African Journal of Agricultural Research Vol. 7(12), pp. 1915-1918, 26 March, 2012
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR11.1977
ISSN 1991-637X ©2012 Academic Journals

Full Length Research Paper

Effects of tillage on weed density and performance of rice in the Mazandaran province of Iran

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Accepted 3 February, 2012

Using non-chemical weed control methods can play an important role in reducing herbicide use as well as protecting the environment. Appropriate land preparation especially puddling has been known as one of the best factors for weed control in rice fields. Plowing once in late winter and tilling again at one or two weeks before transplanting in spring is the current method in Iran. Number of tillages and type of equipment used depends on conditions and farming system in different sites in Iran. Kind of equipment and number of tillage operations may affect weed density. An experiment was conducted in 2011 with 6 treatments in RCBD. The treatments included: conventional method with one or two tillage operation (tillages separated by a 10-day interval), tilling once or twice with a rotivator, or tilling once or twice with a cone-puddler. These trials were conducted in rice fields of Jhad Research Institute of Iran (JRII) with 3 replications. Main weeds were: *Echinochlea crus-galli* (water grass), *Cyperus difformis* (small flower) and *Alisma plantago-aquatica* (water plantain). The results indicated that number of tillages and kind of equipment affected weed population and density. The best treatment was conventional method of plowing followed by two tillage operations which reduced weed density 2/3 times in comparison with the worst treatment (cone puddler with one tillage operation).

Key words: Rice, weed density, plant population, tillage.

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for more than half of the world population (Sinha and Talati, 2007; Ginigaddara and Ranamukhaarachchi, 2009). The global rice production is 455 million ton annually with an average yield of 4.25 ton ha^{-1}. The average yield is about 4.9 ton ha^{-1} in Iran which is the 11th largest rice producer in the world (IRRI, 2010). However, Iran produces only 60% of its rice consumption, thus more production is needed for the country. Globally, rice consumption has been expanding beyond the traditional rice-growing areas, particularly in western Asia and Europe. Wheat, rice and barley are the most important cereals cultivated in Iran and rice is the second main 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 mechanized farming, and legal and administrative hindrances, all preventing the rapid growth of rice production. In rice cultivation, a

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Abbreviations: OM, organic material; **ºC,** Celsius; **DAT,** days after transplantation; **DBT,** days before transplantation; **Moh,** Muou (Ohm-1); **EC,** electrical conductivity; **PH,** positive hydrogen; **Ppm,** part per million; ***,** significant at 5% of confidence level; ****,** significant at 1% of confidence level; **ns,** not significant; **ha,** hectare; **RCBD,** randomized complete block design.

considerable portion of production cost involves weed control. Hand weeding and weed control comprise approximately 20% of production cost (Islam, 1991). Using non-chemical weed controls methods can help reduce herbicide use as well as protect the environment. Timely and appropriate land preparation in rice fields is one of the best methods to control weeds. Land preparation for transplanted wetland rice involves an initial plowing, a second tillage operation and field leveling before transplantation.

Initial plowing which is done in winter buries weed seeds in soil. The second tillage operation breaks the remaining lumps of earth into smaller parts (Ampong-Nyarko and Datta, 1991). Correct land preparation especially second tillage is recognized as one of the most important weed control factors in rice fields (Barker, 1970). The conventional method for preparing rice land in Iran consists of initial plowing in winter and tilling one or two weeks before transplanting in spring. Cruz et al. (1992) showed that when weed density was low, one tillage operation with a rotivator was sufficient. However, if weed density was high, the land needed to be tilled twice with a rotivator. Secondary tillage also facilitates tractor maneuvering in rice fields since by penetrating shallowly, they decrease the slippage of tractor tires and therefore result in saving time and leaving a more level surface after tillage operation. Also, effectiveness with respect to weed control as well as soil moisture preservation and increasing available soil nutrients are the benefits of second tillage. Reddy and Hukeri (1983) found that performing puddling at three replications in 3 to 12.5 cm depth reduces the *Eleocharis dulcis* weed population to 49%. Kuipers (1983) showed that land preparation has different effects on weed species. In South America, puddling replication at 3 to 5 weeks intervals before seeding resulted in a reduced population of annual weeds such as *Echinochloa crus-galli* but it increased the population of algae, *Amania* sp., *Cyperus microiria* and red rice. Khan and Bautista (1988) reported that in Philippines and Japan, the appropriate soil depth for second tillage in rice fields is 10 to 15 cm. More depth does not increase yield but it increases production cost.

Rahmati and Salokhe (2001) found that in Thailand, rice yield increased with tillage due to less weeds and subsequent reduction in competition for soil nutrients and water.

Reddy and Hukeri (1983) showed that tilling twice improved grain yield in two out of four methods (second plowing once, second tillage twice, conventional plowing of the area, compressing soil surface). Increased rice biomass, rice plant height, number of tillers, panicle length, number of grains per panicle and grains weight led to a 4.5 ton ha^{-1}. Weed biomass in conventional plowing treatment of the area was significantly higher than those of other treatments, thus weed dry matter weight declined to 0.6 ton ha^{-1} in second plowing twice treatment. Saroch and Thakur (1991) showed that timing of tillage affected rice yield in India; the most favorable results occurred when fields were tilled in the winter. They also found that plowing three times at seven-day intervals increased yield more than tilling only twice after initial plowing (conventional method of the area). Other research in India has shown that a second plowing decreases weed biomass (assessed at the rice clustering stage). However, this decline was not observed in paddies using chemical weed control. Also, Majid et al. (1988) showed that there is a negative correlation between tillage intensity and weed density in Pakistan. Tilling with a rotivator breaks lumps of earth, mixes remaining weeds with soil and leads to a more level surface. IRRI (1987) demonstrated that weed density in transplanted rice in the Philippines decreased with an increase in the number of secondary tillage. Weed density was only 90 plants/m^2 with a second tillage using a hand weeding, while weed density increased to 450 plants/m^2 in the same field if plowing and pruning occurred only once. Das and Choudhury (1985) reported that tillage is one of the most practical methods for perennial weed control such as *Paspalum distichum*. It is noteworthy that this weed is one of the most destructive weed species in rice cultivation in Iran, especially in northern rice fields.

The purpose of this examination is to determine the most appropriate second tillage equipment and its application frequencies in a way that in addition to decreasing weed density, it must be recommendable with respect to other factors especially yield.

MATERIALS AND METHODS

The experiment was conducted with 6 treatments (comparing number of tillage and three implements for puddling) in a factorial study arranged as a RCBD with 3 replications at Jahad Research Institute of Iran (JRII). The treatments were comprised of: number of plowing: 1-once, 2-twice. Tillage implements: 1-conventional tillage, 2- rotivator; 3- cone- puddler. Size of plots was 500 m^2 (25 × 20). Initial plowing involved a two-way moldboard plow as used in conventional methods of the area at the first half of March. After the initial plowing, the plots were flooded to prepare them for second tillage operation. The applied two-wheel tractor for tillage with two-way moldboard plow (conventional implement) but the type of their puddler was different which comprised different treatments. Throughout the second tillage operation, parameters such as tillage depth and tiller's forward movement speed were measured. The second tillage treatment involved either one or two operations 3 (DBT). After tillage treatments had been implemented, all plots were leveled similarly. Rice transplantation was done with *Tarom* cultivar (the common cultivar of the area) in 2011. Crop management such as fertilization, irrigation, and pest and disease control were performed similarly across all treatments. Weed sampling and counting were done 15 DAT and before weeding stage when weeds had two or three leaves. The dominant weed species were *E. crus-galli p.beauv., Cyperus difformis L.* and *Alisma plantago aquatic L.* Weed density was determined in quadrants 0.25 m^2 at 20 random locations in each plot.

The number of each weed species were recorded separately. Data were converted to density/m^2. When rice was ready to be harvested, 20 m^2 was gathered from each plot, threshed and then weighed. Paddy yield was calculated considering 14% moisture for all the treatments and then statistical analysis was carried out through SAS software.

Table 1. Analysis of variance treatment study on the weed density and yield crop.

Source of variation	DF	Mean of square			
		Echinochloa crus-galli	*Cyperus difformis*	*Alisma plantago-aquatica*	Yield
REP	2	55 ^{ns}	280 ^{ns}	9.4 ^{ns}	0.001 ^{ns}
Type of tools puddling	2	9473 **	2590 **	1902.4 **	0.034 **
Number of puddling	1	25013 **	19143 **	2403.6 **	0.025 *
Type of tools × Number of puddling	2	100 *	1945 *	929.1 **	0.001 ^{ns}
Error	10	21	21	13.8	0.004
C.V.	-	2.5	3	4.6	2

Table 2. Comparison of means number of weeds and yield crop.

Type of tool	Number of puddling							
	Once				Twice			
	Echinochloa crus-galli (N/m^2)	*Cyperus difformis* (N/m^2)	*Alisma plantago-aquatica* (N/m^2)	Yield (kg ha^{-1})	*Echinochloa crus-galli* (N/m^2)	*Cyperus difformis* (N/m^2)	*Alisma plantago-aquatica* (N/m^2)	Yield (kg ha^{-1})
Conventional tillage	180. 0 ^{c}	184.3 ^{b}	60.3 ^{c}	3204 ^{abc}	96.0 ^{c}	89.0 ^{b}	63. 0 ^{b}	3302 ^{a}
Rotivator	225.0 ^{b}	159.0 ^{b}	98.0 ^{b}	3243 ^{ab}	155.3 ^{b}	133.6 ^{a}	73.0 ^{a}	3290 ^{a}
Cone- puddler	251.0 ^{a}	217.3 ^{a}	120.0 ^{a}	3118 ^{c}	181.0 ^{a}	139.0 ^{a}	73.0 ^{a}	3117 ^{bc}

RESULTS AND DISCUSSION

Our study showed that two important measurement factors in this examination, weed population density and yield of treatments had a significant difference (Table 1). Weed density which grew after transplantation was affected by the types of the equipment used and also puddling frequencies (Table 1). Considering equipment type effect, conventional tillage had the lowest weed density. Being 46 and 25% less compared with cone-puddler and rotivator respectively, (Table 2). The highest weed density occurred with the cone-puddler. In comparison to two other tools, it was classified in the separate group (a) (Table 2). With respect to puddling frequency, generally tilling twice decreased weed density 33% compared to tilling once after initial plowing. Tillage frequency also affected weed density, for example, *E. crus-galli p.beauv*. Density was 87% less in treatments with two tillage compared to only one tillage. The highest was *E. crus-galli p. beauv.* Density occurred in the puddling treatment by cone-puddler. Similar trends were noted with *C. difformis L.* The lowest and highest *C. difformis L.* densities contributed to twice puddling treatment by conventional tillage and once puddling treatment by cone-puddler, respectively, a difference of about 2.5 times (Table 2). Regarding *Alisma plantago aquatic L.*, the highest density occurred in the once puddling treatment by the cone-puddler. Considering the impact of equipment type and tillage frequency, it can be stated that depth of weed seed burial was greater with moldboard plowing (15 cm deep compared to 10 cm deep with the rotivator and cone-puddler), thus reducing weed density and increasing crop yield. Therefore, conventional tillage prevailed over other tools with respect to seed burial of those weeds which were not able to germinate. These results were compatible with the results obtained from the research done in Philippines and Japan (Khan and Bautista, 1988).

The effect of equipment type was greater with treatments that included two tillage operations (Table 1). This fact indicates that conventional tillage is the most appropriate tool but it is dependent to tillage frequency. Therefore, it is

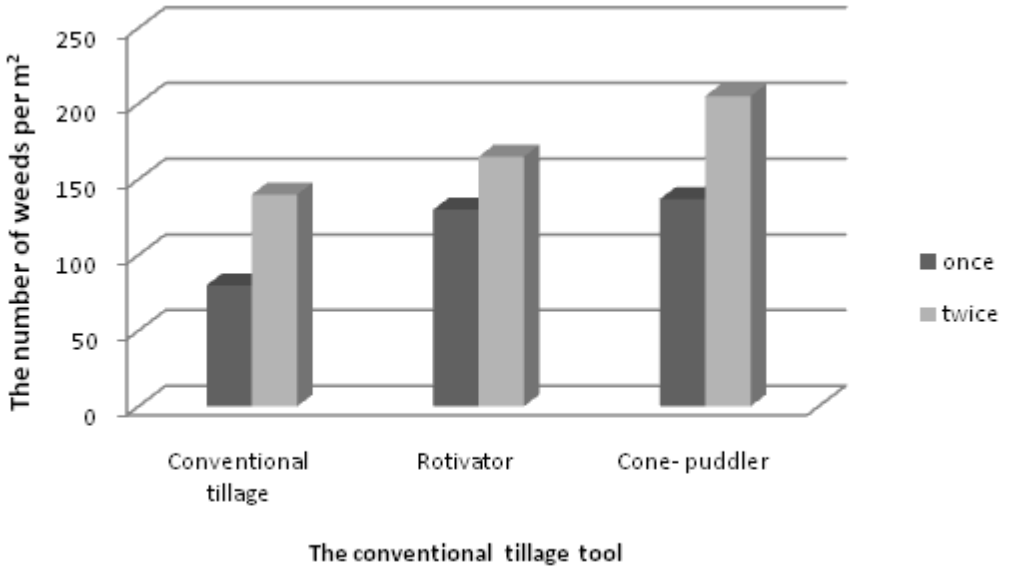

Figure 1. Weed density in different implement of conventional tillage.

essential to perform till twice (Figure 1). Our results regarding effect of multiple tillages agree with results by researchers in most rice-growing countries such as Barker (1970) in Philippines, Saroch and Thakur (1991) in India and Majid et al. (1988) in Pakistan. Comparison of grain yields showed that tilling twice increased yield with all three tools compared with only one tillage operation.

Conclusion

Results showed that there are differences among treatments in weed growth and rice yields. Increasing tillage frequency reduced weed density which led to higher rice yields. Extra tillage also may have increased soil nutrients available for rice transplantation. Conventional tillage (moldboard plowing followed by two tillage operations), the highest yield and the lowest weed density. Burying weed seeds deeper in soil with the moldboard plow may have contributed to improve weed management.

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