Comparison of efficiencies and costs of different weed control methods in paddy production in Iran

Reza Tabatabaekoloor*, Hasan Yousefnia pasha, Jafar Hashemi

(*Department of Farm Machinery*, *Sari Agricultural Scieneces and Natural Resources University*, *Sari*, *Iran*)

Abstract: Using of efficient and inexpensive method for weed control has an important role in increasing efficiency and reducing costs of production. In this study, field experiments were carried out to evaluate the efficiency and costs of several weed control methods in paddy production during summer in Mazandaran, the north province of Iran in 2011. Seven weed control treatments (T1 to T7) were applied at three stages of rice growth (20 and 35 days after transplanting and grain harvesting time). Weed density, weed dry weight, labor used and economical comparison were determined in the basis of a complete randomized block design with three replications. Results showed that there were no significant differences among efficiencies of six treatments (except for weedy check method (T6) treatment). The minimum weed density and dry weight were obtained at herbicide+hand weeding once (T5) and herbicide application once (T7) treatments during all three stages. The costs of weed control were different among the treatments. Selection of control method has an important role in reducing labor. Hand weeding twice method (T1), because of its high weeding cost, hard work and worker restriction in the required time, is not useful. Powered weeding twice method (T2), due to its zero environment pollution, reducing costs of weed control and high benefit/cost, is the best and most appropriate treatment. Amount of weed damage in weedy check method (T6) varied between 30.5% and 45.3%.

Keywords: weed control, paddy production, economic evaluation, mechanical weeding, chemical weeding, yield
DOI: 10.3965/j.ijabe.20120502.004

Citation: Tabatabaekoloor R, Yousefnia pasha H, Hashemi J. Comparison of efficiencies and costs of different weed control methods in paddy production in Iran. Int J Agric & Biol Eng, 2012; 5(2): 28－33.

1 Introduction

Weeds are one of the major problems of production technology for lowland rice (*OryzA sativa* L.). Weeds grow in a field as an unwanted plant and rival with the main plant in the absorption of light, water and nutrients[1-3]. Combating with weeds is one of the expensive actions that is used to increase the products and has a direct effect on ultimate price[4-6]. In order to control weeds, there are different ways all over the world such as hand weeding methods, chemical weeding, mechanical weeding and a combination of them[7-8]. Hand weeding is the most common method of weed control in rice, but it requires a very high labor input. The labor requirement for weeding can be too variable and depends on such factors as weed intensity, time of weeding, conditions at the time of weeding and efficiency of weeders[9]. Reliance on herbicide weed management systems can be costly and can led to herbicide-resistance concerns, whereas herbicide use is often recommended and required for maximum economic returns[10]. During the early stage of establishment, weed develops 20-30 percent of its growth while the crop performs 2-3 percent of its growth stage[11].

The performance of mechanical weeders alone and in combination with herbicide in upland rice was compared. Result indicated that combined application of Butachlor +

Received date: 2011-12-25 **Accepted date:** 2012-05-23
Biographies: Hasan Yousefnia pasha, Email: pasha911218@yahoo.com; **Jafar Hashemi,** Email: szhash@yahoo.com.
***Corresponding author: Reza Tabatabaekoloor,** Assistant Professor, Head of Department of Farm Machinery, Sari Agricultural Scieneces and Natural Resources University, Sari, Iran. Email: r.tabatabaei@sanru.ac.ir.

two mechanical weeding, 30 and 45 days after sowing was more effective in reducing weed growth, and maximizing grain yield and net return[12]. The performance of four mechanical weeders for paddy crop in Orissa, India was evaluated. Results showed that the Central Rice Research Institute weeder was found to be the most suitable for the paddy crop with regards to its highest field capacity (0.014 ha/h), higher weeding index (77.2%), highest performance index (1052.05), and less plant damage (2.66%)[13].

Loss of weed on transplanted rice in Gillan province of Iran was reported 46%-67% and loss of barnyard grass weed itself was reported 8%-53% and according to this report loss of weeds in transplanting rice is 44%-96% at the global level in the case of not controlling[14]. Lack of weed control in rice fields causes 80%-100% yield reduction in Nigeria[15]. Cost of mechanical weeding is almost 30% to 50% less than hand weeding[16]. Studies showed that without using weed killers and controlling weeds by other methods causes 31 percent reduction of product and about 13 million dollars loss. Currently each year farmers spend about 3.6 million dollars on chemical controlling of weeds and almost 2.6 million dollars on other methods[17]. To select one method or combination of several methods for combating depends on the amount of efficiency and the cost of each method. Nowadays, efforts are to use all possible and economic methods to control weeds in the fields such as rice cultivation. Therefore, the objectives of this study were to evaluate and compare the efficiency and costs of seven weed control methods in paddy production in Iran.

2 Materials and methods

2.1 Field experiments

The field experiments were conducted on a farm in the Babol region, the north part of Iran during summer of 2011. The average rainfall during the first 6 months was 36 mm and average temperature was 22.7℃. The average comparative humidity of air during the first 6 months was 77.5%, the average sunshine hours were 174 hours and average evaporation was 129.4 mm.

Prior to start measurements, the main field was transformed into flooding state and plowed by rototiller. Then, the process of leveling was done by trowel. After the preparation of the field, measurements were performed in the 500 m^2 with 21 plots and the size of each plot was 4 m×5 m. The experimental layout was designed in such way that entry and exit of water in each plot was done independently. In order to prevent water inference into plots, the boundaries between the two plots were covered with plastic. When the rice seedlings grew about 25 cm (4-5 leaf stage) were transferred to the main field and were transplanted in the 30×18 cm^2 spaces and 3 plants in each pile. The fertilizer requirement of the plots was done according to the soil test. Sampling of the weeds were done in three stages, 20th day after transplantation (before the first weeding), 35th day after transplantation (before the second weeding) and just before the harvest of rice. Thus, for each treatment in different replications the processes of sampling were done randomly through 4 boxes with the size of 0.5 m× 0.5 m. The weeds in each box were taken out and their density was measured. Then, in order to determine the dry weight they were put in an oven for 48 h. The temperature of the oven was 72℃. After that, the dry weight was measured by a precision scale. In order to determine grain yield, after complete ripening, each plot of 2 m^2 was harvested with elimination of marginal effects. After harvesting, grain and yield were estimated in kilograms per hectare with 14% moisture content.

2.2 Treatments and analyses

The experiment used a randomized complete block design with seven treatments and three replications (i.e. 21 plots) on local rice variety Tarom as follows:

a. Hand weeding twice, the first on 20th day and the second on 35th day after transplantation (T1)

b. Powered weeding twice, the time of performance the same as T1 (T2)

c. Powered weeding, 20th day after transplantation + hand weeding once, 35th day after transplantation (T3)

d. Conoweeder weeding twice, the time of performance the same as T1 (T4)

e. Herbicide application (Butachlor), 5th day after transplantation and 3-4 L in each Hectare + hand weeding once, 35th day after transplantation (T5)

f. Non-management for controlling weeds (Weedy check) (T6)

g. Herbicide application once, 5th day after transplantation and 3-4 L in each Hectare (T7)

Measured parameters were evaluated statistically employing SAS software to determine probabilities of treatment significance using analysis of variance and LSD test, as appropriate.

3 Results and discussion

Table 1 shows the results of analysis of variance for weed density and weed dry weight. According to Table 1, all treatments had a significant effect (p<0.01) on weed density and weed dry weight. Also, the replication effect was significant (p<0.01) for the weed dry weight in 20 days after planting.

3.1 Weed density

Table 2 shows the mean comparison of treatments on weed density and weed dry weight. As it is seen, the maximum weed density was observed on the 20th day after transplanting (before the first weeding) in cono-weeder weeding twice treatment (T4) and the minimum weed density were observed in treatments that used herbicide application + hand weeding (T5) and herbicide application once (T7). The maximum weed density on the 35th day after transplantation (before the second weeding) was observed in non-management treatment (T6) and the minimum weed density was observed in T5 and T7. The amount of weed density in T2 and T4 on the 35th day after transplantation was found to be the same with T6. Therefore, the amount of weed density respectively decreased 52.2% and 51.1% than that of T6 while the amount of weed density was less in other treatments (Table 2). During the harvesting time, the maximum density of weed was observed in T6 and the minimum density of weeds was observed in T5 and T7. Statistically, the amount of weed density in the treatment that was weeded by T2 placed in the third level, after T6 and T4. Therefore, the weed densities for T6 and T4 decreased 87.2% and 37%, respectively. The amounts of weed density in other treatments were less and placed in the next compared levels (Table 2).

Table 1 Results of variance analysis for weed density and weed dry weight in different weed control methods

Weed dry weight/g · m^{-2}			Weed density per square meter			df	Source of variation
Grain harvest time	35 days after planting	20 days after planting	Grain harvest time	35 days after planting	20 days after planting		
55575.5**	122.8**	248.5**	76097**	8340.6**	27072.7**	6	Treatments
8.1^{ns}	1.2^{ns}	3*	6.3^{ns}	54.9^{ns}	29.7^{ns}	2	Replication
22.3	0.53	0.67	11.2	20.1	68.2	12	Error
92.3	8	13.4	93.2	56.6	121.07		Total mean
5.1	9.1	6.1	3.6	7.9	6.8		CV (%)

3.2 Weed dry weight

Mean comparison of data showed that maximum weed dry weight was observed in T2 on the 20th day after transplantation (before the first weeding) and the minimum weed dry weight was observed in T5 and T7 (Table 2). Maximum weed dry weight was observed on 35th day after transplantation in T6 and the minimum weed dry weight was observed in T5 and T7. Statistically the treatment that was weeded by T3 was placed in the second level and the treatment that was weeded by T4 was placed in the third level while the treatment that was weeded by T2 was between the second and third level showing no significant difference with T3 and T4. At the harvest time, the weight of dry weed in T6 and T2 were more than that in other treatments, while minimum weight of dry weed at the harvest time was observed in T5 and T7. Statistically the treatment that was weeded by T5 was placed after treatment that was weeded by T2. Non-management treatment (T6) was placed in the third level and the rest treatments were placed in the next levels (Table 2).

Table 2 Mean comparisons of treatments on weed density and weed dry weight in different weed control methods

Weed dry weight/g · m^{-2}			Weed density per square meter			Treatments
Grain harvest time	35 days after planting	20 days after planting	Grain harvest time	35 days after planting	20 days after planting	
19.04d	2.1 d	17.3 c	17.67 e	21.67 d	139.67d	T1
118.33 b	11.37 bc	20.56 a	57.33c	73.33b	214.33 b	T2
22.88 d	12 b	17.42 c	25.67d	64 c	169 c	T3
101.1c	10.6 c	19.52 ab	91 b	75 b	236.33a	T4
0.58 e	0.92 d	0.19d	4 f	5.33 e	1.67 f	T5
381.67 a	17.23 a	18.73bc	447.67 a	153.33a	89.33 e	T6
2.5 e	1.58 d	0.21d	9.33 f	3.67 e	1.67 f	T 7
8.4	1.3	1.45	5.96	7.98	14.7	LSD (5%)

Note: Numbers followed by the same letters within a column are not significantly different at the 5% level with LSD test.

3.3 Mean of labor used for weeding and herbicide application

Table 3 shows the labor used in different weed control methods. As it is evident from Table 3, the minimum time duration of performed action for controlling weeds was related to the first stage of T5 and T7. The ratio of time duration of performed action in T2 to T4 and T1 showed a reduction of 50% and 83.3%, respectively. The minimum duration of time of performed action for controlling weeds in the second stage was in T2 and the maximum was in T3. Time duration of weed control for treatments T2 to T5, T4, T1 and T3 showed a reduction of 50%, 60%, 75%, 77.7%, respectively. Mean hours of performed action for controlling weeds during 2 stages for T7 was minimum and for T1 was the maximum. Time duration of performed action in T2 toward T5, T4, T3 and T1 showed a reduction of 2.44%, 55.5%, 63.6% and 80%, respectively.

Table 3 Labor used in different weed control methods (man-hour/ha)

Mean in each weeding and herbicide application/h			Treatments
The two- stages	The second stage	The first stage	
200	80	120	T1
40	20	20	T2
110	90	20	T3
90	50	40	T4
41	40	1	T5
0	0	0	T6
1	—	1	T7

3.4 Economic comparison

Table 4 shows the economic comparison of different weed control methods. The maximum and minimum product yields were related to the T5 and T6 treatments, respectively. The treatments with higher yields than T6 were showed as follows: T5 (45.35%), T7 (44.22%), T3 (39.2%), T4 (35.1%), T1 (33.94%) and T2 (30.46%). The costs required to control weeds in different treatments are tabulated in Table 4. The maximum cost for combating weeds was realized in T1, since in this method more labor was used and the cost-benefit ratio was lower than in other methods. The minimum cost for combating weeds was found in T7. The cost for combating weeds in T2 in comparison with T4, T3 and T1 was reduced by 29.8%, 46% and 66.67%, respectively. The maximum cost-benefit ratio was realized in T7 and increased by 96.36% in comparison with T1. In comparison with T4, T3 and T1, the cost-benefit ratios in T2 increased by 26%, 40% and 68%, respectively. These studies showed that selection of a method for controlling weed has a significant role in the reduction of labors' number. Hand weeding method (T1) is not economical due to its costly weeding, difficulty of performance and limitation of labor at the proper time. According to the cost on chemical management, it is necessary to note that most of the cost which are related to the production and use of chemical technology such as herbicides are not considered in the ultimate cost of products and just nominal price of herbicides are evaluated. This includes the purchase of alternative water supplies, medical costs, yield reduction resulting from losses and damages and cost to eliminate pollutants that are not paid by manufacturers and users. These lateral costs from herbicides were separated because that the real costs of chemical management are not estimated properly and toward reality and showed off no more economical. These prices are only understandable to beneficiaries when the additional cost is considered in ultimate price of product. Estimating costs of the non-apparent chemical management is complex, because quantifying them is difficult and on the other hand the loss to ecosystem and human health will be specified after a long period of time. If the cost of chemical inputs on human health and environmental damage is estimated, then the high cost of chemical inputs can be explained more. Therefore, according to the above context it can be realized that by using mechanical weeding method, desirable performance and also displacement of water in the paddy can be concluded due to reduction of weed density and the removal of harmful gases from the soil. The advantage is that there is no environmental pollution in this method and this method also reduces the cost of weed management in the paddy field.

Table 4 Economic comparison of different weed control methods

Benefit/Cost ratio	Benefit / $\$\cdot ha^{-1}$	Cost of control /$\$\cdot ha^{-1}$	Yield value/ $\$\cdot ha^{-1}$	Grain yiel /$kg\cdot ha^{-1}$	Treatments
6.9	4140.5	600	4740.5	3792.4	T1
21.5	4303.1	200	4503.1	3602.5	T2
12.9	4780.0	370	5150.0	4120.0	T3
15.9	4537.2	285	4822.2	3857.7	T4
37.3	5580.8	149.5	5730.3	4584.2	T5
—	3131.6	—	3131.6	2505.3	T6
189.3	5584.9	29.5	5614.4	4491.5	T7

Note: Price of paddy for Tarom variety (1.25$\$.kg^{-1}$) has been calculated based on Iran market in 2011.
The cost of hand weeding and Butachlor was calculated to be 30 $\$.day^{-1}$ and 7 $\$.L^{-1}$ based on 2011 prices in Iran, respectively.

4 Conclusions

In this study, seven weed control treatments (T1 to T7) were applied at three stages of rice growth (20 and 35 days after transplanting and grain harvesting time). It was observed that there were no significant difference among efficiencies of six treatments (T1 to T7 except for T6). The minimum weed density and dry weight were obtained at T5 and T7 during all the three stages. The costs of weed control were different among the treatments. Selection of control method has an important role in reducing labor. The T1 is not economical because of the high weeding cost, hard work and workers limitation in the required time. The T2 is the best and most appropriate treatment due to its zero environment pollution, reducing costs of weed control and high benefit/cost.

Acknowledgments

The authors would like to thank the Research Council of Sari Agricultural University for the financial support for this research.

[References]

[1] Nojavan M. Principles of weed control. Urmia: University of Urmia Press. 2001; 430 p.
[2] Vakili D. Shomal weeds and their control. Shadman press. 2000; 117 p.
[3] Yaghoobi B, Yousefi Deylami M. Weeds and herbicide in rice cultivation. Gilan: Agricultural Management, Coordination and Extension press. 2008; 35 p.
[4] Arab Mohammad Hosseini A. Design of a mechanical eeder. Journal of Agricultural, 2007; 63-76.
[5] Baldwin F L, Santelmann P W. Weed science in integrated pest management. BioScience, 1980; 30: 675-678.
[6] Ghasempour M, Khodabandeh N. Rice cultivation. Ghaemshahr: University of Islamic Azad Press. 2005; 167 p.
[7] Abdollahi F, Ghadiri H. Effect of separate combined applications of herbicide on weed control and yield of sugar beet. Weed Technology, 2004; 18: 968-976.
[8] Anaya A L. Allelopathy as a tool in the management of biotic resources. Review Plant Science, 2003; 19: 697-739.
[9] Singh C M, Moody K, Cho S C. Weed control through inter-row cultivation in upland rice. Agricultural Mechanization in Asia, Africa and Latin America, 1984; 16(3): 35-40.
[10] Place G T, Reberg-Horton S C, Jordan D L. Interaction of cultivar, planting pattern and weed management tactics in

peanut. Weed Science, 2010; 58: 442-448.

[11] Moody K. Post-planting weed control in direct seeded rice. Paper presented at a Rice Symposium 25-27Sept, Malaysian Agricultural Development Institute, Penang Malaysia, 1990.

[12] Singh R P, Reddy B G, Rao A S. Comparative performance of mechanical weeder alone and in combination with herbicide. Agricultural Mechanization in Asia, Africa and Latin America, 1994; 25(3): 41-43.

[13] Behera B K, Behera D, Swain S, Sahoo P K. Performance evaluation of manual weeders for paddy crop in Orissa, India. Agricultural Mechanization in Asia, Africa and Latin America, 1996; 37(3): 20-23.

[14] Mohammad Sharifi M. Integrated method control of rice weeds. Zeitun, Monthy in Agriculture, 1994; 42-45.

[15] Mahadi M A, Dadari S A, Mahmud M, Babaji B A. Effect of pre-emergence herbicide on yield and yield components of rice. Journal of Food Agriculture and Environment, 2006; 4(2): 164-167.

[16] Atajuddin F. Mechanizing Indian agriculture. Kisan World, 2004; 31(6): 46-50.

[17] Rashed M H, Rahimian H, Banayan M. Applied weed science. Mashhad: University Jihad Press. 2006; 575 p.