Original Article

EFFECTS OF SPATIAL PATTERN AND CULTIVAR ON WEED CONTROL AND GRAIN YIELD IN RICE AT REDUCED RATES OF HERBICIDE

EFEITOS DO PADRÃO ESPACIAL E CULTIVAR ON CONTROLE DE PLANTAS DANINHAS E RENDIMENTO DE GRÃOS DO ARROZ COM TAXAS REDUZIDAS DE HERBICIDA

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ABSTRACT: To evaluate the effects of herbicide rate, cultivar, and spatial pattern on rice grain yield and weed suppression, a field experiment was conducted on a lowland rice field at the Rice Research Station of Tonekabon, north of Iran, in 2011. The experimental design was a split plot-factorial where the whole plot portion was a randomized complete block with three replicates. Main plots were pretilachlor rates (0, 0.5, 1, 1.5, 2 L ha^{-1} of pretilachlor). The subplots were factorial combinations of two crop spatial patterns (uniform and wide-row planting patterns, 20× 20 and 30 × 13 cm, respectively) and two traditional rice cultivars ('Hashemi' and 'Deylamani'). Regardless of cultivar and spatial pattern, rice grain and biological yields, panicle number per m^2, leaf area index, and herbicide efficacy increased, while weed biomass decreased with increasing pretilachlor application rate. Rice grain and biological yields, panicle number per m^2, leaf area index, and herbicide efficacy were significantly greater in uniform planting pattern than in wide-row planting pattern when averaged over cultivars and pretilachlor rates. Moreover, uniform planting pattern of rice plants suppressed weeds 39% better than wide-row planting pattern as averaged across pretilchlor rates and cultivars. 'Deylamani' produced grater grain and biological yields, panicle number per m^2, leaf area index than 'Hashemi' as averaged across pretilachlor rates and spatial patterns. This experiment illustrated that uniform spatial pattern increased weed suppression, herbicide efficacy, and grain yield.

KEYWORDS: Herbicide. Planting pattern. Rice cultivars. Weed competition.

INTRODUCTION

Weeds reduce rice grain yield up to the extent of 32% (SINGH et al., 2007) by competing for space, nutrients, water and light. Moreover, some weeds serve as alternate hosts for pests and diseases. In rice fields of Iran, most important grass weed species are *Echinochloa crus-galli* (L.) P. Beauv, and *Echinochloa oryzicola* Vasing, sedges are *Cyperus difformis* L., *Scirpus juncoides* Roxb., *Scirpus maritimus* L., *Scirpus mucronatus* L., and broad-leaved weed species are *Sagittaria trifolia* L., and *Alisma plantago-aquatica* L..

Weed control in rice fields of Iran largely depends on chemical methods, but the development of weed resistance, economic incentives, adverse effects on human and animal health, and unwanted environmental side-effects have served as the impetus for investigating reduced rates of herbicides for weed control (HEAP, 2010; POWLES; YU, 2010). It was hypothesized that combining the weed competitive cultivar with an appropriate spatial pattern could contribute to reduce herbicide rates for weed control in lowland rice systems. Weed competitiveness (WC) is the ability of a crop to suppress and tolerate weeds (JANNINK et al., 2000) which include; 1- weed-suppressive ability (WSA),

or the ability of the cultivar to reduce weed growth and subsequent seed production, 2- weed tolerance (WT), or the ability of the cultivar to maintain high grain yield when weeds are present. Crop cultivars can differ in their competitiveness with weeds, and cultivars with strong weed-competitive ability are a low-cost and safe tool for integrated weed management (SPIES et al., 2011; PAYNTER; HILLS, 2009, SHIVRAIN et al. 2009). It has been reported that using rice cultivars with the stronger weed-suppressive ability is an effective method to reduce herbicide rates and may decrease dependence on herbicides in weed control (GIBSON et al. 2001). GEALY et al. (2003) suggested that growing weed-suppressive rice cultivars in combination with reduced herbicide rates could be an effective weed management strategy for rice in the southern United States. Competitive crop cultivars are even more important for weed control in organic agriculture where herbicides are prohibited (MASON et al. 2008). At the same time, agronomic practices such as crop rotation, crop density, and spatial arrangement can be manipulated to reduce weed interference in some crop-weed associations. In north of Iran, rice is transplanted either manually or by rice transplanters. In manual methods, the seedlings are transplanted in straight rows with a

uniform spacing between plants (at planting distance of 20 × 20 cm for traditional cultivars and 25 × 25 cm for improved cultivars), while in machine transplanting; the seedlings are transplanted in straight rows with inter-row spacing of 30 cm and intra-row spacing from 11 to 19 cm. The use of these machines is increasing because manual transplanting is a labour intensive operation in the cultivation of rice. At the same time, previous studies have shown that crop spatial pattern can affect crop growth, grain yield and herbicide efficacy (OLSEN et al., 2012, OLSEN et al., 2005, WEINER et al., 2001). A recent study, Olsen et al. (2012) observed that increased crop uniformity had a negative effect on weed biomass, and concluded that crop pattern effects on weeds occur only through size-asymmetric competition. Olsen et al. (2005) have shown that a highly uniform pattern of wheat plants suppresses weeds 30% better than plants distributed in row pattern. Weiner et al. (2001) reported that a highly uniform sowing pattern combined with increased crop density reduced weed biomass in spring wheat by 60% compared with normal sowing practice. It has been suggested that the most important reason for increasing yield in uniform spatial pattern is decreased intra-specific competition for light, water, and nutrients because of a more equidistant spatial arrangement of plants. Therefore, the objective of this study was to assess whether rice cultivar and crop spatial pattern affect weed suppression, herbicide efficacy and crop yield at reduced rates of herbicide.

MATERIAL AND METHODS

Experimental design, plant culture and management

A field experiment was conducted on a lowland rice field at the Rice Research Station of Tonekabon (36° 51' N, 50° 46' E), north of Iran, in 2011. The previous crop was rice. Physical and chemical soil properties, were determined at 0-30 cm before experiment establishment, were as follows: 19% sand, 44% silt, 37% clay, 6.8 pH, 2.2% organic matter, 0.2% total nitrogen, 11 mg kg^{-1} P_2O_5, and 112 mg kg^{-1} K_2O. Monthly weather data are shown in Table 1. The experimental design was a split plot-factorial where the whole plot portion was a randomized complete block with three replicates. Main plots were pretilachlor rates (0, 0.5, 1, 1.5, 2 L ha^{-1} of pretilachlor[*]) (0, 25, 50, 75, and 100 % of recommended rate, respectively) applied at six days after transplanting, according to the manufacture recommendation. The subplots were factorial combinations of two crop spatial patterns (uniform and wide-row planting patterns, 20 × 20 and 30 × 13 cm, respectively) and two traditional rice cultivars ('Hashemi' and 'Deylamani'). These cultivars are extensively cultivated in north of Iran. Subplot size was 7 rows × 4 m, and both cultivars were transplanted on May 19, 2011. Fertilizer was applied as a basal application of 25 kg N as urea, 70 kg P_2O_5 as triple super phosphate and 100 kg K_2O as KCl per hectare. Additional N was applied at 25 kg ha^{-1} as topdressing at 40 days after transplanting for both cultivars.

[*]2-Chloro-N-(2,6-diethylphenyl)-N-(2-propoxyethyl) acetamide (50% EC)

Table 1. Monthly precipitation and temperature from April to September in 2011 at Rice Research Station of Tonekabon.

Month	Precipitation (mm)	Temperature (°C)		
		Maximum	Minimum	Average
April	39.6	16.6	10.7	13.6
May	10.4	21.9	16.5	19.2
June	73.9	26.8	20.8	23.8
July	2.9	31.4	24.2	27.8
August	131.3	28.8	23.1	25.9
September	271.1	25.4	19.7	22.5

Plant sampling

Green leaf area was measured with a leaf area meter (LI-3000A, LI-COR, Lincoln, NE, USA) at 25 and 45 days after transplanting. Leaf area index (LAI) was calculated as the ratio of green leaf area divided by the ground area. Plant height was measured from the soil surface to the tip of the panicle based on 12 individual measurements in each plot just before harvesting. At maturity stage, yield components of rice (panicle number per m^2, grain number per panicle, and 1000-grain weight) were measured according to Gomez (1972). Rice

grain yield, biological yield, and weed biomass were determined from 2.5 m² per plot. Grain yield was corrected to 140 g kg⁻¹ grain moisture content. Biological yield and weed biomass from each plot were dried at 70 °C for 96 h, and weighted. Harvest index was calculated by dividing the dry weight of the grain by the dry weight of aboveground (biological yield).

Statistical analyses

The relationship between rice yield and herbicide rate was described using the following quadratic model:

$$y = y_0 + ax + bx^2 \qquad [1]$$

Where y is estimated rice yield as a function of herbicide rate (x), y_0 is rice yield in the absence of herbicide application, and a & b are calculated regression parameters.

The relationship between weed biomass and herbicide rate was described using the following exponential model:

$$y = a /(1+\exp(-(x-x_0)/b)) \qquad [2]$$

Where y is estimated weed biomass as a function of herbicide rate (x), a is weed biomass in the absence of herbicide application, x_0 is the herbicide rate that 50 % inhibition occurred, b is calculated regression parameter.

The herbicide efficacy was calculated from the following equation (LESNIK, 2003):

$$HE = \frac{W_{Un} - W_T}{W_{Un}} \qquad [3]$$

Where HE is the herbicide efficacy, W_{Un} is weeds dry weight in non treated plot with herbicide, W_T is weeds dry weight in treated plot with herbicide. The relationship between the herbicide efficacy and herbicide rate was described using the following linear model:

$$Y = ax + b \qquad [4]$$

Where y is the herbicide efficacy as a function of herbicide rate (x), b is y intercept and a is calculated regression parameter.

Analyses of variance were performed using SAS procedures (SAS Institute, 2004). Means were compared using fisher's protected LSD test at α=0.05. When interactions between factors were not significant, main effects were presented. Moreover, if the analysis of variance indicated a significant F value for herbicide rate, a linear, quadratic, or exponential function was fit to the herbicide rate data using regression functions present in the graphics program (SigmaPlot version 10, Systat Software, Inc., Point Richmond, CA). Standard errors were calculated for all means.

RESULTS AND DISCUSSION

Analysis of variance (Table 2) indicated that the main effect of herbicide rate (H) was significant for plant height (PH), grain yield (Y), relative yield reduction (RYR), panicle number per m² (PN), grain number per panicle (GN), biological yield (BY), leaf area index at 45 days after transplanting (LAI45), weed biomass (WB), and herbicide efficacy (HE), but was not significant for 1000-grain weight (Thgw), harvest index (HI), and leaf area index at 25 days after transplanting (LAI25). Cultivar (C) had significant effect on plant height (PH), grain yield (Y), relative yield reduction (RYR), biological yield (BY), leaf area index at 25 and 45 days after transplanting (LAI25 and LAI45, respectively), while panicle number per m² (PN), grain number per panicle (GN), 1000-grain weight (THGW), harvest index (HI), weed biomass (WB), and herbicide efficacy (HE) were not significantly affected by cultivar. Moreover, main effect of spatial pattern (S) was significant for plant height (PH), grain yield (Y), relative yield reduction (RYR), panicle number per m² (PN), biological yield (BY), leaf area index at 25 and 45 days after transplanting (LAI25 and LAI45, respectively), weed biomass (WB), and herbicide efficacy (HE). In contrast, main effect of spatial pattern (S) was not significant for grain number per panicle (GN), 1000-grain weight (Thgw), and harvest index (HI). Effect of H×S interaction was significant only for weed biomass (WB), and herbicide efficacy (HE). Other 2-way interactions were not significant. Also, the 3-way interaction was not significant for all traits.

Averaged across cultivar and spatial pattern, plant height of rice was significantly increased from 113 cm to 130 cm (15%) as herbicide application rate increased from 0 to 2 L ha⁻¹ (Table 2). This is probably due to better weed suppression at higher application rate of pretilachlor.

Table 2. Analysis of variance (ANOVA) for plant height (PH), grain yield (Y), relative yield loss (RYL), panicle number per m² (PN), grain number per panicle (GN), 1000-grain weight (THGW), biological yield (BY), harvest index (HI), leaf area index at 25 and 45 days (LAI25 and LAI45) after transplanting, weed biomass (WB), and herbicide efficacy (HE) as affected by herbicide rate, cultivar, and spatial pattern

Source of variation	df	Ph	Y	RYL	PN	GN	THGW	BY	HI	LAI25	LAI45	WB	HE
Block (R)	2	405**	2130313**	177 ns	1242 ns	269*	0.8 ns	4010963**	3.9 ns	0.00001 ns	0.218 ns	761 ns	146*
Herbicide rate (H)	4	560***	2359702***	1565***	4404**	335*	2.3 ns	6298837***	0.8 ns	0.00043 ns	2.237***	253595***	17152***
Error (a)	8	19	50674	42	411	52 ns	1.2	378679	3.4	0.00036	0.035	1470	85
Cultivar (C)	1	627***	1096850**	432*	12 ns	44 ns	2.9 ns	4743405**	2.0 ns	0.00121*	0.447***	149 ns	7 ns
Spatial Pattern (S)	1	224**	4348549***	2733***	5080**	48 ns	0.2 ns	10128832***	3.1 ns	0.00181**	0.358***	49415***	1311***
H* C	4	23 ns	79076 ns	64 ns	872 ns	25 ns	0.3 ns	242360 ns	2.0 ns	0.00003 ns	0.002 ns	41 ns	4 ns
H* S	4	39 ns	174780 ns	108 ns	764 ns	76 ns	0.7 ns	471931 ns	0.3 ns	0.00008 ns	0.003 ns	4596***	281***
C* S	1	1 ns	188384 ns	150 ns	587 ns	51 ns	0.1 ns	92134 ns	2.9 ns	0.00004 ns	0.008 ns	40 ns	1 ns
H* C * S	4	5 ns	15542 ns	13 ns	218 ns	244 ns	0.4 ns	188482 ns	1.5 ns	0.00002 ns	0.001 ns	70 ns	2 ns
Error (b)	30	29	110650	70	568	71	0.9	601584	4.6	0.00023	0.013	739	32

*, **, and ***: significant at the 0.05, 0.01, and 0.001 probability level, respectively.
ns, not significant at the 0.05 probability level.

Table 3. Mean comparison for plant height (PH), seed yield (Y), relative yield loss (RYL), panicle number per m² (PN), grain number per panicle (GN), 1000-grain weight (THGW), biological yield (BY), harvest index (HI), leaf area index at 25 and 45 days (LAI25 and LAI45) after transplanting, weed biomass (WB), and herbicide efficacy (HE) response to pretilachlor rate, cultivar, and spatial pattern

Traits \ Factors	Ph (Cm)	Y (Kg ha⁻¹)	RYL (%)	PN (No. m⁻²)	GN (No. panicle⁻¹)	THGW (g)	BY (Kg ha⁻¹)	HI (%)	LAI25	LAI45	WB (g m⁻²)	HE (%)
Pretilachlor rates (L ha⁻¹)												
0	130	2356	39.9	180	77	27.0	3909	37.6	0.103	0.87	371	-
0.5	119	2543	35.0	199	84	27.3	4217	37.7	0.110	1.01	352	15.6
1.0	122	2927	24.9	208	86	28.0	4853	37.6	0.100	1.27	248	40.5
1.5	116	2954	24.4	209	88	27.9	5029	37.1	0.100	1.67	120	71.1
2.0	113	3507	10.2	233	91	27.7	5760	37.8	0.093	1.89	36	91.2
LSD (0.05)	4	211	6.1	19	6	1.1	579	1.7	0.017	0.19	36	8.6
Cultivars												
'Hashemi'	124	2722	29.6	205	84.7	27.4	4472	37.8	0.106	1.26	227	44.0
'Deylamani'	117	2993	24.2	206	86.4	27.8	5035	37.4	0.097	1.43	224	43.3
LSD (0.05)	3	175	4.4	12	4.4	0.5	408	1.1	0.008	0.06	14	3.0
Spatial patterns												
20 × 20	122	3127	20.1	215	86.4	27.5	5164	37.8	0.107	1.42	197	48.3
30 × 13	122	2588	33.6	197	86.6	27.6	4343	37.3	0.096	1.26	274	39.0
LSD (0.05)	2	175	4.4	12	4.4	0.5	408	1.1	0.008	0.06	15	3.0

The reduction in plant height of rice due to weed competition was reported by several earlier researchers (BEGUM, 2006; BEGUM et al., 2008). Similarly, Chauhan and Johnson (2010) noted that the reduction in plant height of rice was increased in higher weed density. 'Hashemi' cultivar was significantly taller than 'Deylamani' as averaged across herbicide rates and spatial patterns. Rice plants were significantly taller in uniform pattern (122 cm) compared to wide-row pattern (118 cm). This may be contributed greater weed biomass in wide-row pattern (254 gm^{-2}) compared to uniform pattern (197 gm^{-2}). Therefore, it seems that stronger competition between weeds and rice for nutrients in wide-row pattern reduced rice plant height.

A quadratic equation expressed the relationship between rice grain yield and herbicide rate (Figure 1). Regardless of cultivar and spatial pattern, grain yield was significantly increased with increasing pretilachlor rate. The highest yields (3507.6 kg ha^{-1}) were observed in plots receiving 2 L ha^{-1} of pretilachlor, while the lowest yields were obtained in plots receiving 0 or 0.5 L ha^{-1} of pretilachlor, 2356.5 and 2543.8 kg ha^{-1}, respectively.

'Deylamani' produced greater grain yield than 'Hashemi' (2993 vs. 2722 kg ha^{-1}) as averaged across pretilachlor rates and spatial patterns. Regardless of pretilachlor rate and cultivar, significantly higher grain yields were recorded in plots with uniform planting patterns (3127 kg ha^{-1}) compared to the plots with wide-row planting pattern (2588 kg ha^{-1}). Similar results were reported for wheat by OLSEN et al. (2005), who concluded that there may be other advantages to a uniform planting pattern of the crop in addition to increased weed suppression, such as better absorption of nutrients and utilization of space resources. The interaction between herbicide rate and spatial pattern was not significant for grain yield, indicating that a similar response for grain yield was observed in uniform and row planting pattern to different weed density (due to various application rate of pretilachlor). Contrary to this result, Weiner et al. (2001) reported that the advantage of uniform planting pattern occurs only when weeds are present, while when weeds are absent or well controlled, uniform planting pattern may has no superior to row planting pattern.
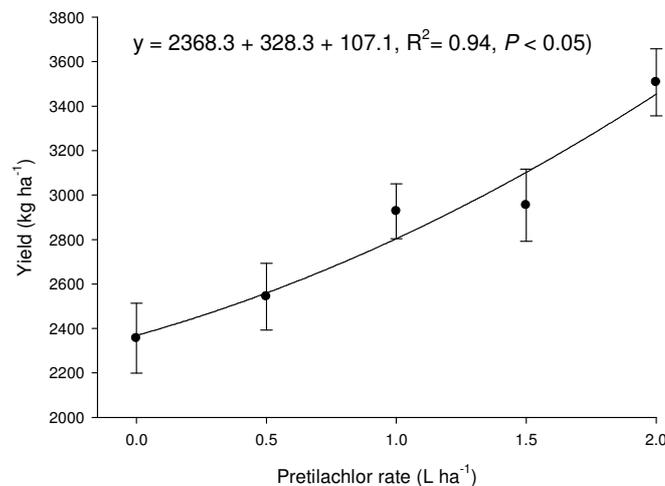
Figure 1. Influence of pretilachlor rate on rice grain yield (averaged across to cultivars and spatial patterns)

Averaged across cultivars and spatial patterns, relative yield loss was significantly reduced from 39.9% to 10.2% when pretilachlor rate increased from 0 to 2 L ha^{-1} (Table 3). Relative yield loss was significantly greater in 'Hashemi' (29%) compared to 'Deylamani' (24%), as averaged across pretilachlor rates and spatial patterns (Table 3). Averaged over cultivars and pretilachlor rates, relative yield loss was significantly greater in wide-row planting pattern compared to uniform planting pattern (Table 3). ZHAO et al. (2006) reported that the relative yield losses of rice cultivars caused by weed competition ranged from about 11 to 63% and

concluded that the cultivars had a wide range in both weed-suppressive ability and yield under weed competition.

Averaged across cultivars and spatial patterns, panicle number per m^2 and grain number per panicle increased by 29% and 19%, respectively, as pretilachlor rate increased from 0 to 2 L ha^{-1}. Regardless of cultivar and pretilachlor rate, rice plants grown in uniform planting pattern produced greater panicle number compared to ones grown in wide-row planting pattern. At the same time, 1000-grain weight was not significantly influenced by pretilachlor rate, cultivar and spatial

pattern (Table 2 & 3). 'Hashemi' and 'Deylamani' produced similar panicle number per m² and grain number per panicle, when averaged across pretilachlor rates and spatial patterns (Table 2 & 3). Spatial pattern also had no significant effect on grain number per panicle (Table 2 & 3). These results indicated that panicle number per m² was the most sensitive component to weed competition and spatial pattern. Khaliq et al (2011) reported that all yield components for wheat (productive tiller number m⁻², spikelets per spike, grains per spike, and 1000-grain weight) were significantly increased when herbicide application rate increased.

Regardless of rice cultivar and spatial pattern, the highest (5760 kg ha⁻¹) and the lowest (3909 kg ha⁻¹) biological yields were obtained when pretilachlor were applied at the rate of 2 and 0 L ha⁻¹, respectively, while harvest indices were similar among pretilachlor rates (Table 3). This indicates that the percentage reductions of grain yield and of biological yield by different weed pressure (due to various application rates of pretilachlor) were similar. Contrary to this result, Khaliq et al. (2011) concluded that harvest index for wheat was significantly increased with increasing herbicide [Atlantis 3.6WG (iodo+mesosulfuron)] application rate. Averaged across pretilachlor rates and spatial patterns, 'Deylamani' accumulated more biomass than 'Hashemi', but no significant difference in harvest index was found between 'Hashemi' and 'Deylamani' (Table 3). Rice biomass was significantly greater in uniform planting pattern than in wide-row planting pattern when averaged over cultivars and pretilachlor rates, whereas there was no significant difference in harvest index between uniform and wide-row planting patterns (Table 3).

Leaf area index at 25 days after transplanting (LAI25) was not significantly influenced by pretilachlor rates, cultivars and spatial patterns (Table 2 & 3). Regardless of cultivar and spatial pattern, leaf area index at 45 days after transplanting (LAI45) was significantly increased from 0.89 to 1.43 with increasing herbicide application rate from 0 to 2 L ha⁻¹ (Table 3), indicating 61% increases in LAI due to better weed suppression at higher application rate of pretilachlor (2 L ha⁻¹). Haefele et al. (2004) reported that leaf area index of rice cv. Sahel108 reduced by 32% due to natural weed competition. 'Deylamani' had more LAI45 than 'Hashemi', when averaged across spatial patterns and pretilachlor rates (Table 3). Contrary to this result, Saito et al. (2010) reported that rice genotypes did not significantly differ in LAI at 42

days after seeding, but significantly differed in LAI at 63 days after seeding under weed-free conditions. Moreover, uniform planting pattern produced significantly greater LAI at 45 days after transplanting than wide-row planting pattern when averaged across cultivars and pretilachlor rates (Table 3).

Averaged across cultivars and spatial patterns, weed biomass reduced and herbicide efficacy increased with increasing pretilachlor rate (Table 3). Significant reduction in weed biomass was achieved when at least 50% of recommended or higher rates of pretilachlor were applied (Table 3). Barros et al., 2007 and Khaliq et al. (2011) reported similar results and concluded that significant weed suppression can be achieved with reduced herbicide rates. Uniform planting pattern of rice plants suppressed weeds 39% and improved herbicide efficacy 23% better than wide-row planting pattern as averaged across pretilchlor rates and cultivars (Table 3). Regardless of cultivar, uniform planting pattern of rice plants suppressed weeds 22%, 24%, 15%, and 32% better than wide-row planting pattern when pretilachlor was applied at the rate of 0.0, 0.5, 1.0, 1.5 L ha⁻¹, respectively, but there was no significant difference in weed biomass between uniform and wide-row planting patterns when pretilachlor was applied at the rate of 2 L ha⁻¹ (Figure 2). Averaged across to cultivars, uniform planting pattern improved herbicide efficacy by 57%, 28%, 17% compared to wide-row planting pattern when pretilachlor was applied at the rate of 0.5, 1.0, 1.5 L ha⁻¹, respectively, while no significant difference was observed for herbicide efficacy between uniform and wide-row planting patterns when pretilachlor was applied at the rate of 2 L ha⁻¹ (Figure 3). It has been suggested that an equidistant spacing of crop plants hasten canopy closure and increase crop competitiveness which may reduce light penetration or affect light quality (or both) under the crop canopy. This may restrict germination, growth of weed seedlings, and seed production of late-season weeds (BAGAVATHIANNAN et al., 2011). Weed biomass and herbicide efficacy in 'Hashemi' was equal to those observed in 'Deylamani' when averaged across pretilachlor rates and spatial patterns (Table 3). Contrary to this result, Gealy et al. (2003) reported that 'PI 3127779' rice cultivar suppressed barnyardgrass more than did 'Lemont'. Moreover, Saito et al. (2010) found large variation in weed biomass among rice genotype.
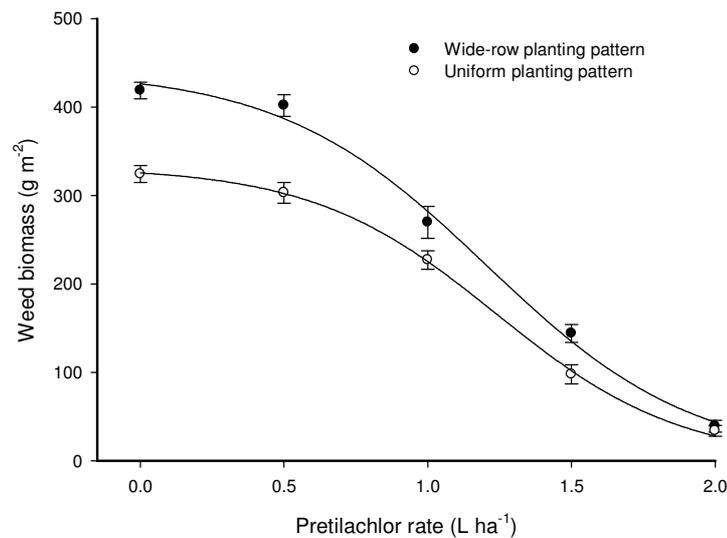
Figure 2. Influence of pretilachlor rate on weed biomass in uniform (○) and wide-row (●) planting patterns (averaged across to cultivars). Vertical bars represent ± 1 SE of means. Fitted lines are based on the equations: $y = 332.2/(1+\exp(-(x-1.2)/-0.3)))$, $R^2=0.99$, $P < 0.01$ (uniform planting pattern); and $y = 441.2/(1+\exp(-(x-1.2)/-0.3)))$, $R^2=0.99$, $P < 0.01$ (wide-row planting pattern)
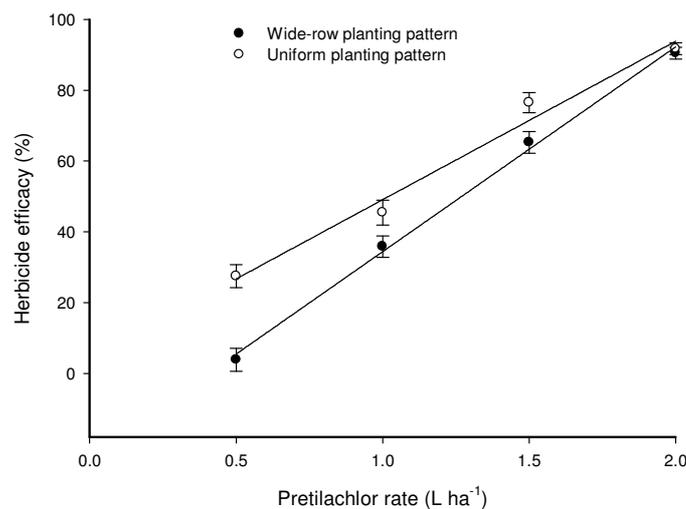
Figure 3. Influence of pretilachlor rate on herbicide efficacy in uniform (○) and wide-row (●) planting patterns (averaged across to cultivars). Vertical bars represent ± 1 SE of means. Fitted lines are based on the equations: $y = 4.3 + 44.7x$, $R^2=0.97$, $P < 0.01$ (uniform planting pattern); and $y = -23.4 + 57.8x$, $R^2=0.99$, $P < 0.01$ (wide-row planting pattern)

CONCLUSION

This experiment illustrated that uniform planting pattern suppressed weeds 39% better than wide-row planting pattern, and can play an important role in increasing the crop's competitive advantage over weeds. There were no significant differences in weed biomass between 'Hashemi' and 'Deylamani'. At the same time, rice grain yield and herbicide efficacy increased, while weed biomass decreased as pretilachlor application rate increased.

RESUMO: Para avaliar os efeitos da taxa de herbicida, cultivar e padrão espacial em arroz produção de grãos e supressão de plantas daninhas , um experimento de campo foi realizado em um campo de arroz irrigado na Estação de Pesquisa do Arroz de Tonekābon , norte do Irã, em 2011. O delineamento experimental foi uma fração de lote - fatorial , onde toda a parte de enredo foi em blocos casualizados com três repetições. As parcelas foram as taxas pretilaclor (0, 0.5,

1, 1.5 , 2 L ha^{-1} de pretilaclor) . As subparcelas foram combinações fatoriais de dois padrões de culturas espaciais (uniformes e padrões de plantio em toda a linha, 20 × 20 e 30 × 13 cm , respectivamente) e duas cultivares de arroz tradicionais (' Hashemi ' e ' Deylamani ') . Independentemente de cultivar e padrão espacial , grãos de arroz e os rendimentos biológicos , número de panículas por m^2 , o índice de área foliar e eficácia do herbicida aumentou, enquanto a biomassa de plantas daninhas diminuiu com o aumento da taxa de aplicação pretilaclor . O grão de arroz e os rendimentos biológicos , número de panículas por m^2 , o índice de área foliar e eficácia do herbicida foram significativamente maiores no padrão de plantio uniforme do que em toda a linha de plantio padrão quando calculados sobre cultivares e taxas pretilaclor . Além disso, o plantio uniforme padrão de plantas de arroz suprimida ervas daninhas 39% melhor do que em toda a linha de plantio padrão como média entre as taxas de pretilchlor e cultivares . ' Deylamani "produzido grão ralador e os rendimentos biológicos , número de panículas por m^2 , índice de área foliar do que" Hashemi ", como média entre as taxas de pretilaclor e padrões espaciais. Este experimento mostrou que padrão espacial uniforme aumento supressão de plantas daninhas , eficácia do herbicida , e rendimento de grãos.

PALAVRAS CHAVE: Herbicida. Plantio padrão. Cultivares de arroz. A competição de plantas daninhas

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