Australian Journal of Crop Science AJCS
AJCS 5(8):1007-1013 (2011) ISSN:1835-2707

Evaluation of traditional, mechanical and chemical weed control methods in rice fields

Fazlollah Eskandari Cherati[*,1], Hoshang Bahrami[2], Abbas Asakereh[3]

[1]Department of Agricultural Machinery Engineering, Shahid Chamran University of Ahvaz, Iran
[2]Department of Agricultural Machinery Engineering, Shahid Chamran University of Ahvaz, Iran
[3]Department of Agricultural Machinery Engineering, Faculty of Agricultural Engeenring and Technology, University of Tehran, Karaj, Iran

***Corresponding author: f.eskandaricherati@gmail.com**

Abstract

The effect of different weed control methods and efficiency of weeding in mechanized cultivation was evaluated on rice yield. The treatments consisted of (I) control treatment, where no weeding was accomplished (II) three hand weeding, (III) application of commercial herbicide (Butachlor®, 2-Chloro-diethyl-N- acetanilide), (IV) application of mechanical weeding without engine power and (V) power mechanical weeding. Results showed that experimental treatments had significantly different effects (p=0.05) on yield traits and number of filled grains per panicle, while treatments had the significant effects on grain weight and dry weight of weeds in the first, second and third weeding methods at 1% of confidence level. Treatment (III) had its most significant effect on number of filled grains per panicle and yield performance standpoint, which was 3869.73 kg ha-1 in its highest peak. Treatment (IV) was ranked as second influential with 3705.97 kg ha^{-1}. In addition, under (II) and (V) treatments, 3559.8 kg ha^{-1} and 3444.94 kg ha^{-1} of yield produced, respectively. The minimum dry weight of weeds in all weeding methods was related to the treatment (III), (I) and (V), respectively. The correlation coefficient analysis showed that total yield had a significant positive correlation with the panicle grain yield per plant (r= 0.56*) and the number of grains per panicle^{-1} (r= 0.58*) and the number of filled grains (r= 0.62*). Total rice yield also had negative correlation of r = -0. 63* with weed dry weight at second weed sampling time (17 DAT). The weed dry weight at third and fourth sampling times (24 and 40 DAT) had negative correlations of -0.64** and r= -0.60* with rice yield, respectively.

Keywords: dry weight; without engine mechanical weeder; herbicide; power mechanical weeder; yield rice.

Abbreviations:
OM_Organic material
Cº_Celsius
DAT_Days after transplantation
Moh_Muou (Ohm^{-1})
EC_Electrical conductivity
Ha_Hectare
pH_positive hydrogen
ppm_part per million

Introduction

Rice (*Oryza sativa* L.) is the staple food of more than a half of the world population (Sinha and Talati, 2007; Ginigaddara and Ranamukhaarachchi, 2009). The global rice production is 454.6 million ton annually, which has a yield of 4.25 ton ha^{-1}. The average yield is about 4.9 ton ha^{-1} in Iran, which is the 11th rice producer in the world (IRRI, 2010). However, Iran consumes about 2.05 million ton of its production inside the country. For the last decades, rice consumption has been expanding beyond the traditional rice-growing areas, particularly in western Asia and Europe. In most countries, surveillance measures are taken regarding the presence of different elements in important foodstuff such as (Samadi-Maybodi and Atashbozorg, 2006). Wheat, rice and barley are the most important cereals cultivated in Iran and rice is the second main plain food in Iran, after wheat. Self-sufficiency in the production of agricultural commodities has been taken as a national objective in Iran but rice production in Iran is adversely affected by such inhibiting factors as traditional modes of production, small-scale operations, irrigation difficulties, lack of appropriate tools and equipment for mechanized farming, and legal and administrative hindrances, all preventing the rapid growth of rice production. In Iran, rice transplanting is done manually and requires about 306 man-h ha^{-1}, which is roughly 42% of the total labor requirement of rice production. At transplanting time, there is an acute labor shortage, which results in increased labor wages and delay in the transplanting operation. Hand transplanting also results in a non-uniform and inadequate seedling populations. These problems necessitate the introduction of mechanized rice transplanting to achieve timelier establishment and better crop stands (Hemmat and Taki, 2003). In addition, weeds are the bounding factors of agricultural production in Iran, which compete crop plants (especially rice) with their rapid growth. Weeds decrease about 25% of ground's potential yield in the developing countries like Iran and they are serious threat for agricultural products. Besides, weeds compete to crop plants in catching vapor, light and food in growth season and causing disturbance in cultivation, maintenance, yield withdrawal and reduction in quality and quantity of products

(Tamado and Milberg, 2000). Anaya (2003) showed in an experiment that almost 12% of the total waste production is related to the lack of weeds control in fields. 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. Remington and Pasner, (2000) have done a research about weeds control in the direct cultivation of rice in Gambia and they found that every day delay in weeding causes 25 kg ha^{-1} decrease in rice yield crop in direct cultivation. Fernandes and Uphoff, (2002) found that application of rotary weeders in American rice fields can play as a key factor of weed controlling. They showed that rotary weeders cause an increase in ventilation and give air to the soil and finally the better growth of root, stem and claw. Mahadi et al. (2006) reported that the lack of weed control in rice fields causes 80-100% yield resuction in Nigerea. Senthillkumar (2003) compared the rotary hand weeders with the common methods of weeding in India. In that study the mechanical weed control significantly increased the grain yield of rice plants. Mechanical weeding has advantage of 10.9% of increase per hectare in yield crop rather than using hand weeding. To many researchers such as Moody (1990), Shibayama (1991), Uphoff (2003), Ramamoorthy et al. (1993), Rajkhowa (2008) studied the influence weeding on weeds/crop production. Atajuddin (2004) reported that the cost of mechanical weeding is almost 30% to 50% less than hand weeding. The advent of herbicides in early 1940 in order to solve weeds problem was one of the most important agricultural successes (Abernathy, 1992). Today weeds management has an important role in increasing agricultural products all over the world (Ashton and Monaco, 1991). Rice production has some problems and seems that weed is one of them with major effect and cause 75 to 100% decreases in production (Imeokparia, 1989). Some of the effective factors in weeds population are rice genotype (variety), humidity, cultivation pattern, ploughing method, cultivation system, technology of weed controlling and etc. (Azmi and Baki, 2002). Acceptability of herbicides increased rapidly after 1980 due to the easiness of use and lack of need to costly labor. Herbicides look better than other methods because of their performance in decreasing weeds competition, easy usage and economic low cost and less workforce. Therefore, weed control in rice is strongly dependent on herbicides (Kim et al., 2006; Khizar et al., 2003; Ishaya et al., 2007; Awan et al., 2000). Nowadays, finding the suitable methods of weed control has been aimed beside the consideration of environmental hazards. The purpose of this research is to examine the probability metrics of using weeder machines in order to control rice field weeds and compare the effects of mechanical, chemical and traditional ways on growth characteristic, yield and the yield components of rice.

Results and discussion

Vegetative traits

Table 1. shows the results of variance analysis for effect of treatments on the vegetative properties. The table indicates the difference of plant height in weeding at 30 DAT. However, among different treatments there is no significant attribute for other samples. The comparison of means (Table 2) showed that in treatment (III) the least rice plant height achieved in the second sampling time fallowed by treatment (V). This was because of the soil factor of this weeder machine which generally damages the scattered roots of rice, in the depth of operation of machine, and causes delay in rice growth. Plant height average in growth stages (five sampling stages) of different weeding methods was shown in Fig (1). The maximum of plant height in five stages of sampling of rice growth was related to treatment (I) and (V), respectively. It seems that high dry weight and biomass of weeds in these treatments cause the plant height increase. This is mainly because of higher population of weeds in the related treatments and therefore higher competition between weeds and rice to achieve more light and growing space and necessary conditions. Nangju et al. (1976) reported that use of herbicide with high doses, significantly decrease rice height. Based on the correlation table attributes (Table 5), in the second sampling date (30 DAT) the bush height has a positive and significant correlation with the stem height in harvest time. The plant height in the second sampling date (30 DAT) had a negative and significant correlation with number of filled grains $panicle^{-1}$ (r=0.52*), in which the mean value of bush height increases and causes more number of filled grains $panicle^{-1}$.

Yield and yield components of rice

Variance analysis on grain yield, grain weight, numbers of panicles $plant^{-1}$, panicle length, number of grains $panicle^{-1}$ and number of filled grains $panicle^{-1}$ have been shown in the Table 1. As it is seen, the treatments does not have a significant effect on the number of spikes $plant^{-1}$, panicle length and number of grains $panicle^{-1}$, but it has a significant effect on yield and number of filled grains $panicle^{-1}$ in the level of 5% and on the weight of thousand seeds (p=0.01). The comparison of treatments (Table 2) shows that all treatments compared to witness treatment (control) has impact on yield and increases the performance of crop in to a degree. Among other treatments, no statistically significant difference was observed. However, the highest grain yield in different treatments was related to treatment (III), which had 3870 kg ha^{-1}. Adigun et al. (2005) reported that application of herbicides before blossoming has effect on weeds control and increases the performance of rice yield. Ishaya et al. (2007) also stated that the most yield and growth could be achieved by consumption of combination of herbicides. According to the attribute correlation (Table 5), crop yield has positive significant correlation with number of panicles $plant^{-1}$ (r= 0.56*), number of grains $panicle^{-1}$ (r= 0.58*), number of filled grains (r=0.62*). Conversely, crop yield has negative and significant correlation with dry weight of weeds (r= -0.63*) in the second sampling date (17 DAT), dry weight of weeds (r= -0.64**) in the third sampling (24 DAT) and dry weight of weeds (r= -0.60*) in the fourth sampling date (40 DAT). Negative correlation between crop yield and dry weight of weeds in different sampling dates, indicate the importance of weeding in increase of rice yield. Obviously, application of chemical treatment is one of the main reasons of increasing yield, in which weeds are controlled in a better way. In overview, percentage of filled grains $panicle^{-1}$ is a good index, which reflects yield increase by better allocation of photosynthesis material into the seeds.

Table 1. Analysis of variance on the vegetative and yield traits indicators

Source of variation	df	Mean of square									
		Yield	Grain weight	Number of spikes plant^{-1}	Panicle length	Number of grains panicle^{-1}	Number of filled grains panicle^{-1}	Plant height in the first sample date (10 DAT)	Plant height in the second sample date (17 DAT)	Plant height in the third sample (24 DAT)	Plant height in the fourth sample (40 DAT)
REP	2	496966.44 ^{ns}	0.4686 *	8.65 ^{ns}	0.13 ^{ns}	27.59 ^{ns}	78.14 ^{ns}	6.91 ^{ns}	13.75 ^{ns}	21.89 ^{ns}	73.48 ^{ns}
Treat.	4	1059774.91 *	10.24 **	21.21 ^{ns}	0.58 ^{ns}	191.78 ^{ns}	260.78 *	8.10 ^{ns}	51.90 *	77.63 ^{ns}	68.00 ^{ns}
Error	8	243781.51	0.089	10.79	0.29	87.55	49.68	6.36	11.97	40.53	45.03
C.V.	-	14.56	1.16	17.89	2.21	8.15	11.09	6.53	4.45	5.63	3.73

Table 2. Comparison of experimental treatments (Duncan 5%)

Treatments	Mean									
	Yield	Grain weight	Number of spikes plant^{-1}	Panicle length	Number of grains panicle^{-1}	Number of filled grains panicle^{-1}	Plant height in the first sample date (10 DAT)	Plant height in the second sample date (17 DAT)	Plant height in the third sample date (24 DAT)	Plant height in the fourth sample date (40 DAT)
Chemical (III)	3869.73 ^{a}	25.73 ^{b}	17.80 ^{a}	24.96 ^{a}	83.76 ^{a}	73.93 ^{a}	35.98 ^{a}	71.20 ^{c}	106.48 ^{a}	167.39 ^{a}
Mechanical weeding without engine power (IV)	3559.84 ^{a}	28.73 ^{a}	20.63 ^{a}	24.83 ^{a}	72.46 ^{ab}	59.56 ^{bc}	38.60 ^{a}	77.53 ^{abc}	110.93 ^{a}	171.67 ^{a}
No control (I)	2364.73 ^{b}	24.96 ^{bc}	14.96 ^{a}	24.40 ^{a}	66.16 ^{b}	49.60 ^{c}	38.91 ^{a}	81.85 ^{a}	118.31 ^{a}	175.56 ^{a}
Hand mechanical weeder (II)	3705.97 ^{a}	24.06 ^{d}	17.43 ^{a}	24.30 ^{a}	78.53 ^{ab}	66.40 ^{ab}	40.53 ^{a}	78.85 ^{ab}	118.10 ^{a}	176.17 ^{a}
Power mechanical weeder (V)	3444.88 ^{a}	24.56 ^{cd}	17.00 ^{a}	23.86 ^{a}	82.35 ^{ab}	68.16 ^{ab}	38.95 ^{a}	74.03 ^{bc}	111.41 ^{a}	172.22 ^{a}

Average number of filled grains in treatment (III) was the highest, while in treatment (I) was the least. Khizar et al. (2003) reported that use of herbicides, produces heavier seeds compare with control condition when no herbicides applied. They also observed that application of herbicide and its using time has a significant effect on weight of thousand of seeds. Based on the correlation coefficient (Table 5) the number of filled grains had positive and significant correlation with yield (r= 0.62*). Moreover, this character had positive and significant correlation with number of grains panicle^{-1} (r= 0.84**), but has high negative correlation with dry weight of weeds (r=-0.46*) in third sampling date and rice height (r= -0.52*) in second sampling. Negative correlation between the number of filled grains and weed dry weight in the third sampling date indicates that effect of weeding in this stage of rice growth is very vital and seems to be a critical point in weeding process. In this experiment, weight of each grain is the most stable yield component, which indicates that under different weeding conditions a uniform stream of photosynthesis material flows into the seeds. The least weight of thousand grains related to treatments (V) and (IV), while the highest values related to treatments (II) and (III), respectively. According to the Table 5 weight of thousand grains has negative and significant correlation with dry weight of weeds (r= -0.68**) in the first sampling (30 DAT) and dry weight of weeds (r= -0.53**) in second sampling date (17 DAT) but there is no significant correlation with other measured attribute. This shows that weed control has important effect on increase of thousand grains weight. Treatments (II) in first sampling date had the least amount of weeds and Treatments (III) had the least amount of weeds in total, which can be one of the reasons of increasing weight of thousand seeds. The tillering ability in rice is an important agronomic attribute for producing grain. However, according to variance analyses in this study (Table 3) there was no difference about this attribute among all treatment. Table (3) showed treatment effects on height of rice at harvest time and variance analyses showed no significant difference between treatments on height of rice at harvest time. Pandey (2009) studied the chemical and hand methods of weed controlling and combination of them in rice. In this study the best time and method of weeds control for weeding were 3 times hand weeding and soil ventilation in 28, 14, 42 (DAT), respectively. This also had the highest number of tillers plant^{-1}.

Dry weight of weeds

Table 3. shows the analysis of variance of treatments on dry weight of weeds. treatments have significant effects on dry weight of weeds in the fourth sampling date. Looking further in to the table of dry weight of weeds (Table 4) reveals that the most dry weight of weeds in first sampling date (10 DAT) is related to the treatments (I), (IV) and (IV), probably because in this study the mechanical weeding was not done at the first positioned transplantation because it was damaging

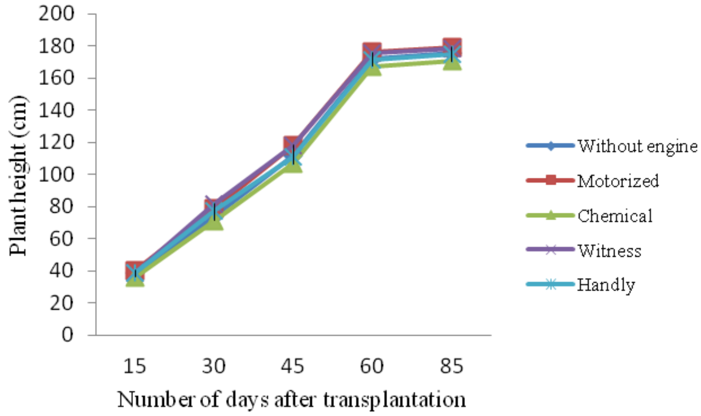

Fig 1. Mean of plant height in stages (five stages of sampling) in different methods of control

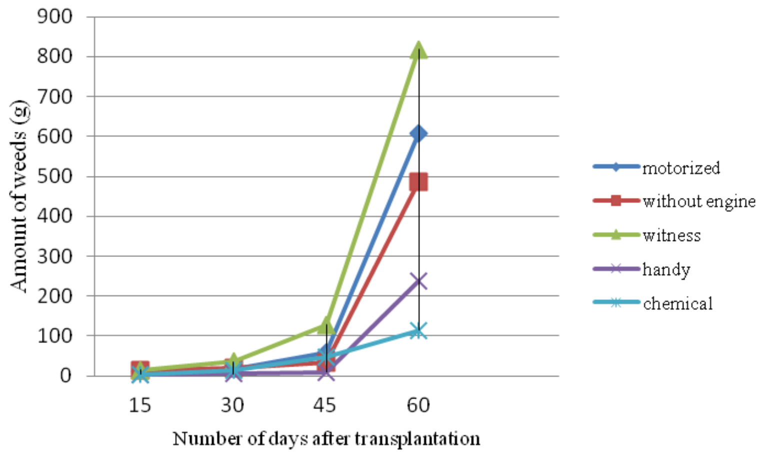

Fig 2. Average of weed dry weight (g) in different methods of weed control in rice

the rice plants. Treatment (II) and (III) has the least dry weight of weeds. Adigan et al. (2005) expressed that growth of weeds would be decreased by means of hand weeding or using herbicides. In addition, Mahadi et al. (2006) expressed that dry weight of weeds are strongly reduced by herbicides treatment. Singh et al. (2005) reported that chemical and hand control of weeds significantly affect the rice weeds. The most dry weight of weeds in second sampling (17 DAT) was related to the Treatment (I) and between the other treatments was not any difference, while in the third sampling (24 DAT) there was significant difference among the treatments. The most dry weight of weeds produced by treatment (I) followed by (V) and (III) treatments, respectively. In this sampling, the least belong to treatments (II) and (IV), respectively. In the fourth sampling date (40 DAT) the most dry weight of weeds gained after treatment (I) following the (IV) and (V). The least amount of this trait belonged to treatment (III) (Fig 2). In all stages, treatment (III) had the least weed's dry weight suggesting a suitable weed control with positive effects on rice yield as the most rice production was related to this treatment, while least dry weight of weeds associated with treatment (V) with the lowest yield after treatment (I). The main reason of yield decrease in this treatment was the increase of weeds dry weight. The main reason of increasing of weeds dry weight is that the rotary of this machine moves in a constant division among the row and it cannot appropriately accomplish weeding in the bush sides because if rotary got close to the bush more than usual, it can damage roots by cut them. Therefore, the operator should have suitable distance from the bush because places beside the bush are full of weeds and the rotary cannot catch it. These places are exactly beside the bush and can impose many damages to the growth attributes. The correlation table (Table 5) between attributes indicates that dry weight of weeds in the first sampling date (10 DAT) has positive and significant correlation with weed's dry weight. Moreover, significant correlation were observed between dry weight of weeds in second date (r= 0.55*)(17 DAT) and fourth sampling date (40 DAT) of dry weight (r=0.73**). On the other hand it had negative and significant correlation with weight of thousand grains (r= -0.68**). In the second sampling (17 DAT), there was a positive and significant correlation with third sample (24 DAT) of dry weight (r= 0.89**) and fourth sample (40 DAT) of dry weight (r= 0.80**). It also showed a negative and significant correlation with rice yield crop (r= -0.63*) and weight of thousand grain (r= -0.53*) and the fourth sampling date (60 DAT) of tiller number (r= -0.59). Dry weight of weeds in the third sampling date had positive and significant correlation with the fourth sample of dry weight

Table 3. Analysis of variance on the vegetative and yield traits indicators

Source of variation	df	Mean of square								
		Height of plant harvest time	Number of tillers in the fourth sample	Number of tillers in the third sample	Number of tillers in the second sample	Number of tillers in the first sample	Fourth sampling weed dry weight	Third sampling weed dry weight	The second sample weed dry weight	First sampled weed dry weight
Rep	2	38.16 ns	1.52 ns	6.28 ns	7.41 ns	0.76 ns	81732.12 ns	149.35 ns	12.03 ns	2.27 ns
Treat.	4	53.28 ns	26.29 ns	27.31 ns	13.83 ns	2.00 ns	239487.68 **	5999.34 **	377.03 **	108.41 **
Error	8	41.44	9.72	12.44	14.86	1.17	21004.56	149.14	25.38	11.40
C.V.	-	3.65	17.59	18.80	21.23	13.92	32.05	22.17	27.84	33.43

Table 4. Comparison of means experimental treatments (Duncan 5%)

Treatments	Mean								
	Height of harvest time	Number of tillers in the fourth sample	Number of tillers in the third sample	Number of tillers in the second sample	Number of tillers in the first sample	Weed dry weight in fourth sampling	Weed dry weight in third sampling	Weed dry weight in second sample	Weed dry weight in first sampling
Chemical (III)	170.40 a	18.37 a	21.20 a	15.26 a	6.53 a	113.51 c	47.80 b	12.91 b	3.83 b
Costume (IV)	174.66 a	23.40 a	26.50 a	21.50 a	7.63 a	237.70 bc	8.68 c	5.51 b	3.46 b
Non control (I)	181.23 a	15.93 a	19.60 a	17.66 a	8.43 a	817.90 a	127.56 a	35.72 a	15.40 a
Hand mechanical weeder (II)	179.16 a	21.60 a	25.43 a	20.63 a	8.60 a	484.90 abc	32.21 bc	20.04 b	15.35 a
Power mechanical weeder (V)	175.23 a	18.30 a	21.07 a	15.73 a	7.73 a	606.04 ab	59.11 b	16.25 b	12.46 ab

(r= 0.72**). It also revealed a negative and significant correlation with rice yield (r= -64**) and number of panicles plant^{-1} (r= -0.61*) and number of filled grains panicle^{-1} (r= -0.46*) and the third sample of tiller (r= -0.72**). Dry weight of weed in the fourth sampling had positive and significant correlation with amount of operation (r= -0.06*) and spikes height (r= -0.53*). There was no significant correlation among other attributes.

Materials and methods

This research was done in 2010 in a rice field in Haraz Technology Propagation and Development Center in Iran. The area resides at longitude 52° 10' east and latitude 36° 53' north 31'. Based on regional climate classifications, a semi-hot Mediterranean climate has been reported. According to statistical analysis based on climate with average of rainfall is about 800 mm annually with the average annual temperature of 16 Cº. The soil samples were collected from 0–30 cm depth and then sent to the laboratory for soil analysis. The soil of the experiment site was categorized as Loam. The pH=7.61, electrical conductivity (EC)= 1.06 mMoh and the organic material of soil (OM)=1.08%. The absorbable phosphorus and potassium were equal to 6 ppm and 180 ppm, respectively. The experiment was setup as randomized complete block design with 5 treatments and 3 replications in 6×20 m plots. The treatments consisted of (I) control treatment: where no weeding was done (II) three hand weeding, (III) application of commercial herbicide (Butachlor, 2-Chloro-diethyl-N- (butoxymethyl) acetanilide), (IV) use of mechanical weeding without engine and (V) power mechanical weeding. A native rice landrace, Tarom, was used which had about 114 cm height, elegant stems and tall and thin and almost horizontal leaves. The growth period is about 103 days. Tarom's yield is about 3600 kg ha^{-1} and the cooking quality and taste is very good. The rice sampling was done at 15, 30, 45, 60 (DAT) and at final harvest time (for rice yield). Then, ten constant samples from each plot were chosen and their heights measured in five above-mentioned growing stages. The number of spikes, number of grains in each spike, number of filled seeds, sterile seeds and height of spikes were measured. In order to calculate weight of thousand seeds, four bushes in each plot were selected and then 100 seeds were chosen randomly. The weight of thousand seeds was measured according to 14% moisture. A 0.25 m^2 frame work was thrown in a random way to four points of each plot in order to measure the dry weight of weed in 10, 17, 24, 40 (DAT). The weed samples were taken and sent to the laboratory and placed in the oven for 48 hours at 80 °C and then weighted.

Conclusion

Results showed that there are differences among treatments in growth attributes and yield, which depends on rice yield and dry weight of weeds. Results also revealed that there is a negative relation between weed's amount and full seed's percentage, weight of thousand seeds and field operation, which indicate the importance of weed control in rice production. The more weed exist, the more competition would be on the light and appropriate condition which causes increase in height of rice plant to get the appropriate condition. There is a strong negative solidarity between number of filled grains and dry weight of weed in the second sampling date (17 DAT). The effect of second weeding on maintaining stage of rice is so important and can be considered as critical point of weeding. Chemical treatment were the best treatments because in all sampling stages, the least dry weight of weed produced. This appropriate control has an important effect on yield while the most yield rate belonged to this treatment.

Table 5. Correlation coefficients between agronomic traits and yield components in rice

Recipes	yield	Grain weight	Number of spikes plant^{-1}	Panicle length	Number of grains panicle^{-1}	Number of filled grains panicle^{-1}	Number of sterile grains panicle^{-1}	Height of harvest time	First sampled weed dry weight	The second sample weed dry weight	Third Sampling weed dry weight	Fourth Sampling weed dry weight	Plant height in the first sample	Plant height in the second sample	Plant height in the third sample	Plant height in the fourth sample	Number of tillers in the first sample	Number of tillers in the second sample	Number of tillers in the third sample
Grain weight	0.15 ^{ns}																		
Number of spikes plant^{-1}	0.56 *	0.18 ^{ns}																	
Panicle length	0.29 ^{ns}	0.47 ^{ns}	-0.05 ^{ns}																
Number of grains panicle^{-1}	0.58 *	-0.18 ^{ns}	0.20 ^{ns}	0.22 ^{ns}															
Number of filled grains panicle^{-1}	0.62 *	-0.09 ^{ns}	0.10 ^{ns}	0.30 ^{ns}	0.84 **														
Number of hollowed grains panicle^{-1}	-0.10 ^{ns}	-0.17 ^{ns}	0.17 ^{ns}	-0.15 ^{ns}	0.23 ^{ns}	-0.31 ^{ns}													
Height of harvest time	-0.09 ^{ns}	-0.24 ^{ns}	0.01 ^{ns}	-0.19 ^{ns}	-0.11 ^{ns}	-0.24 ^{ns}	0.23 ^{ns}												
First sampled weed dry weight	-0.44 ^{ns}	-0.68 **	-0.28 ^{ns}	-0.37 ^{ns}	-0.18 ^{ns}	-0.25 ^{ns}	0.12 ^{ns}	0.37 ^{ns}											
The second sampled weed dry weight	-0.63 **	-0.53 *	-0.43 ^{ns}	-0.27 ^{ns}	-0.40 ^{ns}	-0.46 ^{ns}	0.14 ^{ns}	0.46 ^{ns}	0.76 **										
Third sampling weed dry weight	-0.64 **	-0.44 ^{ns}	-0.61 *	-0.23 ^{ns}	-0.36 ^{ns}	-0.46 *	0.20 ^{ns}	0.37 ^{ns}	0.55 *	0.89 **									
Fourth sampling weed dry weight	-0.60 *	-0.39 ^{ns}	-0.39 ^{ns}	-0.53 *	-0.41 ^{ns}	-0.48 ^{ns}	0.15 ^{ns}	0.37 ^{ns}	0.73 **	0.80 **	0.72 **								
Plant height in the first sample	0.21 ^{ns}	-0.20 ^{ns}	-0.38 ^{ns}	-0.25 ^{ns}	-0.06 ^{ns}	-0.10 ^{ns}	0.19 ^{ns}	0.65 **	0.25 ^{ns}	0.07 ^{ns}	0.02 ^{ns}	0.18 ^{ns}							
Plant height in the second sample	0.27 ^{ns}	-0.06 ^{ns}	0.12 ^{ns}	-0.14 ^{ns}	-0.37 ^{ns}	-0.52 *	0.29 ^{ns}	0.86 **	0.37 ^{ns}	0.48 ^{ns}	0.37 ^{ns}	0.44 ^{ns}	0.67 **						
Plant height in the third sample	-0.03 ^{ns}	-0.29 ^{ns}	0.23 ^{ns}	-0.27 ^{ns}	-0.20 ^{ns}	-0.32 ^{ns}	0.23 ^{ns}	0.87 **	0.41 ^{ns}	0.49 ^{ns}	0.36 ^{ns}	0.46 ^{ns}	0.82 **	0.88 **					
Plant height in the fourth sample	-0.19 ^{ns}	-0.09 ^{ns}	0.16 ^{ns}	-0.27 ^{ns}	-0.22 ^{ns}	-0.37 ^{ns}	0.29 ^{ns}	0.92 **	0.29 ^{ns}	0.37 ^{ns}	0.25 ^{ns}	0.29 ^{ns}	0.62 *	0.87 **	0.82 **				
Number of tillers in the first sample	-0.13 ^{ns}	-0.23 ^{ns}	0.13 ^{ns}	-0.06 ^{ns}	0.03 ^{ns}	-0.22 ^{ns}	0.46 ^{ns}	0.32 ^{ns}	0.29 ^{ns}	0.24 ^{ns}	0.11 ^{ns}	0.33 ^{ns}	0.49 ^{ns}	0.44 ^{ns}	0.52 *	0.33 ^{ns}			
Number of tillers in the second sample	0.35 ^{ns}	0.24 ^{ns}	0.61 *	0.14 ^{ns}	0.01 ^{ns}	-0.22 ^{ns}	0.43 ^{ns}	0.39 ^{ns}	-0.21 ^{ns}	-0.24 ^{ns}	-0.35 ^{ns}	-0.22 ^{ns}	0.53 *	0.46 ^{ns}	0.45 ^{ns}	0.42 ^{ns}	0.63 *		
Number of tillers in the third sample	0.44 ^{ns}	0.30 ^{ns}	0.81 **	0.07 ^{ns}	0.18 ^{ns}	-0.04 ^{ns}	0.40 ^{ns}	0.13 ^{ns}	-0.38 ^{ns}	-0.47 ^{ns}	-0.62 **	-0.42 ^{ns}	0.33 ^{ns}	0.23 ^{ns}	0.22 ^{ns}	0.30 ^{ns}	0.37 ^{ns}	0.84 **	
Number of tillers in the fourth sample	0.48 ^{ns}	0.38 ^{ns}	0.77 **	0.15 ^{ns}	0.29 ^{ns}	-0.09 ^{ns}	0.35 ^{ns}	0.02 ^{ns}	-0.46 ^{ns}	-0.59 *	-0.72 **	-0.50 ^{ns}	0.25 ^{ns}	0.09 ^{ns}	0.08 ^{ns}	0.18 ^{ns}	0.36 ^{ns}	0.80 **	0.97 **

References

Abernathy JR (1992) Winds of change. Weed Technol 6:760-764.

Adigun JA, Lagoke STO, Adekpe ID (2005) Efficacy of selected herbicides for weed control in rain- fed upland rice in the Nigerian Northern Guidea Savanna. Agricultura Tropica Et Subtropica 38(3): 99-104.

Anaya AL (2003) Allelopathy as a tool in the management of biotic resources. Cr Rev Plant Sci 19: 697-739.

Ashton FM, Monaco TJ (1991) weed science: principle and practices. 3rd edn. John Wiley and sons, New York, p 466.

Atajuddin F (2004) Mechanizing Indian Agriculture. Kisan World, 31, No 6, p 46.

Awan IU, Shahid M, Nadeem MA (2000) Comparative study of variable seeding rates and herbicides application for weed control in direct wet seeded rice. Pak J Bio Sci 3:1824-1826.

Azmi M, Baki BB (2002) Impact of continuous direct seeding rice culture on weed species diversity in the Malaysian rice ecosystem. Paper presented at the Regional Symposium on Environment and Natural Resource. Kualalumpur, Malaysia, 10-11 April 2002.

Fernandes EC, Uphoff N (2002) Summary from conference reports. In Assessment of the System for Rice Intensification (SRI). Paper presented at the Int Conf held in Sanya, China, 1–4 Apri 2002 .

Ginigaddara GAS, Ranamukhaarachchi SL (2009) Effect of conventional, SRI and modified water management on growth, yield and water productivity of direct-seeded and transplanted rice in central Thailand. Aust J Crop Sci 3(5):278-286.

Hemmat A, Taki O (2003) Comparison of compaction and puddling as pre-planting soil preparation for mechanized rice transplanting in very gravelly Calcisols in central Iran. Soil & Tillage Res 70: 65–72.

Imeokparia PO (1989) Control of cut grass (Leersia hexandra) in direct seeded low land rice at Badeggi. Agronomy Seminar Ahmadu Bello University, Zaria.

IRRI (2010) International Rice Research Institute. A handbook of weed control in rice. P 113.

Ishaya DB, Dadari SA, Shebayan JAY (2007) Evaluation of herbicides for weed control in three varieties of upland rice (Oryza Sativa L.) in the Nigerian Savannah. Crop Prot 26: 1490- 1495.

Khizar H, Awan IU, Hassan G (2003) Effect of different application times of herbicides on yield and yield components of rice in direct wet seeded rice culture. Online J Biol Sci 3: 119-123.

Kim DS, Marshall EJP, Brain P, Caseley JC (2006) Modeling the effects of sub- lethal doses of herbicide and nitrogen fertilizer on crop- weed competition. Weed Res 46: 492-502.

Mahadi MA, Dadari SA, Mahmud M, Babaji BA (2006) Effect of pre- emergence herbicides on yield and yield components of rice. J Food Agric Environ 4(2): 164-167.

Moody K (1990) Post- planting weed control in direct seeded rice. Paper Presented at a Rice Symposium, Malaysian Agricultural Development Institute, Penang, Malaysia, 25-27 September 1990.

Nangju D, Plucknett DL, Obien SR (1976) Performance of carboncoated rice seed on flooded soil. Weed Sci 24: 73-80.

Pandey S (2009) Effect of weed control methods on rice cultivars under the system of rice intensification (SRI). Master science of thesis, Institute of agricultural and animal science, Nepal. p 133.

Rajkhowa DJ (2008) Effect of herbicides with or without paddy weeder on weeds in transplanted summer rice(oryza sativa). Indian J Agron 52(2):107-110.

Ramamoorthy K, Selvarao KV, Chinnaswami KN (1993) Varietal response of rice to different water regimes. Indian J Agron 38: 468-469.

Remington TRJ, Posner L (2000) On-farm evaluation of weed control technologies indirect-seeded rice in The Gambia. Starkey P and Simalenga T (eds), Animal power for weed control, Technical Centre for Agricultural and Rural Cooperation, Wageningen, The Netherlands.

Samadi-Maybodi A, Atashbozorg E (2006). Quantitative and qualitative studies of silica in different rice samples grown in north of Iran using UV–vis, XRD and IR spectroscopy techniques. Talanta 70: 756–760.

Senthillkumar l (2003) Effect of weed control methods on rice cultivars in Indian rice field. Online J Biol Sci 3: 119-123.

Shibayama H (1991) Integrated management of paddy weeders in Japan. National agricultural research center (NARC).

Singh VP, Singh G, Singh SP, Kumar A Singh Y (2005) Effect of rice–wheat establishment methods and wheat management in the irrigated rice–wheat production system . Paper presented at the Workshop on Direct Seeded Rice in the Rice–Wheat System of the Indo-Gangetic Plains held in Pantnagar, Uttaranchal, University of Agriculture and Technology, India, 1–2 February 2005.

Sinha SK and Talati J (2007) Productivity impacts of the system of rice intensification (SRI): A case study in West Bengal, India. Agr Water Manag 87: 55-60.

Tamado T, Milberg P (2000) Weed flora in arable fields of eatern Ethiopiawiht emphasis on the occurrence of (parthenium hysteroph orus). Weed Res 40: 507-512.

Uphoff N (2003) Higher yields with fewer external inputs? The system of rice intensification and potential contributions to agricultural sustainability. Int J Agr Sustain 1(1): 38–50.