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Investigation the Growth, Yield and Yield Components of Rice Varieties in Rotation with Garlic, Faba Bean, Lettuce, Pea and Fallow in North of Iran

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Abstract: In order to investigating the effects of second crop cultivation on growth, yield and yield components of rice, a field experiment was conducted at the Rice Research Institute of Iran-Deputy of Mazandaran (Amol) during 2004 and 2005. Tarom as a traditional variety and Fajr as a improved variety were used in this research. Faba, pea, Lettuce and garlic were used as a second crop in rotation with rice. Second crop cultivation, variety and interaction between them had a significant effect on tiller number at 0.01 probability level. Results showed that rice yield after lettuce and garlic rotation was lower than with Faba bean, pea and fallow rotation. These results indicated that rice varieties had different reaction to second crop cultivation. For example, Tarom variety in rotation with lettuce and garlic had higher yield deficiency than Fajr variety. These results suggested that Lettuce and garlic can not be a permanent second crop in paddy field. According to results, pea and faba bean in rotation with rice for the best performance of yield attributes of rice varieties were recommended.

Key words: Rice, garlic, pea, yield, rotation, fallow

INTRODUCTION

More than one-third of the human population rely on rice for their daily sustenance, making it the most important of the world's food crops (Brennane *et al*., 1994). The rice industry, world wide, is facing the challenge of a dramatic rise in demand due to population pressure where almost 100 million additional people must be fed each year. Thus, the global rice production needs to be increased by 75% by 2020 to feed the world rice consumers (Donald, 1994). Since arable land is becoming limited, improving productivity and increasing cropping intensity by adopting rice cultivation with second crops in potentially irrigated areas will be required to meet the food demand of the region's increasing population (Regmi, 1994). There are many reports about rice-second crop-rice rotation systems in many tropical Asian countries. The analyses of some of these experiments have shown declining rice and second crop yields (Cassman *et al*., 1995; Yadave *et al*., 2000; Duxbury *et al*., 2000). Whereas in others, yield either increased or were maintained (Dawe *et al*., 2000). Where a yield decline is reported, the major causes suggested are a gradual decline in the supply of soil nutrients because of inappropriate fertilizer application, decline in soil organic matter content, atmospheric pollution, pest and disease infestations and negative changes in the biochemical and physical composition of soil organic matter (Nambiar, 1994; Yadav *et al*., 2000). Also second crop cultivation maybe had positive effect in rice rotation. For first time second crop cultivation has been used at Iran's paddy field in 1965 (Fallah, 2000). In the first years, foliage crops and oil seed crops were used as a second crop. Different experiments had been showed that Berseem Clover (*Trifolium alexandrinum*) could be a good crop as a second crop in rice rotation also had a positive effect on soil texture (Ying, 1993). Rice yield with wheat rotation is lower than with potato rotation (Sidhu and Rakotonaivo, 1988). Handand and Dhillon (1993) showed the positive effects of *Vigna unguicuta* as a green manure on rice yield, they reported that rice yield in the plots with green manure was more than in fallow plots. Sing *et al*. (1988) studied the effects of *Phaseolus vulgaris* and cluster bean as green manures on rice growth. They showed that *Phaseolus vulgaris* make the most quantity of nitrogen for rice growth. Know about the positive or negative

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effect of different plants on rice growth is very important. The farmer's should be aware about the plants that can be as a second crop in paddy field. They should know which plant have a positive effects on rice growth indices. A purpose of this research is investigating the effect of some plants as a second crops on rice varieties in North of Iran's paddy field and indicate the best plant as second crop in rice rotation.

MATERIALS AND METHODS

The experiment was conducted at the Rice Research Institute of Iran-Deputy of Mazandaran (Amol) located in North of Iran (52° 22′ N, 36° 28′ E, altitude 28 m) during 2004 and 2005. After rice harvesting, the field was prepared for second crops cultivation. Lettuce (*Lactuca sativa*), Faba bean (*Faba vulgaris*), Pea (*Pisum sativum*) and Garlic (*Allium sativum*) and fallow were choosed as a second crop. The soil total N and organic carbon contents were low, the available P and exchangeable K contents are medium (Table 1). Cultivation of second crop was done as a experiment in Randomized Completely Block Design with three replications. Standards cultural practices were carried out until each second crop was mature. After harvesting the all of second crops the field was prepared for rice varieties cultivation. The plots related to second crop were divided in two sections and rice cultivation was done as a experiment in Split plot in basis of Randomized Completely Block Design with three replications. Tarom variety as a traditional variety with yield average of 4 t ha^{-1} and Fajr variety as a improved variety with yield average of 6 ton per hectare were choosed for this research. Standard cultural practices were carried out until the rice was mature. Six hills (excluding border hills) were randomly selected from each plot prior to harvest for measure rice components. Grain yield was determined from harvest area of 5 m^2 adjusting to 14% moisture content. All statistical tests (simple and combined analysis) were done using the statistically analysis system (SAS, Institute, 1996) and mean value were compared by Duncan Multiple Rang Test (DMRT).

Table 1: Physical and chemical properties of the top soil in the experimental field at Iran Rice Research Institute

Soil parameters	
pH	7.5
Organic carbon (%)	0.73
Total N (%)	0.071
P available (mg kg^{-1})	9.8
K exchangeable (cmol(+)kg^{-1}	0.24
Textural class	Loam

RESULTS

Plant height: Results showed that second crop cultivation had significant effect on rice height at 0.01 probability levels (Table 2, 5 and 8). This results showed that rice height affected by genetically and environmental factors such as second crop cultivation in rotation. Mean comparison of data showed that the least rice height was obtained after lettuce cultivation and the most rice plant height was obtained after garlic cultivation in each two years. There was a significant difference between varieties height at 0.05 probability levels. In this research maximum Tarom height (160.2 cm) and maximum Fajr height (156.4 cm) were obtained after garlic cultivation in paddy field (Table 10).

Tiller number: Results showed that second crop cultivation, variety and interaction between them had a significant effect on tiller number at 0.01 probability levels. In combined analysis of data the effect of second crop cultivation and interaction between year with second crop cultivation had significant effect on tiller number at 0.01 probability level (Table 8). Also interaction effect between year and variety on tiller number was significant at 0.05 probability levels (Table 4 and Table 7). In this research there was a significant difference between varieties tiller number In all of treatments the tiller number of Fajr variety is more than Tarom variety. The tiller number of Fajr and Tarom varieties were least after use of fallow treatment and Garlic in paddy field in each two years respectively (Table 3 and 6). This results showed that garlic had negative effect on Fajr tiller number more than Tarom tiller number. Results indicated that tiller number was not different in each two years when rice was cultivated after fallow treatments but tiller number was different significantly with use of second crop in rice rotation in each two years (Table 10).

Panicle length: Results showed that second crop cultivation in rice rotation had not significant effect on panicle length in each two years but the variety had significant effect on panicle length at 0.01 probability levels. The panicle length average were 24.8 and 30.3 cm in Tarom and Fajr variety, respectively. The effect of year was not significant on this character (Table 8).

Total spikelet per panicle: Results showed that second crop cultivation treatments had not significant effect on total spikelet per panicle. Variety had significant effect on total spikelet per panicle in each two year. Fajr variety had more spikelet per panicle than Tarom variety in each two years.

Table 2: Mean squares of rice yield and yield components (Year, 2004)

Source of variation	df	Plant height	Tiller No.	Panicle length	Total spikelet per panicle	Filled grain (%)	Grain yield
Rep	2	0.88ns	0.67ns	2.08ns	615.2ns	7.73ns	38944.9ns
SCC♣	4	40.78**	12.80**	2.42ns	1788.19ns	11.85ns	192313.9ns
Rep×SCC	8	0.33ns	0.10ns	0.99ns	1119.36ns	14.65ns	89501.3ns
Variety	1	12032.02**	77.40**	255.79**	21482.92**	126.65**	31773462.5**
SCC×Variety	4	28.00**	14.03**	2.2ns	538.16ns	21.08ns	207737.9*
Experimental error	10	1.37	0.19	1.91	1269.55	11.23	69415.6
CV		0.86	2.97	5.02	20.82	3.78	5.4

♣SCC: Second crop cultivation. ns: *, ** non significant, significant at 0.05 and 0.01 probability level, respectively

Table 3: Mean comparison of rice yield and yield component in different treatments (Year, 2004)

Treatments	Plant height (cm)	Panicle length (cm)	Total spikelet panicle (No)	Filled grain (%)	Tiller No.	Grain yield (kg ha^{-1})
Second crop cultivation						
Lettuce	132.8d	27.4ab	148.0a	86.7a	16.6a	4778.3ab
Garlic	139.8a	28.3a	190.5a	88.4a	14.4c	4600.3b
Faba	137.5b	28.0b	181.2a	88.7a	15.6b	4827.7ab
Pea	135.4c	27.3b	179.8a	89.6a	14.4c	5071.0a
Fallow	137.2b	26.6b	159.0a	90.4a	12.7d	4957.0ab
Rice variety						
Tarom	159.6a	24.6b	144.3b	90.8a	13.2b	3817.7b
Fajr	116.5b	30.4a	197.8a	86.7b	16.4a	5876.0 a

Means with similar letter(s) in each column are not significantly different at the 5% probability level according to DMRT

Table 4: Interaction effect of second crop cultivation and rice variety (year, 2004)

Treatments	Rice variety	Plant height (cm)	Tiller No.	Panicle length (cm)	Total spikelet No.	Filled grain (%)	Grain yield (kg ha^{-1})
Second crop cultivation							
Lettuce	Tarom	153.3c	14.9c	25.1b	120.7d	91.3a	3526.7d
	Fajr	112.3c	18.3a	29.8a	175.3ad	82.1b	6030.0a
Garlic	Tarom	160.7a	15.1c	26.0b	161.3ad	88.2ab	3715.3c
	Fajr	119.0d	14.4c	30.5a	219.7a	88.5ab	5485.3b
Faba	Tarom	156.4b	14.7c	24.3b	144.7cd	89.8a	4014.0c
	Fajr	118.7d	16.5b	31.7a	217.7ab	87.6ab	5641.3ab
Pea	Tarom	152.5c	12.4d	24.3b	147.0bcd	92.8a	4052.0c
	Fajr	118.3d	16.3b	30.3a	206.7abc	86.4ab	6090.0a
Fallow	Tarom	160.0a	8.9e	23.3b	148.0ad	91.9a	3780.7c
	Fajr	114.3c	16.5b	29.9a	170.0ad	89.0a	6133.3a

Means with similar letter(s) in each column are not significantly different at the 5% probability level according to DMRT

Table 5: Mean squares of rice yield and yield components (Year, 2005)

Source of variation	df	Plant height	Tiller No.	Panicle length	Total spikelet per panicle	Filled grain (%)	Grain yield
Rep	2	1.37ns	0.32ns	1.1ns	883.6ns	29.1ns	28930.5ns
SCC ♣	4	44.52**	10.98**	2.6ns	2250.2ns	13.8ns	915796.5ns
Rep×SCC	8	0.73ns	0.13ns	1.1ns	1327.1ns	17.3ns	374731.4ns
Variety	1	11248.20**	112.13**	205.4**	24596.0**	106.7**	12954726.5**
SCC×Variety	4	16.20**	15.69**	2.0ns	593.9ns	16.8ns	977562.9ns
Experimental error	10	1.60	0.35	2.4	1749.3	10.3	919513.6
CV		0.90	2.97	5.6	24.0	3.6	20.9

♣SCC: second crop cultivation. ns, *, ** non significant, significant at 0.05 and 0.01 probability level, respectively

Table 6: Mean comparison of rice yield and yield components in different treatments (Year, 2005)

Treatments	Plant height (cm)	Panicle length (cm)	Total spikelet per panicle No.	Filled grain	Tiller No. (%)	Grain yield (kg ha^{-1})
Second crop cultivation						
Lettuce	132.9d	27.2ab	150.1a	86.9a	15.7b	4610.0ab
Garlic	140.5a	28.4a	194.6a	89.2a	14.0d	4013.0b
Faba	138.0b	28.1ab	185.0a	89.8a	16.4a	5062.3a
Pea	136.8b	27.4ab	184.6a	89.2a	14.8c	4778.3ab
Fallow	136.8b	26.7b	157.6a	91.1a	12.9e	4452.7ab
Rice variety						
Tarom	156.4a	25.0b	145.7b	91.1a	12.8b	3926.1b
Fajr	117.6b	30.2a	203.0a	87.3b	16.7a	5240.4a

Means with similar letter(s) in each column are not significantly different at the 5% probability level according to DMRT

Table 7: Interaction effect of second crop cultivation and rice variety (Year, 2005)

Treatments	Rice variety	Plant height (cm)	Tiller No. (No)	Panicle length (cm)	Total spikelet	Filled grain (%)	Grain yield (kg ha^{-1})
Second crop cultivation							
Lettuce	Tarom	153.0d	13.1de	25.3b	122.2b	91.0a	3735.3bc
	Fajr	112.9f	18.2a	29.2a	177.9ab	82.7b	5484.7ab
Garlic	Tarom	159.7a	14.1d	26.1b	165.9ab	88.9ab	3900.0c
	Fajr	121.2e	13.9d	30.7a	223.4a	89.6a	5126.0ab
Faba	Tarom	156.4bc	15.4c	24.6b	143.8ab	91.7a	4265.3abc
	Fajr	119.5e	17.3ab	31.5a	226.1a	87.9ab	5859.3a
Pea	Tarom	154.2cd	12.7e	24.6b	152.8ab	90.3a	4680.0abc
	Fajr	119.5e	17.0b	30.3a	216.5a	88.1ab	4876.7ab
Fallow	Tarom	158.5ab	8.8f	24.2b	144.1ab	93.7a	4050.0abc
	Fajr	115.1f	17.1b	29.3a	171.1ab	88.4a	4855.3

Means with similar letter(s) in each column are not significantly different at the 5% probability level according to DMRT

Table 8: Combined Varianse Analysis of rice yield and yield components (Years 2004 and 2005)

Source of variation	df	Plant height (cm)	Tiller No. (No)	Panicle length (cm)	Total spikelet per panicle	Filled grain (%)	Grain yield (kg ha^{-1})
Year	1	2.95ns	0.03ns	0.03ns	162.01ns	3.2ns	1042274.4**
Year (Rep)	4	1.12ns	0.49ns	1.59ns	749.4ns	18.4ns	33937.7ns
SCC	4	84.04**	22.13**	5.00**	4004.8**	24.6**	792400.8ns
Year×SCC	4	1.26ns	1.65**	0.05ns	33.5ns	1.0ns	315709.6ns
Rep(year×SCC)	16	0.53ns	0.11ns	1.06ns	1223.2ns	16.0ns	232116.3ns
Variety	1	23273.58**	187.97*	459.82*	46026.3*	232.9*	42652429.1ns
Year×variety	1	6.60**	1.60*	1.38ns	52.6ns	0.4ns	2075760.0*
SCC×variety	4	42.68**	29.42**	3.88**	1120.7**	32.9*	473807.2ns
Year×SCC×variety	4	1.50ns	0.29ns	0.30ns	11.3ns	4.9ns	711493.5ns
Total error	20	1.49	0.27	2.16	1509.4	10.8	494464.6
CV		0.89	3.52	5.33	22.5	3.7	14.9

♣SCC: Second crop cultivation. ns, *, ** non significant, significant at 0.05 and 0.01 probability level, respectively

Table 9: Combined mean comparison of rice yield and yield components

Treatments	Plant height (cm)	Tiller No.	Panicle length (cm)	Total spikelet No.	Filled grain (%)	Grain yield (kg ha^{-1})
Year effect						
2003	136.6a	14.8a	27.5a	171.1a	89.7a	4846.9a
2004	137.0a	14.8a	27.6a	174.4a	89.2a	4583.3b
Second crop cultivation effect						
Lettuce	132.9 c		27.3ab	149.0d	86.8c	4694.2a
Garlic	140.1 a	14.4a	28.3a	192.6a	88.8b	4306.7a
Faba	137.7 b	16.0ab	28.0ab	183.1b	89.2b	4945.0a
Pea	136.1 c	14.6bc	27.4ab	180.7b	89.4b	4924.7a
Fallow	137.0 b	12.8d	26.7b	158.3c	90.7a	4704.8a
Variety effect						
Tarom	156.5a	13.0b	24.8b	145.0b	91.0a	3871.9b
Fajr	117.1b	16.6a	30.3a	200.4a	81.0b	5558a

Means with similar letter(s) in each column are not significantly different at the 5% probability level according to DMRT

Filled grain: Results showed that variety had significant effect on filled grain percentage at 0.01 probability level in annual data analysis and had a significant effect on filled grain percentage at 0.05 probability level in combined data analysis. Mean comparison of treatments in 2004 and 2005 showed that second crop cultivation had not significant effect on filled grain percentage. Combined mean comparison showed that Tarom variety with average 91% filled grain had more filled grain percentage than Fajr variety with average 81% filled grain (Table 9).

Grain yield: Variance Analysis of year 2004 did not show a significant effect of second crop cultivation on rice yield. Also, variance analysis of year 2005 didn't show a significant effect of second crop cultivation on rice yield (Table 2, 5 and 8). But variety had significant effect on grain yield in each two years. Combined Varians Analysis for two years showed a significant effect of year and interaction of year with variety on rice yield (Table 8). The least rice grain yield was obtained in rotation with garlic in each two years. Results showed that rice yield with lettuce or garlic rotation was least than rice yield with faba or pea rotation. Interaction of treatments in combined mean comparison showed that all of treatments were in the same statistically group but Interaction effect of year with variety indicate that yield of Fajr variety in 2005 is least than 2004. Results of Table 10 showed that Tarom and Fajr varieties had the least yield after rotation with garlic.

Table 10: Combined comparison mean of treatments interaction effects

Treatments		Plant height (cm)	Tiller No.	Panicle length (cm)	Total spikelet No.	Filled grain (%)	Grain yield (kg ha^{-1})
Year	**Second crop cultivation**						
2003	Lettuce	132.8e	16.6a	27.4abc	148.0a	86.7a	4778.3a
	Garlic	139.8a	14.7ab	28.3a	190.5a	88.3a	4600.3ab
	Faba	137.5bc	15.6c	28.0abc	181.2a	88.7a	4827.7a
	Pea	135.4d	14.4e	27.3c	176.8a	89.6a	5071.0a
	Fallow	137.2bc	12.7h	26.6c	159.0a	90.4a	4957.0a
2004	Lettuce	132.9c	15.7c	27.2abc	150.1a	86.9a	4610.0ab
	Garlic	140.5a	14.0f	28.4a	194.6a	89.2a	4013.0b
	Faba	138.0b	16.4b	28.1ab	185.0a	89.8a	5062.3a
	Pea	136.8c	14.8d	27.4abc	184.6a	89.2a	4778.3a
	Fallow	136.8c	12.9g	26.7bc	157.6a	91.1a	4452.7ab
Year	**Variety**						
2003	Tarom	156.6a	13.2b	24.6b	144.3b	90.8a	3817.7c
	Fajr	116.5c	16.4a	30.4a	197.8a	86.7b	5876.0a
2004	Tarom	156.4a	12.8b	25.0b	145.7b	91.1a	3926.1c
	Fajr	117.6b	16.7a	30.2	203.0a	87.3b	5240.4b
Variety	**Second crop cultivation**						
Tarom	Lettuce	153.1c	14.0d	25.2dc	121.4h	91.2abc	3631.0d
Fajr		112.6f	18.2a	29.5c	176.6c	82.4e	5757.3a
Tarom	Garlic	160.2a	14.6cd	26.0d	163.6e	88.6bcd	3307.7d
Fajr		156.4d	14.1d	30.6b	221.5a	89.0bcd	5305.7bc
Tarom	Faba	156.4b	15.1c	24.5cf	144.2g	90.8ad	4139.7cd
Fajr		119.1d	16.9b	31.6a	221.9a	87.7cd	5750.3ab
Tarom	Pea	153.4c	12.5e	24.5ef	149.9f	91.6ab	4366.0bcd
Fajr		118.9d	16.7b	30.3bc	211.6b	87.3d	5483.3abc
Tarom	Fallow	159.3a	8.8f	23.7f	146.0fg	92.8a	3915.3d
Fajr		114.7e	16.8b	29.6c	170.6d	88.7bcd	5494.3 bc

Means with similar letter(s) in each column are not significantly different at the 5% probability level according to DMRT

DISCUSSION

Results showed that second crop cultivation in rice rotation had not significant effect on panicle length in each two years. Panicle length usually not affected by environmental conditions and it seemed be a genetically characteristic (Hatami, 2002). Tiller number is a important component in grain yield of rice varieties (Islam *et al*., 2002). Any factor that influenced this component can change rice yield (Hoseini, 2003). In this research, the tiller number of varieties were least after use of garlic in paddy field. In this experiment garlic had a negative effect on Fajr tiller number more than Tarom tiller number. Garlic can carry and transmit diseases. Some of these diseases and pests in garlic may contaminate the soil and make the field unusable for future crop production (Hannan, 2002). Fajr variety was seemed more sensitive to pests and diseases than Tarom variety. According to these results, Faba bean (*Faba vulgaris*) and Pea (*Pisum sativum*) can be a good second crops in rice rotation. Rodelas *et al*. (2004) got almost the similar results. They indicated that faba bean can be good crop in rotation with other crops because of its nitrogen fixation role. Yield of Fajr variety in 2005 is least than 2004 because in 2005 these varieties cultivated late. Tarom variety yield was not decreased, because this variety had a difference with Fajr variety in growth period. For these varieties, Rice-Faba bean-Rice and Rice-Pea-Rice rotation systems for the best performance of rice yield in north of Iran's paddy field were recommended.

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