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# Effect of chemical and biological fertilizer on rice yield, growth and quality in paddy soil of Guilan province (Iran)

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**Key words:** Azolla compost, fertilizer, protein, rice, yield.

**Abstract**

In order to evaluation of the effect of chemical and biological fertilizers on yield ,biomass and Quality parameters consist of protein content, amylose content (AC), gel consistency (GC), gelatinization temperature (GT) were considered at rice research institute of Iran. This research was applied in a factorial experiment based on a randomized complete block design with 3 replications (2008 and 2009). In this experiment 4 biological treatment including:M1- (no 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-control (no N fertilizer); S2-40 kg N /ha; S3-60 kg N /ha and S4-80 kg N /ha were compared. Results showed: the effect of N application on yield increasing, was remarkable whereas in both of 2 years, in Biological fertilization M4 produced maximum grain yield (3387kg/ha) also in chemical fertilizers by increasing of N rate, yield increased, as maximum yield was observed in S4 (3373kg/ha). Also the different chemical fertilizer created a significant difference on quality parameters, as from S1 to S4 (GC) increased, whereas (GT) decreased so the highest GC and GT obtained in S4 and S1(46.56 and 4.53) respectively , also biological fertilization showed the highest GC and GT belonged to M2 and M1(47.12 and 4.46) respectively, In considering the chemical and biological fertilizers no significant difference was observed in AC . Also in biological fertilization the highest protein content (9.39%) belonged to M3 whiles S3 created maximum in chemical fertilization (9.51%).

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## Introduction

Rice as a main meal stands in third place after wheat and tomato among the mostly used agricultural products in our country, and its use has been considerably increased since 1995. Therefore, nowadays, improving the quality characteristics is an important factor for satisfaction of consumers (balder *et al.*2005). However, rice grain quality characteristics in terms of quality cooking and nutritional quality is affected by many variables (Jiang *et al.*, 1979 and ,joliano 1993).The gelatinization temperature (GT), gel consistency (GC) and amylose content (AC), amount and type of protein are the three major rice traits that are directly related to cooking and eating quality (Little *et al.*, 1958).

Overall AC in rice grain will determine the Softness and hardness of grain after cooking process. Rice cultivars with high AC will be dry and separate after cooking and be hard after cooling however The seeds have low Amylose will be soft and sticky glace after cooking, (Huang *et al.,*1998) Amylose amount of numbers that have to be between 20 - 25%, after cooking and cooling will be soft that explain the excellent quality of cooking (chanseok*et al.*, 2005), also Quality characteristics affected by the other factors that named gelatinization temperature(GT), which is the water temperature of starch granules when the start a irreversible expansion (Jiang *et al.,* 2003 and salem , 2006) . Rice that have high GT need more time for cooking; also most of rice variety which have same AC might be have different time for cooking (Je young, 2006). The Other factors that qualitative properties of rice are effective is gel consistency, (GC) is the rate of mucilage during cooking. Overall verities with high AC, medium GC and GT are preferred by consumers (Jiang *et.al.* 2003 and Jing *et al.*. 1979 ).Protein, in addition of nutritional value, impact on quality of cooking (Hao *et al.*, 2007). The quantity and quality of rice is affected by many factors such as type and content of fertilizers, length of growing period, the alkaline properties of soil and fertilizing time (Damardjati , 1985).

Up to now many studies have been done about correlation between nitrogen content and baking quality, which shows with increasing of nitrogen content will increase GC and protein in grain While AC will decrease (Damardjati *et al.,* 1988 and Matsuo*et al.,* 1995). In other words, a negative correlation appears between the amount of nitrogen and AC and it showed that by controlling the amount of nitrogen fertilizer, control of the amount of amylose, protein and rice taste is attainable. (Dong *et al.,* 2007). Overall, throughout the growth period of rice the need for nitrogen is necessary and nitrogen disabsorbtion in every phase of growth will decrease yield (balder *et al.,* 2005). Therefore, rice yield and taste which is related to protein content, amino acids type and amount of moisture can be modified by nitrogen fertilizers management ( joliano ,1993). With regards to not having enough information about effect of different type and level of fertilizers on quality of Iranian rice, the aim of this study is to examine the comparison of chemical and biological fertilizer on nutritional quality and yield of rice in Guilan province.

## Materials and methods

*Field experiment site*

A field experiment involving flooded rice (Oryza sativa L.) was conducted during two consecutive years (2008 and 2009) at rice research institute of Rasht, Iran.

*Rice cultivar/nursery*

Date of transmission of seedling from nursery to the main field was 22th may in first year (2008) and 12th Jun in second year (2009). The units were 3× 4 $m^2$ plots and transplanting was done at 3 plants per hill spacing of 20 cm × 20 cm. Plots were flooded three days before transplanting and water maintained between 5 and 10 cm deep until physiological maturity.

*Soil properties*

Soil initial chemical characteristics are presented in Table 1.

Kind of soil was Si-Ci. Soil analysis methods used in this study are described in a soil analysis manual published by Embrapa (1997).

*Fertilizer treatments*

The experiment was laid out in randomized complete block design with three replications of of four biological fertilizers levels ($M_1$: no fertilizer , $M_2$:10 ton per hectare cow dung , $M_3$: 20 ton per hectare cow dung and $M_4$: 5 ton per hectare azolla compost) And 4 chemical fertilizers ($S_1$:no fertilizer,$S_2$: 40 kg nitrogen per hectare , $S_3$:60 kg nitrogen per hectare and $S_4$:80 kg nitrogen per hectare ; all of chemical fertilizers were applied as single incorporated application of urea (46% N).

*Sampling and measuring*

Quality control was consisted of measuring protein content, Amylose content (AC), gel consistency (GC) and temperature of gelatinization (GT). For determining AC color rating method was used (Jiang *et al.,* 2003). GC according to the rate of movement of gel produced from Flour sample was recorded (Cammamgng ,1973). In consideration of changes in endosperm of rice grain, temperature of gelatinization process was distinguished (joliano , 1993). The amount of rice nitrogen with the usage of Kjeldal method was measured and with N×5.95relation protein content was calculated. MSTATC, SAS and SPSS soft ware's were used in variance analysis, comparison of average and determining simple correlation between characteristics.

**Table 1.** Soil chemical characteristics (top 20 cm).

| Absorbent k(ppm) | Absorbent p (ppm) | N total% | pH | Electrical conductivity (dS $m^{-1}$) | SP% |
|---|---|---|---|---|---|
| 280 | 17.8 | 0.189 | 7.4 | 1.12 | 75 |

**Table 2.** Grain yield (kg $ha^{-1}$) of rice across biological and chemical fertilizer.

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

*, **, NS Significant at the 1 and 5% 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.

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

| Protein % | GT | GC | AC | $D_f$ | Source of variances |
|---|---|---|---|---|---|
| 0.29ns | 0.53** | **52 | 2.4** | 2 | r |
| *0.1 | **0.13 | **39.1 | 0.07ns | 3 | M |
| **1.04 | **0.29 | **30.7 | 0.01ns | 3 | S |
| **0.62 | **0.3 | **13.3 | 0.2* | 9 | M×S |
| 0.19 | 0.003 | 3.4 | 0.08 | 30 | Error |

*, ** = significant at the 0.05 and 0.01 probability levels, respectively ns = not significant

**Table 4.** Results of comparison of average of studied variables between biological fertilizer contents.

| Variable | AC | GC | GT | PRO% |
|---|---|---|---|---|
| Year | | | | |
| 2008 | 22B | 45.8A | 4.3B | 9.2A |
| 2009 | 23A | 44.2B | 4.45A | 9.1A |
| Biological fertilizer | | | | |
| M1 | 22.89A | 44.18B | 4.46A | 8.99B |
| M2 | 22.81A | 47.12A | 4.37B | 9.35A |
| M3 | 22.92A | 44.25B | 4.4B | 9.39A |
| M4 | 22.81A | 44.37B | 4.3C | 9.19AB |
| Chemical fertilizer | | | | |
| S1 | 22.84A | 44.5BC | 4.53A | 8.89C |
| S2 | 22.89A | 43.75C | 4.4B | 9.32AB |
| S3 | 22.83A | 45.12B | 4.31C | 9.51A |
| S4 | 22.87A | 46.56A | 4.28C | 9.12BC |

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

**Results and discussion**

*Effect of chemical and biological fertilizer on grain Yield*

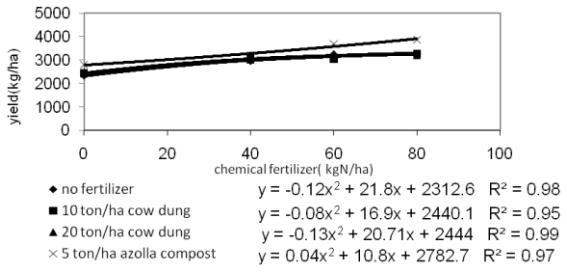


**Fig. 1.** relationship between yield and chemical fertilizer under different biological fertilizer.

There was remarkable influence of chemical and biological fertilizer treatments and also their interactions on grain, However, all of data for 2 years are presented (table1).biological fertilizer results were showed both 2 years azolla compost which produced maximum grain yield and also increasing of cow dung as a fertilizer, created positive effect on yield content, nevertheless, Maximum yield (3387 kg/ha) was obtained with 5 ton/Ha azolla compost ($M_4$) (table 3). The effect of azolla on rice yields has been studied by several researchers. Kannaiyan et .al, 2005, showed use of 5 to 10 ton/Ha azolla compost equivalent to 30 to 60 N kg/Ha , and Evangelista ,2001, considered that application of

compost to the soil improved the soil organic matter .The average organic matter, P, and Zn contents of compost application were 2.85% , while the values of farmers' practice were 2.18%. So, rice plant with compost application contained higher N than that of farmers' practice, and azolla compost as green manure can improve soil properties. (Kannaiyan *et al.,* 2005 and Embarapa, 1997).

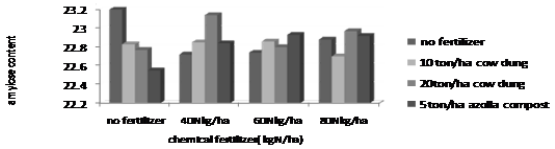


**Fig. 2.** comparison of average of amylase content in contraction between chemical and biological fertilizer.

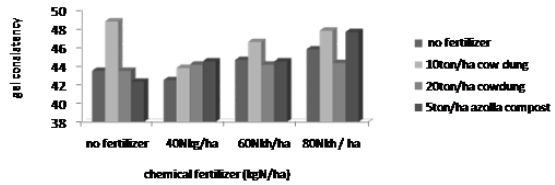


**Fig. 3.** comparison of average of gel consistency in contraction between chemical and biological fertilizer

The use of chemicals displayed by increasing N rate in fertilizers yield increased as maximum yield was observed in $S_4$ in both of the years, too , whereas maximum yield (3373kg/ha) was observed in $S_4$ (80 kgN/ha) (table 4). Overall, average data of two years showed that grain yield ranged from 2948 to 3387 Kg/ha and 2523 to 3373 Kg/ha during biological and chemical fertilization, respectively, and in biological and chemical fertilizers azolla compost and 80 kg N /ha produced maximum yield. Differences in grain yield have been widely reported and these differences are associated with the effect of application of biological and chemical fertilizers on rice. 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). According to regression equations all of 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), ($0.95<R^2<0.99$), so $M_4S_4$, created the most yield (3867kg/ha) while $M_1S_1$ showed the least (2320 Kg/ha) (Figure1). Indicating that, in most cases, by using of organic treatment, higher N of chemicals would be due to higher yield. salem *et al.*, 2006 showed the maximum yield was obtained with the application of azolla compost interaction with the highest N ratetreatment

*Effect of chemical and biological fertilizer on quality parameters*

Rice quality is of great importance for all people involved in producing, processing, and consuming, since it affects the nutritional and commercial value of grains.quality parameters are including:

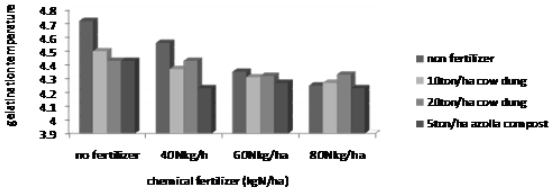


**Fig. 4.** comparison of average of gelatinization temperature in contraction between chemical and biological fertilizer

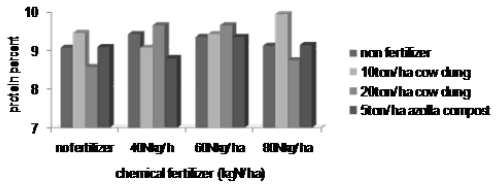


**Fig. 5.** comparison of average of protein percent in contraction between chemical and biological fertilizer

*Amylose content*

Considering the result of variance analysis and the comparison of the amylose content shows no significant differences between chemical and biological fertilizers (Table 1) with comparison averages review was determined by increasing of N

rate in cow dung (M2 to M3) AC reach to the highest content (22.92) whereas in chemical fertilization a slight increase in AC from S1 to S2, was showed that it will be the highest (22.89) , Also Interaction between chemical and biological fertilizers on the amount of amylose was obtained , AC was the most and least in M1S1 and M4S3 (23/2 and 22/55%) (figure2). With study results that can be find certainly there is a negative and significant correlation between amount of nitrogen and AC also Jeyoung (2006) showed that there is a negative correlation between nitrogen rate and AC. Li *et al.,* (2010) confirms with the above results. In his research showed that with an increase in the amount of nitrogen fertilizer, activation of starch branching enzymes increased and as a result Amylopectin percentage increases and in contrary AC decreases. Thus a significant negative correlation was observed between the activity of these enzymes and AC. Each time the amount of nitrogen fertilizer increases, enzyme activity will decrease and as a result AC will increase.Evaluation of gel consistency (GC) analysis of variance in table (1) and figure (2) show that effect of year, chemical and biological fertilizer on GC is significant (Table 5). Comparison average also supports this idea. Results showed that by Nitrogen increasing in fertilization from S1 to S4, GC increased whereas Maximum GC content (46.56) was obtained with the highest N rate. Also HAO *et al.* (2007) showed, the gel consistency in rice increased with increasing N fertilizer, while amylose content in brown rice decreased. Jeyoung *et al.*(2006) in results of their research showed that in the low amount of nitrogen fertilizer, there is a significant and positive correlation between starch branching enzymes activity and GC. Thus with an increase in those enzymes activity, the amilopectin Percentage increased and GC also showed an increase. Of course, environmental conditions such as temperature during rice seed maturity affected on the GT to strongly.

Considering the Comparisons average of GC in 5 % confidence level shows significant wherease M2 treatment shows the highest gel consistency (47.12). in addition The results of comparison average of interaction between biological and chemical fertilizers has shown that the order M2S1 and M4S1, cause to the maximum (48.8) and minimum (42.33) gel consistency respectively (figure3).In our study, the amylose content and gel consistency of rice were significantly influenced by N fertilizer application rate, the possible reasons for this phenomenon are as follows: amylose content and gel consistency of rice are also regulated by N fertilizer, and the growing period of rice was prolonged obviously with increasing N fertilizer rate compared with control, resulting in the temperature change during seed setting, and finally influencing the amylose content and gel consistency of rice grain. Hao *et al.* (2007) .
Considering the result of variance analysis and the comparison of the gelatinization temperature shows there was significant influence of year, biological and chemical on GT. in biological and chemical fertilization by increasing of fertilization, GT decreased as minimum GT was obtained with M4 and S4 (4.3 and 4.28) respectively . Also Interaction between biological and chemical fertilizers caused significant differences in GT too whereby M1S1 and $M_4S_4$ created the most and the least (4.23 and 4.72) respectively. The study of results showed there is a negative correlation between nitrogen rate and GT. whereas correlation between nitrogen amount and GC is positive that it means by increasing of N rate GC increased and GT decreased.

*Effect of chemical and biological fertilizer on protein content*

Protein concentration of rice normally accounts for 5–9 g of grain dry weight, and is a key index to reflect grain quality property, especially in nutritional quality, of paddy rice. Formation of protein in rice grains is closely related to plant nitrogen status and affected by fertilization. (Yang *et al.*, 2002).

In review of another variable, the protein change in the results of analysis of variance at different levels

of biological and chemical fertilizers and also assembly of these fertilization show significant differences. this significant difference also appeared in the end results of comparison of average in 5 % confidence level, whereas by increasing of N rate in cow dung from M2 to M3 protein increased as M3 created the highest protein content (9.39%) .Yang *et al.*, (2002) showed Formation of protein in rice grains is closely related to plant nitrogen status and affected by variety traits . Although by using of chemicals as a fertilizer protein rate reached to the higher percentage so S3 create the most protein rate. Also HAO *et al.*(2007) showed , The protein content in rice increased with increasing N fertilizer, while amylose content in rice decreased .The research of Chanseoks *et .al.* in year 2005 showed same as these results there is a positive correlation between protein content and nitrogen fertilizer amount. Also study of interactions shows that the most and the least protein percentage is obtained in M2S4 and M3S1 (9.95 and 8.59%) respectively. Also Liu *et al.* 2005 in his research showed a significant positive correlation between activities of protein synthesizing enzymes and absorption of nitrogen in grain.

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