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Effects of chemical and biological fertilizer on yield and nitrogen uptake of rice

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Key words: Azolla, fertilizer, Nitrogen uptake, rice, yield.

Abstract

A factorial experiment was applied to evaluate the effect of chemical and biological fertilizer on nitrogen uptakes, nitrogen use efficiencies of grain yield and biomass (NUEg and NUEb respectively), yield and yield components of rice. Four biological treatments including:(M1:no fertilizer), (M2:10 ton/ha cow dung),(M3:20 ton/ha cow dung) and (M4:5 ton/ha azolla compost) and four chemical fertilizer treatments including: (S1: no fertilizer),(S2:40 kg N /ha),(S3:60 kg N /ha) and (S4:80 kg N /ha) were compared. Results showed that highest rate of yield (3387 kg/ha), grain nitrogen uptake (45.1 kg/ha) and total nitrogen uptake (81.4 kg/ha) were reached the highest value at M4. Among the chemical fertilizers the highest grain yield (3373 kg/ha), straw nitrogen uptake (42.9 kg/ha) and total nitrogen uptake (87.7) belonged to highest nitrogen level (S4). Interaction effect of chemical × biological fertilizers didn't show significant difference between all parameters except of yield and grain nitrogen uptake, as the most grain nitrogen uptake and grain yield were obtained in M4S4. So it can be concluded that using of biological fertilizers at appropriate rate and type, considering plant requirement, may improve grain yield, nitrogen uptake in rice.

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Introduction

Rice occupies one-third of the world's total area planted to cereals and provide food for the majority of Iran's population (Javan-Nikkhah, 2001).Rice cultivation has been carried into all regions having the necessary warmth and abundant moisture favorable to its growth, mainly subtropical rather than hot or cold. according to the latest statistics from FAO in 2005 Iran is one of the main producers of this crop in Asia. More than 70% of lands under rice cultivation in Iran has been in the three northern provinces (Gilan, Mazandaran, and Golestan). Average annual consumption of rice in the world amounts to 25-45 kilograms per year, while this amount in Iran is 80-90 kilograms per year. By the year 2025, it is estimated that it will be necessary to produce about 60% more rice than what is currently produced to meet the food needs of growing world population. increasing rice grain yields per unit of area is one approach to improving total rice production (Santos *et al.,* 2003).

Current high yields of irrigated rice are associated with large applications of fertilizer and nitrogen as a fertilizer is normally a key factor in achieving optimum lowland rice grain yields and is a constituent of numerous important compounds found in living cells, including amino acids, proteins (enzymes), nucleic acids, and chlorophyll furthermore nitrogen increases the concentration and uptake of other nutrients by rice (Lakshmanan *et al.,* 2005).Some of nitrogen fertilizers, like urea, are substantially cheaper than others, and their use may be justified on economic grounds while that increased rates of nitrogen fertilizer may increase the yield but reduce the quality of the grain.

In addition increasing use of chemical fertilizers effect on environmental pollutions , water health and unsustainable crop yield. Therefore; emphasis should be laid on reducing the use of chemical inputs and improving their use efficiency. (Saravanapandian *et al.,* 2005).Biological farming is an option to solve these problems and application of farmyard manure can obtain N requirement, provides micronutrients and modifies soil physical and chemical behavior .Moreover, use of farmyard manure not only acts as a source of N and other nutrients but also increases the efficiency of applied nitrogen.. The use of Azolla-Anabaena as bio-fertilizer for irrigated rice cultivation has already been found a successful alternative in many countries. Researchers have been estimated that 44% of rice land will be fertilized with Azolla in the near future and combination of chemical and biological fertilizers will be very useful for improvement of grain yield, grain quality, soil fertility and saving in production cost (Kannaiyan and Kumar, 2005). Several studies showed improvement of nitrogen uptake will influence by judicious and proper use of fertilizers. Also nitrogen use efficiency (NUE) is known as a main parameter for determining of nitrogen uptake of rice (Yang *et al.,* 2006). The low N use efficiency of rice is associated with its loss by several mechanisms in the soil-plant systems, as the main N loss mechanisms are: fertilizer application, volatilization of ammonia (NH_3), leaching loss of nitrate (NO_3), soil conditions, and surface run off, soil erosion, environmental factors, and use of nitrification inhibitors (Prasad and Power 1995).So selection of adequate amount and type of N fertilizers is one of the best solutions.

The objective of this study was to investigate rate of nitrogen uptake, nitrogen use efficiency, grain yield and its components under chemical and biological fertilizers and these results could be useful for selecting of fertilizers which increases yield and improves quality properties of rice production.

Material and methods

The field experiment was conducted at site of Rice Research Institute, Rasht, Guilan, Iran, during the growing during two consecutive (2008 and 2009) and geographically, the experimental area is located at 37016 N and 41036 E longitudes at the elevation 7 m below the sea level.The experiment was laid out in randomized complete block design (RCBD) with 3 replications on Hashemi variety that is originally

from Guilan province. The treatments consisted of 4 biological fertilizers levels including: (M1: without fertilizer, M2: 10 ton/ha cow dung, M3: 20 ton/ha cow dung and M4: 5 ton/ha azolla compost) and 4 chemical fertilizers including: (S1: without fertilizer, S2: 40 kg/ha in one division during transplanting of seedling from nursery to the main field, S3: 60 kg/ha in two divisions during transmission of seedling from nursery to the main field and tillering (30 days after transplanting), and S4: 80 kg ha-1 in two divisions at the time of transplanting seedlings from nursery to the main field and in tillering stage). The nitrogen in chemical fertilization was applied as single incorporated application of urea (46% N). Date of transplanting of seedling from nursery to the main field was 12th May in first year (2008) and 8th Jun in second year (2009).The experimental units were 3m× 4m plots and transplanting was done at 3 plants per hill spacing of 20 cm × 20 cm. Pest control was done in all plots to prevent any interference from weeds, diseases or insects that would hinder full quantitative assessment of chemical and biological fertilizers interaction. Physico-chemical properties of the soil were measured by the standard methods of soil chemical analysis (Embrapa, 1997). Soil initial chemical characteristics are presented in Table 1.

Table 1. Soil chemical characteristics.

kind	Potassium (mg/kg)	Phosphorus (mg/kg)	N total%	pH	SP%
Si-Ci	280	17.8	0.189	7.4	75

Grain yield

6 m2 of every plots were randomly selected and tagged for recording yield (kg/ha). Grain weight, adjusted to 14% moisture content, was used as estimates of grain yield (kg/ha).

N uptake

Grain, straw and total nitrogen concentration were determined by the methods of micro-Kjeldal digestion, distillation, and titration (Fageria *et al.,* 2009).

Factorial analysis of variance were conducted using General Linear Model procedure in the SAS package (SAS, 1990) to determine the significance of the effects of biological , chemical fertilization and also, their interaction effects on grain yield, N uptake, and NUE indices. Polynomial regression analyses were used to test treatment effects. Appropriate regression equations were selected on the basis of level significance and R2 values.

Results

Our results show the important effects of fertilization on growth and fertility of rice. The results of analysis for biological and chemical fertilizers and their interactions (in 2008 and 2009) have been presented in tables.

Effect of biological and chemical fertilization on Grain yield

There was remarkable influence of chemical and biological fertilizer treatments and also their interactions on grain yield. The results of the analysis of variance on grain yield for all treatments are shown in Table 2.

Biological fertilizer results were showed in first and second years maximum yield was obtained with 5 ton/ha azolla compost (3440 and 3334 kg/ha respectively), also by increasing of N rate in chemical fertilizers yield increased, whereas maximum yield (3420 and 3326 kg/ha respectively) was observed in S4 (Table 2).

Overall, 2 years results showed: by using of biological and chemical fertilizers, grain yield obtained from 2948 up to 3387 Kg/ha and 2523 up to 3373 Kg/ha, respectively and combination of biological and chemical fertilizers showed azolla compost(M4) and 80 kg N/ha(S4) produced maximum yield (3867 kg/ha) (Fig.1). So the

increasing of the multiplication was dependent on the differences in the fertilization stress between the biological and chemical fertilizer susceptibility to grain yield. According to regression equations all of the biological fertilization was having quadratic responses to chemical fertilization in the range of 0 to 80 kg ha−1 and also Yield had a significant quadratic response to interaction N fertilization (chemical and biological), (0.95<R2 < 0.99), so M4S4, had the most yield (3867 kg/ha) while M1S1 showed the least (2320 Kg/ha) (Fig.1).

Table 2. Grain yield (kg ha−1) of rice across biological and chemical fertilizers.

	1st year	2nd year	Average
Biological fertilize(M)			
No fertilizer (M_1)	2924C	2972 C	2948 B
10 ton/ha cow dung (M_2)	D 2854	3050 C	2952 B
20 ton/ha cow dung (M_3)	B 3081	2879 B	2980 B
5 ton/ha azolla compost (M_4)	A 3440	3334 A	3387 A
Chemical fertilizer (S)			
No fertilizer (S_1)	D 2408	2638 D	2523 B
40 kgN /ha (S_2)	C 3158	2982 C	3070 A
60 kgN /ha (S_3)	B 3314	3258 B	3286 A
80 kgN /ha (S_4)	A 3420	3326 A	3373 A
F-test			
Year(Y)		ns	
Biological fertilizer(M)		**	
Chemical fertilizer (S)		**	
Y*M		**	
Y*S		**	
M*S		**	
Y*M*S		**	

*, **, NS Significant at the 5 and 1% probability level and non- significant, respectively . Means followed by the same letter in the same column are not significantly different at the 5% probability level.

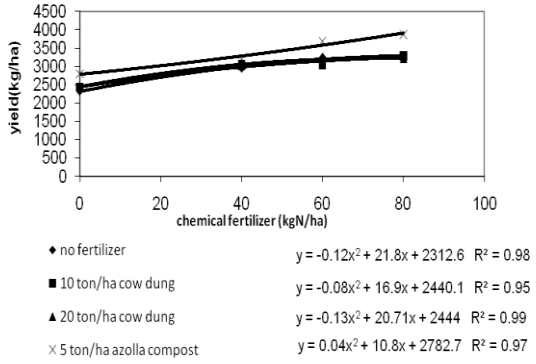

Fig. 1. relationship between yield and chemical fertilizers under different biological fertilizer.

Effect of N application on nitrogen uptake

Grain nitrogen uptake

In this experiment, the grain nitrogen uptake increased with chemical and biological fertilizers, and differences between fertilization were significant (Table 3). mean of 2 years showed by increasing of cow dung (M2 to M3) as a biological fertilizers and azolla compost (M4) grain nitrogen uptake increased strongly as M4 obtained the highest N uptake (45.1) and also chemical fertilization showed grain nitrogen uptake in S3 (60 kg/ha N) was significantly higher than the other treatment (45.4 kg ha-1) (table 4).

Howbeit Study of interactions showed that the most and the least grain nitrogen uptake in M4S4 and M1S1 (51.2 and 27.8 kg ha-1) respectively (Fig. 2).

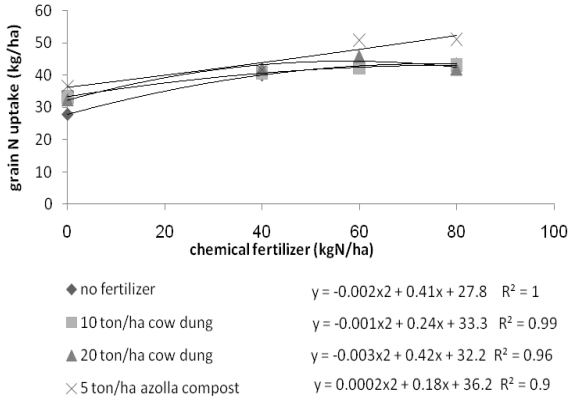

Fig. 2. relationship between grain nitrogen uptake and chemical fertilizers under different biological fertilizer.

Straw nitrogen uptake

There was significant influence of chemical and biological fertilizer on straw N uptake, whereas combined fertilizers had no different effect on it (table 3).Chemical fertilizers showed, by increasing of N rate, straw N uptake is increased whereas S4 (80 kg N/ha) had the highest grain N uptakes (42.9 kg/ ha) In addition The highest straw N uptake obtained from M3 (37.9) and the lowest belonged to M1 (30.8) (table 4).Interaction between biological and chemical fertilizers caused significant differences in straw nitrogen uptake whereby M1S4 and M1S1 created the most and the least (45.5 and 19.9 Kg ha^{-1} (Fig. 3).

Table 3. Results of factorial analysis of variance of studied variable.

Source	D_f	Grain N uptake	Straw N uptake	Total N uptake
Year (Y)	1	**	*	ns
Biological fertilizer (M)	3	**	*	**
Y×M	3	**	**	ns
chemical fertilizer (S)	3	**	**	**
Y×S	3	**	ns	ns
M × S	9	**	ns	ns
Y×M×S	9	**	ns	ns

This significant difference in the concluded results of mean comparison on the 5% probe was visible

Total nitrogen uptake

Experimental findings reveal that chemical and biological fertilization had significant effects on total N uptake (Table 3). As a results in biological fertilizers showed (table 4), Azolla compost (M4) causing the highest total N uptake (81.4 kg ha-1), Since in chemical fertilization the highest total N uptake was due to S4 (81.79 kg ha-1). Monitoring the interaction effect of fertilization showed that the most and the least N uptake of total plant belonged to M4S4 and M1S1 (95 and 47.7 kg ha-1) respectively (Fig.4).

Table 4. Results of comparison of average of studied variables between fertilizers contents in confidence level of 5%.

Variable	Grain N uptake	straw N uptake	total N uptake
Year			
2008	47.5a	30a	77a
2009	47.3a	33b	71b
Biological fertilizer			
M1	38.5C	30.8B	69.3B
M2	39.9BC	36.9AB	76.8A
M3	40.5B	37.9A	78.4A
M4	45.1A	36.3AB	81.4A
Chemical fertilizer			
S1	32.5C	28.2B	60.7C
S2	41.2B	32B	73.23B
S3	45.4A	38.8A	84.26A
S4	44.9A	42.9A	87.79A

M1: no fertilizer, M2: 10 ton cow dung /Ha, M3: 20 ton cow dung /Ha, M4: 5ton azolla compost /Ha
S1: no fertilizer , S2: 40Nkg/ha , S3:60Nkg/ha , S4:80Nkg

Discussion

This study pertained to field appraisal of effects of chemical and biological fertilizer on biomass, yield, and nitrogen uptake and nitrogen use efficiency of rice to enhance the crop establishment:

Yield

Significant variation in grain yield was observed among treatments with N application. Grain yield is the final product of a combination of different yield components, the relative importance of which varies with the type of nitrogen fertilizers, location, season, crop duration, and cultural system (Yoshida 1983; Koutroubas and Ntanos 2003). Results showed maximum yield was obtained with azolla compost. So Azolla is efficient, cost effective and ecologically proven bio-fertiliser (Watanabe and Liu 1992). the effect of azolla on rice yields as a soil improver has been studied by several researchers, Kannaiyan *et al.,* (2005) reported use of 5 to 10 ton/ha azolla compost is equivalent to 30 to 60 kg N/ha for soil.

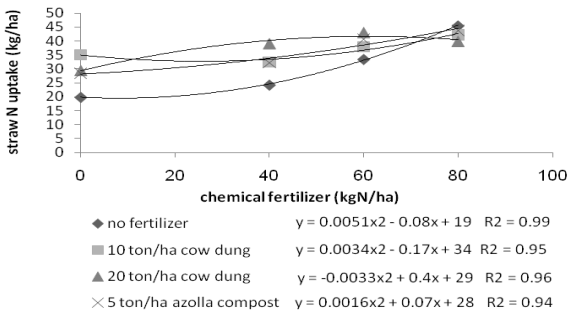

Fig. 3. relationship between straw nitrogen uptake and chemical fertilizer under different biological fertilizer.

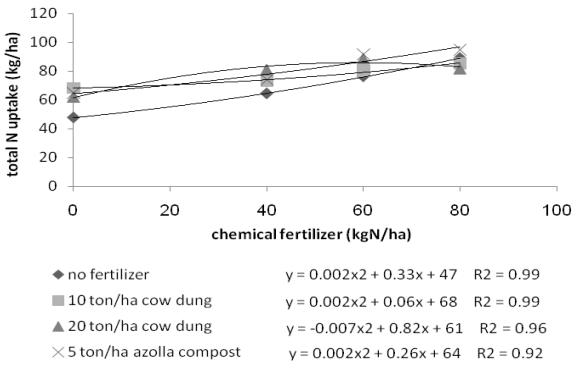

Fig. 4. relationship between total nitrogen uptake and chemical fertilizer under different biological.

So use of azolla is particularly important to increase the efficiency of soil nitrogen for higher yield. Also chemical fertilization showed the most amount of yield is generated from the highest chemicals fertilizers (S4), same as these results Evangelista *et al.,* (2001) showed positive effect of chemical fertilizers on yield. Rammohan *et al.* (2000) studied the influence of different levels of nitrogen on growth and yield of rice in coastal saline soils and reported that increase in nitrogen level increased the growth parameters and yield of rice. Gowda *et al.* (2001) reported about effect of Azolla biofertilizer in combination with inorganic N fertilizers sources on the growth (plant height, tillers and panicles) and yield of rice. Results indicated that the application of 5 t fresh Azolla + 90 kg N/ha recorded significantly maximum yield, height, tillers per hill and panicles/m2 during.

Jayaraman (1990) studied the comparative efficiency of different biofertilizers (Azolla or blue green algae) and levels of N (0, 15, 75 kg/ha) and recommended level of N revealed that the application of 75 kg N/ha supplemented by Azolla or bluegreen algae was found to be more efficient in influencing the grain yield. It showed a significant increase in rice and the increased yield was statistically on rice as compared to the application of recommended level of 100 kg N /ha. In the organic management systems that refrain from the use of synthetic chemicals, soil microorganisms become major determinants of nutrient cycling and plant growth, and also interaction between biological and chemical fertilizers caused to significant differences in the yield (Fraser *et al*. 1988). Indicating that, in most cases, by using of organic treatment, higher N of chemicals would be due to higher yield and combination using of biological and chemical fertilizers showed Azolla compost and 80 kg N/ha produced maximum yield (Fig. 1).

Effect of N application on nitrogen uptake

Grain nitrogen uptake

The influence of biological and chemical fertilization on performance of nitrogen uptake were also defined as main parameters of fertilizers selecting. A great part of the applied nitrogen is escaped to the environment through denitrification and volatilization (Delacruz *et al.,*1994).Results indicated that N accumulation in grain and plant was remarkably affected by N application. N accumulation in grain was increased remarkably with increasing of N application because grain yield increased quickly. It is obvious that all the N fertilizations caused grain N uptake increases; according the results by using of biological fertilizers nitrogen uptake of grain increased. With regard to the quantity of nitrogen fixation and nutrient recycled, Azolla compost corresponds to efficiencies for N uptake (Table 3).the institute of soil and fertilizers in the checkiang agriculture academy china reported that azolla used as a green manure decreased specific gravity , increased porosity (3.4-4.2%) and increased the organic matter content of soil. Kannaiyan and Kumar (2005) were of the opinion that the most important factor in using Azolla as a bio-fertilizer for rice crop is its decomposition in soil and availability of its nitrogen to the rice plants. N uptake of grain by using of chemicals increased that it can be because of it that about 60-70% of the total N accumulated in the rice plant is found in the grain at maturity (Fageria *et al*,. 2003). Also chemical × biological fertilization showed azolla compost as a biologic fertilizer in all range of chemical treatments, had the most N accumulation in grain. Singah *et al.* (1981) reported that addition of chemical fertilizers and azolla increased the NH4-N availability in soil , hence ,the azolla addition may also increase the N uptake in rice grain .

Straw nitrogen uptake

Overall, nitrogen accumulation in the grain was higher compared to straw. Distribution of N in the straw and grain varied with the genotypes. However, across the genotypes, N accumulation of 60% in the grain and 40% in the shoot were observed. Results of

this study showed in all of treatments Nitrogen uptake of straw is lower than grain uptakes too. as by using of azolla compost the most grain and straw N uptakes are created, and also by using of chemical treatments, the most grain and straw uptake are obtained in the highest content of N fertilization and these results are similar to yoshida's (1981) reports , he showed increasing of straw N uptake in highest amount of chemical fertilization was due to this matter that during the ripening 70% of the N absorbed by the straw and then , absorbed N would be translocated to the grain to maintain N content of the grain at a certain percentage. Overall Fageria (2003a) reported that in cereals including rice, nitrogen accumulation is associated with dry matter yield of straw and grain.It indicated that the N ratio in straw enhanced with increasing N application and it led to rice plant uptake N excessively. This result was similar to that of Quanbao *et al.*, (2007)

Total nitrogen uptake

Results indicated that N accumulation in plant was affected by N application. so same as combination results of grain and straw N uptakes in biological fertilizer by increasing of cow dung total N uptake increased however azolla compost produced the most .It can be because of Leaching loss of nutrients must have been minimized by the use of biofertilizers(azolla compost) because these are the products containing living cells which have an ability to bind the nutrients temporarily. In addition Fageria *et al.*, (2003) and Shinano *et al.*,(1995) reported that in cereals including rice, nitrogen accumulation is associated with dry matter production and yield of shoot and grain.

However interaction uses of chemical and biological fertilizers showed the best results, it can be perceived that Azolla increased the concentrations and uptake of nitrogen and phosphorus in rice and change soil properties before the harvest of rice crops so can be increase chemical fertilizers effects. about fertilizer's combination similar results was reported by Evangelista (2007), Also Fageria *et al.,* (2010d)showed that total nitrogen uptake followed a significant quadratic response with the increasing of N rate(chemical and biological fertilization) in the range of 0 to 200 kg /ha .also Pandian and Perumal (2000) reported that application of sole chemical N fertilizer showed the depletion of primary nutrient status of the rice soil, while in combination with the organic manures, the nutrient status were improved.So all the sources of organic manures improve the soil fertilities, And it was important to improve yield, Nitrogen uptake, N use efficiency and quality of rice (Quanbao *et al.,* 2007). Same as these results in this paper Fageria *et al.,* (2010d)showed that total nitrogen uptake followed a significant quadratic response with the increasing of N rate(chemical and biological fertilization) in the range of 0 to 200 kg /ha.

Conclusion

From the present study of chemical and biological rice cultivation, it can be concluded that cultivation practices in organic farming that lead to greater inputs of N in the soil improve the nutrient availability to the crop by enhancing the soil biological activity levels. Nitrogen fertilization increased significantly grain yield, total biomass, and nitrogen uptake and nitrogen use efficiency. also organic sources, being substrates for all beneficial soil microorganisms involved in nutrient cycling, have improved the soil-available nutrient status and overall soil quality, though these were not reflected in greater yields. Despite this matter, organic fertilizers did not result in the increase of all parameters and for some of them chemical fertilizers and interaction between them were found superior. However, repeated application of organics over the years may build up sufficient soil fertility by improving soil biological activity. Proper utilization of Azolla as bio-fertilizers and composts in paddy fields will be reducing the water pollution by chemical fertilizers, especially, making it safe for the Caspian ecosystem in Iran. The climatic conditions in Guilan province, a part of Caspian ecosystem during the rice growing season are extremely favorable and conducive for the

Azolla growth and its rapid multiplication. So results in this research also showed that the response of different fertilization to nitrogen uptake and nitrogen use efficiency was not the same. Significant differences existed among effect of yield increase with N application, N use efficiency, N accumulation, and distribution in rice under different fertilizer conditions whereas combination of biological and chemical fertilizers M4S4 and M1S1 produced maximum and minimum yield (2320 and 3867 kg/ha respectively).Therefore The above results show that with a proper management of chemical and biological fertilizer amount, nutritious and chemical parameters of rice can be improved, although suggestion for the best usage amount requires more investigation.

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