highest grain yield of hybrid rice in 2015 and 2016 seasons. On the other side, irrigation for 4-days on and 6-days off conditions recorded the highest values of dry weight for *E. crus-galli* and total weeds led to produce the lowest number of panicles per hill and grain yield of hybrid rice in the two seasons of study. For *C. difformis,* the highest dry matter was obtained by saturated plots, while the best management of this weed was achieved by water regime of 4-days on and 6-days off in the two seasons.

Generally, it could be observed that under aerobic conditions (4-days on and 6-days off), *E. crus-galli* was the dominant and *C. difformis* recorded the least, Paramita *et al*. (2005) also reported that most of weeds could not germinate under flooding conditions because of lack of oxygen. The obtained results are in agreement with those recorded by Hassan *et al.* (1990), Hassan *et al*. (1991), Hassan, (1996), RRTC (2004) and Kabir *et al*. (2008).

Table 1. Dry weights of *E. crus-galli, C. difformis* and total weeds, panicles per hill and grain yield of hybrid rice as influenced by water regime during 2015 and 2016 seasons.

Water regime	Weed dry weights (g.m^{-2})			Hybrid rice	
	2015 season				
	E. crus-galli	*C. difformis*	Total weeds	Panicles (No. $hill^{-1}$)	Grain yield (t. ha^{-1})
4-days on and 6-days off	50.71 a	54.73 c	105.69 b	17.93 c	8.221 c
Saturation	36.47 b	82.34 a	118.81 a	19.66 b	9.363 b
Continuous flooding	24.98 c	65.79 b	90.77 c	21.83 a	10.126 a
2016 season					
4-days on and 6-days off	38.43 a	45.72 c	84.14 b	18.75 c	8.845 c
Saturation	30.22 b	72.15 a	102.38 a	20.75 b	10.112 b
Continuous flooding	17.46 c	56.24 b	73.69 c	22.92 a	10.796 a

In a column, means followed by the same letter are not significantly different at 5% level according to DMRT.

B- Effect of weed control treatments on weeds and rice:

Concerning weed control treatments, all applied Thiobencarb rates significantly reduced dry weights of *E. crus-galli, C difformis* and total weeds as compared to weedy check plots in both seasons of study (Table 2).

The application of Thiobencarb at the high rate (3.6 kg ai ha^{-1}) recorded the highest weed suppression followed by Thiobencarb at the rate of 2.4 kg ai ha^{-1} as compared with weedy check which gave the highest dry weights of *E. crus-galli, C. difformis* and total weeds. The same trend was obtained during both seasons. The high efficiency of Thiobencarb at 3.6 kg ai ha^{-1} in weed control may refers to the early weed suppression by the pre-emergence treatment.

Data revealed that weed control treatments had a significant effect on weed control efficiency percentages for total weeds (Table 2). Weed control efficiency (%) increased by increasing the rate of Thiobencarb from 1.8 to 3.6 kg ai ha^{-1} during 2015 and 2016 seasons. The better weed control efficiency (%) was observed with the high rate (3.6 kg ai ha^{-1}) of Thiobencarb 50% EC. On the other hand the lower weed control efficiency (%) was observed in weedy check plots during two seasons of study. These results are confirmed with those cited by Paramita *et al.* (2005).

Table 2. Dry weight of *E. crus-galli, C. difformis* and total weeds, weed control efficiency, panicles per hill and grain yield of hybrid rice as influenced by weed control treatments during 2015 and 2016 seasons.

Weed control treatment	Rate (kg ai ha^{-1})	Time DAT	Weed dry weights (g m^{-2})			Weed control efficiency (%)	Hybrid rice	
			E. crus-galli	*C. difformis*	Total weeds		Panicles (No. $hil^{-1}l$)	Grain yield (t. ha^{-1})
2015 season								
Thiobencarb 50%	1. 8	4	25.68 b	25.98 b	51.22 b	83.83	19.67 c	9.952 b
Thiobencarb 50%	2.4	4	17.58 c	15.43 c	33.03 c	89.57	21.77 b	10.949 a
Thiobencarb 50%	3.6	4	9.83 d	9.48 d	19.31 d	99.90	22.67 a	10.997 a
Weedy check	-	-	96.44 a	220.33 a	316.78 a	-	15.11 d	5.049 c
2016 season								
Thiobencarb 50%	1. 8	4	18.03 b	20.14 b	38.17 b	85.79	20.66 c	10.688 c
Thiobencarb 50%	2.4	4	14.09 c	11.60 c	25.69 c	90.44	22.89 b	11.710 b
Thiobencarb 50%	3.6	4	6.26 d	8.19 d	14.45 d	94.46	23.56 a	11.833 a
Weedy check	-	-	76.45 a	192.23 a	268.65 a	-	16.11 d	5.439 d

In a column, means followed by the same letter are not significantly different at 5% level according to DMRT.

Number of panicles per hill and grain yield of hybrid rice were significantly influenced by different weed management practices (Table 2). Significantly higher number of panicle hill^{-1} and grain yield were recorded by the highest of Thiobencarb in the two seasons without significant differences with 2.4 Kg ai ha^{-1} of Thiobencarb on grain yield t. ha^{-1} in the first season, while the weedy check was the lowest in this respect during 2015 and 2016 seasons. Increasing in number of panicles per hill and grain yield of hybrid rice may be due to the high efficiency of the high rate from Thiobencarb in weed suppression and reducing weed competition which enhanced better growth conditions for rice, panicles and yield components. Similar results were observed by Hassan *et al.* (1991), Hassan *et al.* (1992), RRTC (2004) and Paramita *et al.* (2005).

C- Effect of interaction between water regime and weed control treatments:

1- Effect of interaction on *E. crus-galli* dry weights during 2015 and 2016 seasons.

Data in Table (3) showed the interaction effect between water regime and weed control treatments on dry weight (g.m^{-2}) of *Echinochloa crus-galli* in 2015 and 2016 seasons.

The application of Thiobencarb 50% EC at the rate of 3.6 kg ai ha^{-1} under flooding conditions recorded the lowest dry weight (g.m^{-2}) of *Echinochloa crus-galli* as compared to weedy check which gave the highest values of dry weight (g.m^{-2}) of *Echinochloa crus-galli* under 4-days on and 6-days off conditions in 2015 and 2016 seasons. These results may reflect the role of aerobic condition in enhancement of *E. crus-galli* growth.

Table 3. Dry weight (g.m^{-2}) of *E. crus-galli* as influenced by the interaction between water regime and weed control treatments during 2015 and 2016 seasons.

Weed control treatment	Rate (kg ai ha^{-1})	Time DAT	Water regime		
			4-days on and 6-days off	Saturation	Continuous flooding
			2015 season		
Thiobencarb 50%	1. 8	4	36.45 d	23.29 f	17.31 g
Thiobencarb 50%	2.4	4	27.09 e	18.06 g	7.61 i
Thiobencarb 50%	3.6	4	18.03 g	9.79 h	1.68 j
Weedy check	-	-	121.26 a	94.73 b	73.32 c
			2016 season		
Thiobencarb 50%	1. 8	4	25.09 d	18.57 e	10.42 c
Thiobencarb 50%	2.4	4	19.84 e	14.28 f	8.14 h
Thiobencarb 50%	3.6	4	10.72 g	7.65 h	0.40 i
Weedy check	-	-	98.06 a	80.38 b	50.90 c

In a season, means followed by the same letter are not significantly different at 5% level according to DMRT.

2- Effect of interaction between water regime and weed control treatments on *C. difformis* dry weights during 2015 and 2016 seasons.

Data in Table (4) showed the interaction effect between water regime and weed control treatments on dry weight (g.m^{-2}) of *Cyperus difformis* in 2015 and 2016 seasons.

The best control of *C. difformis* was obtained by applying Thiobencarb at the rate of 3.6 Kg ai ha^{-1} under flooding conditions followed by the rate of 2.4 Kg ai ha^{-1} under flooding conditions without significant differences in 2015 and 2016 seasons. These results may be due to the important role of water flooding in raising herbicide absorption rate and efficiency in suppressing weed seed germination and killing germinated weeds. On the opposite, weedy check recorded the highest values dry weight of *C. difformis* under saturation conditions during the two seasons of study.

Table 4. Dry weight (g.m^{-2}) of *C. difformis* as influenced by the interaction between water regime and weed control treatments during 2015 and 2016 seasons.

Weed control treatment	Rate (kg ai ha^{-1})	Time DAT	Water regime		
			4-days on and 6-days off	Saturation	Continuous flooding
			2015 season		
Thiobencarb 50%	1. 8	4	34.29 d	19.22 f	23.12 e
Thiobencarb 50%	2.4	4	23.30 e	14.84 g	8.19 ij
Thiobencarb 50%	3.6	4	9.60 hi	11.23 h	7.60 j
Weedy check	-	-	152.73 c	284.08 a	224.24 b
			2016 season		
Thiobencarb 50%	1. 8	4	23.84 d	14.79 ef	21.79 d
Thiobencarb 50%	2.4	4	16.04 e	12.18 efg	6.59 gh
Thiobencarb 50%	3.6	4	9.35 fgh	10.04 e-h	5.20 h
Weedy check	-	-	133.64 c	251.62 a	191.36 b

In a season, means followed by the same letter are not significantly different at 5% level according to DMRT.

3- Effect of interaction between water regime and weed control treatments on number of panicles per hill of hybrid rice during 2015 and 2016 seasons.

Data indicated that both of water regimes and weed control treatments caused significant differences on number of panicles hill^{-1}(Table 5).

The highest number of panicles per hill was observed in the plots treated with Thiobencarb at the rate of 2.4 or 3.6 kg ai ha^{-1} under flooding conditions. While, weedy check recorded the lowest values of number of panicles per hill under 4-days on and 6-days off conditions in 2015 and 2016 seasons. Soil moisture status

influenced not only weed emergence, but also the herbicide effectiveness. The increase in panicles number hill^{-1} of hybrid rice might be due to the ability of herbicide to achieve a higher weed control under continuous flooding, the obtained results are in agreement with those recorded by Hassan and Rao (1993), Hassan (1996), Hassan (2002) and Ahmed *et al*. (2014).

Table 5. Number of panicles per hill of hybrid rice as influenced by the interaction between water regime and weed control treatments during 2015 and 2016 seasons.

Weed control treatment	Rate (kg ai ha^{-1})	Time DAT	Water regime		
			4-days on and 6-days off	Saturation	Continuous flooding
			2015 season		
Thiobencarb 50%	1. 8	4	17.67 e	20.33 d	21.00 cd
Thiobencarb 50%	2.4	4	20.33 d	21.33 c	23.67 a
Thiobencarb 50%	3.6	4	21.00 cd	22.66 b	24.33 a
Weedy check	-	-	12.67 g	14.33 f	18.33 e
			2016 season		
Thiobencarb 50%	1. 8	4	18.33 f	21.33 de	22.33 cd
Thiobencarb 50%	2.4	4	21.00 e	22.67 c	25.00 a
Thiobencarb 50%	3.6	4	21.67 cde	23.66 b	25.33 a
Weedy check	-	-	14.00 h	15.33 g	19.00 f

In a season, means followed by the same letter are not significantly different at 5% level according to DMRT.

4- Effect of interaction between water regime and weed control treatments on grain yield of hybrid rice during 2015 and 2016 seasons.

Data on grain yield of hybrid rice as influenced by the abovementioned interaction are presented in Table (6). The data showed that there were highly significant differences among the combinations of water regime and weed control treatments. The highest grain yields were recorded by applying Thiobencarb at both rates of 2.4 and 3.6 kg ai ha^{-1} in flooded plots during the two seasons of study. While, the lowest values were scored by weedy check in plots which applied by 4-days on and 6-days off in 2015 and 2016 seasons. The superiority of using higher rates of thiobencarb under flooding condition for high yielding of hybrid rice may be related to the high efficiency of weed control and more favorable conditions for rice growth, Sobnom *et al.* (2014) reported that the application of recommended dose of Pertilachlor under continuous flooding scored the highest grain yield of rice.

Table 6. Grain yield of hybrid rice (ton ha^{-1}) as influenced by the interaction between water regime and weed control treatments during 2015 and 2016 seasons.

Weed control treatment	Rate (kg ai ha^{-1})	Time DAT	Water regime		
			4-days on and 6-days off	Saturation	Continuous flooding
			2015 season		
Thiobencarb 50%	1. 8	4	8.427 e	10.433 d	10.997 b
Thiobencarb 50%	2.4	4	10.617 cd	10.807 bc	11.423 a
Thiobencarb 50%	3.6	4	10.444 d	10.963 b	11.584 a
Weedy check	-	-	3.397 h	5.250 g	6.500 f
			2016 season		
Thiobencarb 50%	1. 8	4	9.113 e	11.047 cd	11.903 b
Thiobencarb 50%	2.4	4	11.000 d	11850 b	12.280 a
Thiobencarb 50%	3.6	4	11.207 c	11.923 b	12.370 a
Weedy check	-	-	4.060 h	5.627 g	6.630 f

In a season, means followed by the same letter are not significantly different at 5% level

To derive maximum benefit, flooding should occur before the emergence of weeds until the advent of herbicides, continuous flooding gave satisfactory weed control (Hassan *et al.,* 1991). Effectiveness of herbicides applied was excellent and provide weed free condition under continuous flooding condition.

CONCLUSION

From the obtained results of current study it could be concluded that, weed flora biomass are depending on soil moisture content, whereas *E. crus-galli* is the common weed in aerobic conditions, while *C. difformis* was the dominant under saturation conditions. The best weed control, growth and yield of hybrid rice were recorded by continuous flooding as well as adding Thiobencarb at the rate of 3.6 kg ai ha^{-1} or 2.4 kg ai ha^{-1} of certain herbicide.

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تأثير معاملات الري ومكافحة الحشائش علي النمو ومحصول الأرز الهجين

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أقيمت تجربتان حقليتان خلال الموسم الصيفي لعامي 2015، 2016 بمركز البحوث والتدريب في الأرز - سخا، - كفر الشيخ- جمهوريه مصر العربية بهدف دراسة تأثير معاملات الري ومكافحة الحشائش علي النمو ومحصول الأرز الهجين (هجين مصرى 1), استخدم تصميم القطع المنشقة مره واحده ذو أربع مكررات حيث وزعت معاملات الري (غمر مستمر، علي اللمعة ومعاملة 4 أيام ري و6 أيام بدون) في القطع الرئيسية عشوائياً وفي القطع المنشقة وزعت معاملات الحشائش عشوائياً وكانت الكنترول (بدون معامله)، ساتيرن بمعدل 1.8 كجم ماده فعاله /هكتار، ساتيرن بمعدل 2.4 كجم ماده فعاله /هكتار وساتيرن بمعدل 3.6 كجم ماده فعاله /هكتار. وأوضحت النتائج المتحصل عليها أن الحشائش ومحصول الأرز الهجين قد تأثرت معنوياً بمعاملات الري ومعاملات مكافحة الحشائش. انخفض الوزن الجاف للدنيبة والحشائش الكلية تحت ظروف الغمر المستمر والري علي اللمعة مقارنه بالري كل 4أيام و 6 أيام بدون وعلي العكس مع حشيشة العجيره حيث انخفض الوزن الجاف مع 4 أيام ري و 6 أيام بدون وذلك مقارنه بالغمر المستمر والري علي اللمعة في حين سجل أعلى عدد سنابل/جورة ومحصول الحبوب للأرز الهجين تحت الغمر المستمر يليه الري على اللمعة. وكانت أفضل معاملات مكافحة الحشائش هي معاملة الساتيرن بالمعدل العالي (3.6 كجم مادة فعالة /هكتار) حيث أعطت اقل وزن جاف للحشائش تحت الدراسة مقارنه بباقي المعاملات وحققت أعلى نسبة في كفاءة مكافحة الحشائش في كلا الموسمين بالإضافة لأعلى عدد سنابل/ جوره ومحصول الحبوب للأرز الهجين مقارنه بأقل معدل ومعامله الكنترول (بدون معامله) . وكانت أفضل معامله في مكافحة الحشائش (دنيبة، عجيرة وحشائش كلية) وأعلي عدد سنابل وأعلي محصول حبوب للأرز الهجين هما معاملتي الساتيرن بمعدل 2.4 و3.6 كجم مادة فعالة/هكتار مع الغمر المستمر خلال موسمي الدراسة.