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EVALUATION OF INTEGRATED FARMING OF RICE AND DUCK ON RICE GRAIN YIELD IN GILAN, IRAN

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Abstract

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In order to evaluate integrated farming of rice and duck on rice grain yield, an experiment was performed on *Oryza sativa* L. in Gilan, Iran in 2013. This experiment was performed based on factorial split and it was also according to plan of randomized complete block (RCB) in three replications. In this experiment the main factor of duck was between two levels (by presence of duck and without presence of duck) and the minor factor was the factorial combination of weeding levels (weeding on the releasing day of ducks and not weeding on the releasing day of ducks); and also the planting spaces were 20×20 cm, 25×25 cm, 30×30 cm.
The results of the analysis of variance show that the presence of duck in a rice field causes increasing in plant height, the number of grains per panicle, the number of filled grains per panicle, weight of thousands grains, harvest index (HI) and grain yield. In total, results and statistics show that using duck in rice fields causes increasing in grain yield and consequently it increases farmer's income and also reduction of using agricultural pesticides and protecting the environment.

Keywords: rice, duck, planting space, weeding, grain yield

INTRODUCTION

Nowadays, human life is dependent on agricultural production and agriculture is considered one of the most common types of employment. Rice plant is one of the most important agricultural productions in the world and after wheat places in secondary positions (Yousefnia Pasha *et al*., 2012). Seventy-five percent of calories for more than two billion people in Asia, one third people in Africa and Latin America are absorbed by rice (Balachandran *et al*., 2006). Rice in Iran also has a significant role in nutrition of people; so that the main part of the meal of people especially in the provinces of Gilan and Mazandaran contains rice (Mohammadi *et al*., 2010). One the most important problems in production of agricultural productions is weed. Weeds are main reasons in reduction of agricultural plants (Krogh *et al*., 2003). In recent years, health necessity in the various agricultural products in terms of remains of pesticides, chemical substances and their effects on human beings' health and the environment caused taking into consideration of new methods. In this regard, one of the methods that has been used recently as an appropriate substitution without using chemical substances and it has been environmentally friendly is organic farming which has been accepted in the world (Gabriel and Tscharntke, 2007) and the rice-duck cultivation system became so popular in Asia and the Pacific (Lu and Huang, 2005) which causes improving the environment and it has a main role in reducing the effects of conventional agriculture of rice on the environment and environmental costs in production of rice (Wang *et al*., 2003). In rice-duck cultivation system, rice plays an important role and duck is a very important component (Long

et al., 2013). In the meantime, duck is considered as a biological factor in the rice fields, and it represents successful mechanism in controlling of factors causing damage to living (pests and weeds). It leads farming system towards sustainable production and environmental protection (Shouhui *et al*., 2006). Rice-duck cultivation system can cause reinforcement of rice growth (Yu *et al*., 2004), it can also cause improving soil properties; in the end, it prevents plant diseases and pests (Li *et al*., 2004), and reduction of methane (Long *et al*.,2011).

Duck plays the role of plow and weeder in farm. It has also a main role in occurance of sheath blight and many other factors (Huang *et al*., 2003). Consequently, the usage of pesticides, herbicides and fertilizers will decrease (Long *et al*., 2013).

The ducks have had an acceptable coexistence with rice and treatments have been enhanced by presence of ducks in yield, and the average of enhancement was more than 5 percent (Karbalaee, 2004). Other studies by Mohammadi *et al.* (2013) also showed that the significant difference between the number of ducks, figure and their interaction in terms of number of tiller, chlorophyll content (SPAD) was a an yield was paddy. Other studies in integrated farming of rice and duck showed increasing the effective yield and yield components (Furuno, 2001; Kishida, 1996; Hossain *et al*., 2001; Hossain *et al*., 2004; Ahmad *et al*., 2004; Wang *et al*., 2003; Yu *et al*., 2005). Therefore, due to the increasing need of human beings to rice and environmental problems, the present experiment aims to evaluate integrated farming of rice and duck on rice yield and yield components.

MATERIALS AND METHODS

The present experiment was done in Baz Ghaleh Dezh village, Gilan, Iran in 2013. The experiment location is as follows:

Height: 26 meters above sea level, latitude: 37 degrees 9 minutes (North), longitude: 49 degrees 45 minutes (East). This area has a mild and humid climate. Before the experiment, soil was sampled from different parts of the project area to a depth of 30 cm (Tab. I) in order to determine soil fertility evaluation and the amount of necessary fertilizer.

According to soil test, soil texture of test site was **clay**. In this study, the impact of three factors: duck, weeding, planting space in the form of split factorial based on randomized complete block design with three replications have been evaluated. Factors tests are: Duck as the **main factor** in two levels of presence in rice field (D_1) and without presence in rice field (D_2), and the **minor factor** as the factorial combination of weeding on the duck releasing day (W_1), and not weeding on the duck releasing day (W_2); and also the planting spaces were 20×20 cm (S1), 25×25 cm (S2), 30×30 cm (S3).

The number of treatments per block is 12 and it is as follows: $D_1W_1S_1$, $D_1W_1S_2$, $D_1W_1S_3$, $D_1W_2S_1$, $D_1W_2S_2$, $D_1W_2S_3$, $D_2W_1S_1$, $D_2W_1S_2$, $D_2W_1S_3$, $D_2W_2S_1$, $D_2W_2S_2$, $D_2W_2S_3$. The sizes of plots and the amount of required land according to plan and were considered 400 ducklings in each hectare. The sizes of plots were 25 m^2, and the total plots area were 900 m^2. The number of plots in the experiment by considering twelve treatments and three replications of each block was 36 plots. The age of ducklings were 20 days, the time of releasing them in rice field was 20 days after transplanting in rice field and the ducklings were removed on the panicle emergence of rice. Weeding was by hand, at the end of stage was based on the plan, after that 18 ducklings were entered to rice field. During the growth period of rice, for combating pests such as *Chilo suppressalis* (rice stem borer), and 200 packages of *Trichgramma* bees in each hectare were used. In all stages of planting, from the beginning of plan to the end of plan no herbicides, pesticides or fungicides were used.

At the end of the growth period, these items were measured: grain yield and yield components such as plant height, number fertile tiller per hill, the number of grains per panicle, filled grain per panicle, one thousand grain weight, harvest index (HI), and grain yield.

In order to analyze of data the Spss and Mstatc software were used. For comparing data Danken method was used, and for charting and drawing tables Word 2007 and Excel 2007 were used.

RESULTS

Plant Height

Variance analysis shows that to be present or not to be present of duck on the paddy field, makes a significant five-percent-difference (5%) in plant height; whereas these items do not show a significant difference: weeding effect on the releasing day of duck, planting space effect, interaction effect of duck in weeding, interaction effect of duck in planting space, interaction effect of weeding in planting space, tripartite interaction effect of duck, weeding and planting space (Tab. II); and also average comparison confirms it and shows planting space by presence of duck on paddy field is 149.500 cm which has 6.7% increase in height in comparison with absence of duck (Tab. III), (Fig. 1).

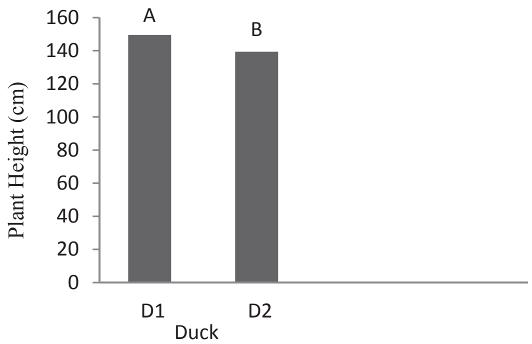
I: *Soil properties of the experimental site*

Soil Texture	Electrical Conductivity ($dS.m^{-1}$)	pH	Organic Carbon (%)	Total Nitrogen (%)	Phosphorus ($mg.kg^{-1}$)	Potassium ($mg.kg^{-1}$)
clay	0.442	7.7	1.48	0.14	17.75	250.79

II: *Analysis of Variance(ANOVA) on Rice Yield and Yield Components in Rice*

S.O.V	Df	M.s						
		Plant Height	Number Fertile Tiller per Hill	Grain Number Per Panicle	Filled Grain Per Panicle	One Thousand Grain Weight	Harvest Index	Grain Yield
REP	2	133.875	1.034	4.702	3.973	1.258	42.552	12596.540
DUCK	1	910.531^{*}	61.361^{*}	2314.893^{*}	2389.906^{*}	5.579^{*}	640.305^{*}	998969.341^{*}
ERROR A	2	35.699	2.268	75.717	77.755	0.637	30.673	143479.912
WEEDING	1	$23.766^{n.s}$	10.454^{**}	$0.449^{n.s}$	$65.826^{n.s}$	$1.156^{n.s}$	$6.121^{n.s}$	$125623.749^{n.s}$
DUCK × WEEDING	1	$76.475^{n.s}$	9.201^{**}	1764.280^{**}	1081.533^{**}	$0.451^{n.s}$	358.122^{**}	3579037.672^{**}
SPACING	2	$13.540^{n.s}$	212.668^{**}	$290.092^{n.s}$	$44.159^{n.s}$	$1.369^{n.s}$	$74.664^{n.s}$	717813.149^{**}
DUCK × SPACING	2	$18.072^{n.s}$	6.868^{**}	$35.362^{n.s}$	$101.458^{n.s}$	4.849^{*}	$27.235^{n.s}$	897416.336^{**}
WEEDING × SPACING	2	$15.613^{n.s}$	$1.068^{n.s}$	$1.135^{n.s}$	$23.361^{n.s}$	3.213^{*}	$93.918^{n.s}$	498585.275^{**}
DUCK × WEEDING × SPACING	2	$35.368^{n.s}$	58.401^{**}	786.419^{**}	499.608^{*}	$0.302^{n.s}$	296.600^{**}	1799271.959^{**}
ERROR	20	56.984	0.618	131.664	130.229	1.137	47.820	53529.491
C.V(%)	-	5.23	4.36	10.67	13.24	7.91	13.97	6.90

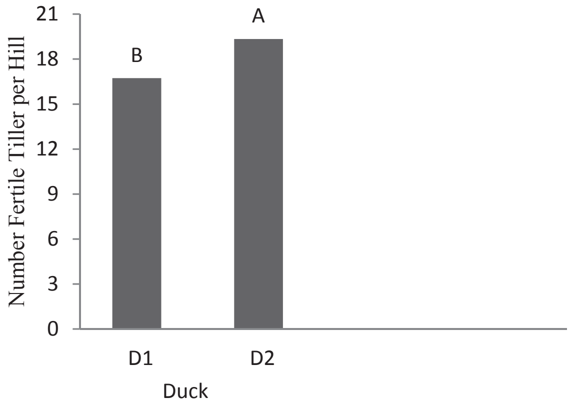
* and **: Sgnificant at the 5% and 1% levels of probability, respectively. $^{n.s}$: Non- significant



1: *Effect of Duck Presence (D_1) and Without Duck Presence (D_2) on Rice Plant Height*

Number Fertile Tiller per Hill

Variance analysis showed that to be present or not to be present of duck on land makes a significant five-percent-difference (5%) in number fertile tiller per hill. In contrast, the weeding effect on the day of releasing duck, planting space effect, interaction effect in weeding, duck interaction effect in planting space, tripartite interaction effect of duck, weeding and planting space show a significant one-percent-difference (1%), and also weeding interaction effect in planting space did not have a significant difference in terms of statistics in number fertile tiller per hill (Tab. II). Average comparison confirms it, and it (average comparison) shows that number fertile tiller per treatment without duck (D_2) is 19.340, and in treatment with duck (D_1) is 16.730 in plants. Presence of duck causes 13.5% increase in number fertile tiller per hill (Tab. III), (Fig. 2).



2: *Effect of Duck Presence (D1) and Without Duck Presence (D2) on Number Fertile Tiller per Hill in Rice*

Grain Number per Panicle

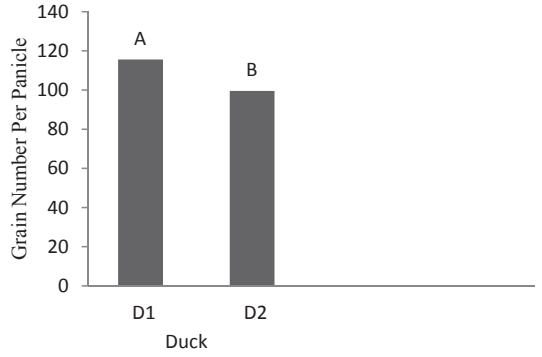
Variance analysis showed a significant five-percent-difference (5%) between to be present or not to be present of duck, while variance analysis of duck interaction effect in weeding, tripartite interaction effect of duck, weeding and planting space showed a one-percent-difference (1%). Statistics also show that weeding on duck's releasing day, planting space

III: *Mean Comparison of Rice Yield and Yield Components in Effect of Duck Presence (D_1) and Without Duck Presence (D_2) in the Field*

	Plant Height (cm)	Number Fertile Tiller per Hill	Grain Number per Panicle	Filled Grain per Panicle	One Thousand Grain Weight (g)	Harvest Index (%)	Grain Yield ($kg.ha^{-1}$)
DUCK Presence (D_1)	149.500A	16.730 B	115.600 A	94.350 A	13.910A	52.420 A	3519.000A
Without Duck Presence (D_2)	139.400B	19.340 A	99.550 B	78.050B	13.050 B	46.590 B	3186.000B

Mean in Each Column Followed by Similar Letter are Not Significantly Different at 5% Probability Level Using Duncan Test

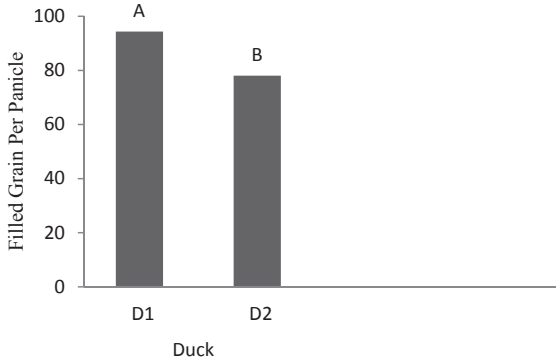
effect, duck interaction effect in planting space, and weeding interaction effect in planting space did not have a significant difference in grain number per panicle (Tab. II). Average comparison showed that duck's presence by 115.600 grains number per panicle had an increase in comparison with duck's absence by 13.89% grains number per panicle (Tab. III), (Fig. 3).



3: *Effect of Duck Presence (D_1) and Without Duck Presence (D_2) on Grain Number Per Panicle in Rice*

Filled Grain per Panicle

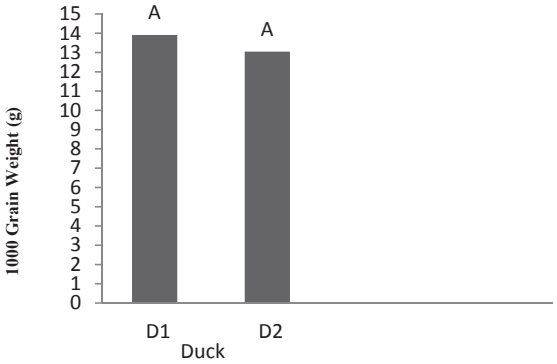
Variance analysis between duck's presence and duck's absence, tripartite interaction effect of duck, weeding and planting space in filled grain per panicle make a significant five-percent-difference (Tab. II). Average comparison confirms this issue, and it showed that there are 94.350 filled grains per panicle on rice land which cause an increase in filled grain per panicle in comparison with duck's absence with 17.28% (Tab. III), (Fig. 4).



4: *Effect of Duck Presence (D_1) and Without Duck Presence (D_2) on Filled Grain Per Panicle in Rice*

One Thousand Grain Weight

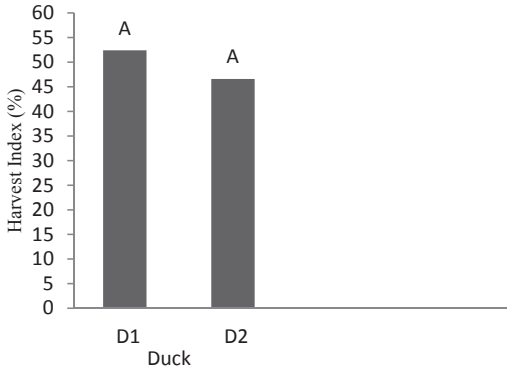
Variance analysis between duck's presence treatment and duck's absence, interaction effect in planting space, and weeding interaction effect in planting space show a significant five-percent-difference (Tab. II). Duck's presence causes an increase of 6.19% in one thousand grain weight in comparison with duck's absence on rice land (Tab. III), (Fig. 5).



5: *Effect of Duck Presence (D_1) and Without Duck Presence (D_2) on One Thousand Grain Weight in Rice*

Harvest Index

Variance analysis between duck's presence and duck's absence showed a significant five-percent-

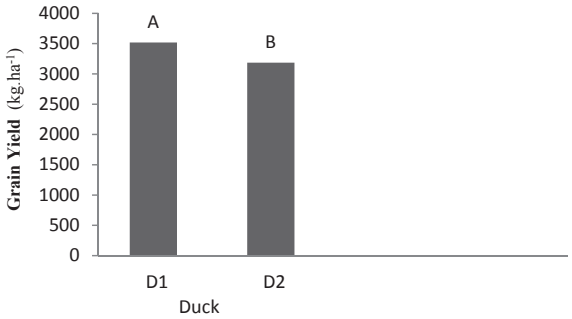


6: *Effect of Duck Presence (D_1) and Without Duck Presence (D_2) on Harvest Index in Rice*

difference in harvest index (Tab. II). Average comparison also confirms this and it shows that the harvest index by duck's presence on rice land is 52.42%, but by duck's absence, it's 11.13% index increase (Tab. III), (Fig. 6).

Grain Yield

Variance analysis showed that duck's presence or absence on rice land has a significant five-percent-difference in grain yield, while planting space effect, duck interaction effect in weeding, duck interaction effect in planting space, interaction effect in weeding, tripartite interaction effect of duck, weeding and planting space showed a significant one-percent-difference (Tab. II). Average comparison confirmed this and it showed that the grain yield by duck's presence on rice land is 3519 $kg.ha^{-1}$ which has a ten-percent-increase in comparison with duck's absence in crop (Tab. III), (Fig 7).



7: *Effect of Duck Presence (D_1) and Without Duck Presence (D_2) on Grain Yield in Rice*

DISCUSSION

Plant Height

Presence of duck on rice land caused increase in rice height. So it can be stated that duck can cause stimulate growth by activity on land, distributing the soil, and pecking pie plants. Duck's excreta can also be helpful, it can increase soil fertility. Duck caused reduction of weeds in rice field, so this reduction makes a proper nutrition space for rice. Rice plant height in rice-duck cultivation system is higher than typical cultivation system (Hossain *et al*., 2004). Duck's activity and its pecking on the soil of rice land causes more oxygenating to root and growth stimulations of rice (Hossain *et al*., 2004). Ahmad *et al.* (2004) reported that there was higher plant height in rice-duck cultivation system in comparison with typical cultivation system (Ahmad *et al*., 2004). Furuno reported that movement and duck's feeding activity in rice plots and duck cause the soil distribution and therefore it results in improving soil physical properties which can improve the root system of rice (Furuno, 1996). Zhang *et al.* (2002) reported that total K, P, N and organic material, rice, and duck had a significant increase (Zhang *et al*., 2002). Hossain and *et al.* (2001) figured out that the height of rice plant in rice-duck cultivation system is more than typical cultivation system (Hossain *et al*., 2001).

Number Fertile Tiller per Hill

Movement and feeding activity, pecking on rice plant pie by duck may cause reduction in number fertile tiller in duck's treatments, but duck could cause increasing in absorbing required elements for plant growth; so reduction in number fertile tiller through a positive effect on other effective characteristics in yield such as grain number per panicle, filled grain per panicle, one thousand grain weight will compensate this reduction and it causes increase in yield in comparison with the treatment without duck. Wang *et al.* (2004) reported that using duck on rice land has a very main role in direct feeding and rice growth increase due to good control of pests, diseases and weeds (Wang *et al*., 2004). Mohammadi *et al.* (2013) reported that number tiller per hill in all numbers of rice had an increasing progression by duck density (Mohammadi *et al*., 2013). The research results it is unlike the obtained results of (Isobe *et al*., 1998; Kim *et al*., 1994; Choie *et al*., 1996; Minh *et al*., 2005; and Hossain *et al*., 2001).

Grain Number per Panicle

Duck's excreta can cause soil fertility, duck's movement and activity on rice land, duck's pecking on rice plant pie cause rice growth stimulation. By duck's pecking soil food can be easily available at the root, and the plant can have a proper growth, so then you have more grain number per panicle. Duck can also control weeds which results in increasing of rice plant food availability.

Ahmad *et al.* (2004) observed that grain number per panicle was more than typical cultivation system in a significant way (Ahmad *et al*., 2004). According to Hossain *et al.* (2004) in Bangladesh, duck causes an increase and panicle number and grain number in rice panicle (Hossain *et al*., 2004) which confirms results from research.

Filled Grain per Panicle

Duck's presence on rice land can protect a high level of soil fertility. Duck's excreta can increase nutrients of soil and by providing macronutrients and micronutrients such as Phosphorus (P), potassium (K), iron (Fe), manganese (Mn), boron (B), and calcium (Ca) which results in possessing required elements rice in grain filling.

Quan *et al.* (2008) by this presupposition that new excrement weight average of duck is 0.14 kilogram in each day, and there are 225 ducks in hectare; so for 60 days they have 7.1 grams of nitrogen (N) per kilogram, 3.6 grams of Phosphorus (P) per kilogram, and 5.5 grams of potassium (K) per kilogram on average; and there are a lot of micronutrient elements such as iron (Fe), manganese (Mn), boron (B), and calcium (Ca) (Quan *et al*., 2008).

One Thousand Grain Weight

Duck's excreta contain macronutrients and micronutrients. Presence of micronutrients in excreta may be a factor for better growth and more photosynthesis substances. It was observed in the experiment that length and width of flag leaf in treatment by duck's presence is more than treatment by duck's absence. Flag leaf has a main role in filling of grains at the end of growth season. One of the most important components of rice yield is one thousand grain weight which is a genetic trait, and its numbers are different. It is necessary to be mentioned that its amount is affected by maturity conditions.

Karbalaee (2004) reported that duck's presence causes increasing of on thousand grain weight average (Karbalaee, 2004). Ahmad *et al.* (2004) results showed that one thousand grain weight in rice-duck cultivation system is more than typical cultivation system (Ahmad *et al.*, 2004). Hossain *et al.* (2004) expressed that rice-duck cultivation system causes increasing one thousand grain weight (Hossain *et al.*, 2004). Esmaili *et al.* (2004) figured out that duck's presence on rice land can cause increasing one thousand grain weight (Esmaili *et al.*, 2004) which is based on the results from research.

Harvest Index

Harvest index is calculated by this formula:

$$\mathrm{HI} = \left[\left(\frac{\text{Economic yield}}{\text{Biological yield}}\right) \times 100\right],$$

but in rice is about 50%. Harvest index shows total share of produced dry matter by plant which is transmitted in grain. The more is the harvest index, it is better.

Harvest index in treatment by duck's presence is 52.42%. Duck causes economic yield increase such as filled grain and one thousand grain weight. Duck caused more produced dry matter is transmitted to grain. Harvest index is calculated by dividing grain yield (economic) to biological yield; and it is expected that quantitative yields effect on this index (Esmaili *et al.*, 2004).

According to Wang *et al.* (2003) report, using duck as a biological yield on rice lands has an important role due to appropriate control of density of pests and diseases; and also has an increase in grain yield (economic) numbers (Wang *et al.*, 2003). Results from research also confirm a significant effect of duck in harvest index.

Grain Yield

Duck causes a ten-percent-increase in grain yield in comparison with a treatment by duck's absence. Duck could control weeds properly on rice land which could increase rice competitiveness ability, by its activity and pecking, and also by adding excreta to rice land can cause increasing of soil fertility. Pecking on rice plant pie by duck causes more oxygenating, and also by providing nutrients in rizhosphere root space causes growth stimulation and increasing yield components such as grain number per panicle, filled grain per panicle, and one thousand grain weight.

The research results of Ahmad *et al.* (2004) showed that grain yield in rice-duck cultivation system was more than typical-rice cultivation system (Ahmad *et al.*, 2004). Choie *et al.* (1996) reported that those plots which had ducks had a better yield rather than those plots which had no ducks (Choie *et al.*, 1996). Grain yield in rice-duck cultivation system was more that typical-rice cultivation system (Hossain *et al.*, 2004). Duck has no negative effects on rice and duck's presence on rice land causes a better yield. Duck can cause mudding water, it feeds weeds, it causes increasing of more oxygenating in soil, and it helps farmers in weeding rice land (Minh *et al.*, 2005). Islam *et al.* (2004) figured out that a duck can cause increasing of soil fertility (Islam *et al.*, 2004).

And finally based on Kang *et al.* (1995) report, using duck as a biological factor on rice land due to proper control of pests density and diseases can be as a significant role in grain yield of rice increasing and in this regard, pests density, diseases, weeds in crops along with rice and duck in many experiments have been proved (Kang *et al.*, 1995; Zhang *et al.*, 2009).

CONCLUSION

Rice-duck cultivation system has a better efficiency in comparison with typical cultivation system. Duck's presence is an effective factor in rice yield and its components. So, duck's presence causes increasing of effective indicators in yield. Duck as a biological factor in controlling of weeds density on rice land can cause reduction or even elimination of weeds which result in increasing of rice competitive ability against weeds. Duck's excreta can cause soil fertility as a result using fertilizer on rice land is reduced. In typical rice cultivation, farmers try to reach a better yield and also try to combat pests and weeds on rice lands; they need to use chemical fertilizers and pesticides. Yet overusing chemical substances is destructive for the environment and rice quality. Simultaneous cultivation of rice and duck can enhance nutrient absorption, soil nutritional improvement, and proper aeration of the soil. So, by this cultivation system (rice-duck cultivation system), the usage of pesticides, herbicides, and chemical fertilizers are reduced, eventually environmental pollution is decreased, so people have a healthy life.

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