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Evaluation of Different Nitrogen Management on Yield and Some of the Yield Components of Rice (Shiroudi cultivar)

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Abstract

Nitrogen (N) is a key growth and yield-limiting factor in cultivated rice areas. This study has been conducted to evaluate the effects of different conditions of N application on rice yield and yield components (Shiroudi cultivar) in Babol (Mazandaran, Iran) during the 2015- 2016 season. A factorial experiment executed of a Randomized Complete Block Design (RCBD) used in three iterations. In the first factor, treatments were four N amounts (including 50, 90, 130, and 170 kg N ha^{-1}), while in the second factor, the treatments consisted of four different fertilizer splitting methods, including T_1:70 % at the basal stage + 30 % at the maximum tillering stage, T_2:1/3 at the basal stage + 1/3 at the maximum tillering stage + 1/3 at the panicle initiation, T_3: 25 % at the basal stage + 50 % at the maximum tillering stage + 25 % at the panicle initiation, and T_4: 25 % at the basal stage + 25 % at the maximum tillering stage + 50 % at the panicle initiation. The results illustrate only the number of panicles (m^2) which was significantly impacted by the year (at the CI of 0.99). Different levels of N had effects on the panicle length, the percentage of filled grain (PFG), whole grain in a plant, and yield (at the CI of 0.95). The panicle length, the PFG, and yield were also significantly affected by different methods of N splitting (at the P-v of 0.01). The interaction of N amount × N splitting had a significant effect on the panicle length, the PFG, and yield (at the CI of 0.95). In general, the most significant impact on the panicle length, the number of panicles (m^2), the whole plant's grain, and yield observed after using 130 kg N ha^{-1}. Besides, T_3 showed the most notable effect on all the studied indices except for the panicle length.

Key words: N splitting, Panicle length, Percentage of filled grain, Yield.

Introduction:

One of the most important cereals and foodstuffs in the world is rice. Rice has the highest production rate after maize and wheat, with production rates of 1.134, 771, and 756 million tones, respectively (1) in these crops. Over 40,000 varieties of rice with the scientific name of *Oryza sativa* have been reported in the world. Asia is referred to as the origin of this plant (2), and approximately 90 percent of the world's rice production belongs to this continent (3). The demand for increasing crop yield is projected to grow at a rate of about 2.4 percent per year (4), according to the forecast to respond to population growth to meet the food needs and economic development of the countries by 2050. In Iran, rice has a significant portion of food consumption following the wheat. The substantial rate of rice production in Iran is allocated to Northern provinces located in the south of the Caspian Sea, which is estimated at 70 percent (5). Transplanting is the main method of crop establishment in Iran.

Managing the effective factors on rice production and reducing environmental risk become essential due to the increasing demand for rice. One of these factors is nutrients management. Nitrogen is the most important factor of limiting growth and yield in all rice-growing areas. According to the study, the use of nitrogen fertilizer to increase crop yield has been raised in the world by 800 percent from 1960 to 2012 (6). On the other hand, in the flooded system, nitrogen losses are higher due to ammonia sublimation, denitrification, leaching, fixation, and immobilization of ammonium and its removal by runoff (7). Therefore, the study of the rate and the way of nitrogen use in different cultivars under different conditions to increase crop yield, protect the environment and reduce the cost of extensive use of fertilizer has been considered by researchers. Fageria and Baligar (8) reported that rice yield and yield components have a significant relationship with different rates of nitrogen fertilizer. Split application of nitrogen also influences rice yield (9). In this regard, Kavoosi and Allahgholipour (10) investigated the effect of rate and split application of nitrogen fertilizer on two cultivars of Gilaneh and Abjiboji in two northern regions of Iran. In this study, the response of two cultivars to N fertilizer was different in terms of grain yield in both test site regions, which represents the impact of location and environmental conditions. Therefore, it seems that in addition to the rate and the split application of fertilizer, regional and environmental conditions are important to achieve maximum potential yield in nitrogen fertilizer management. Anil et al. (11) examined different amounts of nitrogen fertilizer and three methods of splitting on rice in India. They reported that these two factors affect the plant height, number of tillers, dry weight of the plant, and root dry weight. The most suitable plant height, tillers No and dry weight were observed in 180 kg N h^{-1} fertilizer and four splits (basal stage, 20, 40, and 60 days after planting, at each stage 45 kg N h^{-1}). The results of using different rates of nitrogen fertilizer on Kasturi cultivar in India indicated that the highest number of panicle (m^2) was obtained using 90 kg fertilizer per hectare (12). In the report of Mannan et al. (13), the values of 0, 25, 50, 75, and 100 kg nitrogen fertilizer per hectare were evaluated on four Basmati genotypes. The results showed that nitrogen has a positive effect on many traits, and in treatment with 100 kg nitrogen fertilizer, the maximum plant height, number of tillers (m^2), the number of panicles (m^2), and grain yield were obtained. In examining the application of different rates of nitrogen, Abou Khalifa (14) and Yoseftabar (15) reported that grain yield increased with increasing the rate of nitrogen.

Different amounts and application timing of nitrogen fertilizer on some hybrid varieties of rice were also examined in Senegal. According to the results, the usage of hybrid genotypes and the application of 150 kg/ha N fertilizer at four split levels improved rice production (16). According to Noor (17) research, unfortunately, in most agricultural regions of the world, nitrogen fertilizer is recommended based on a general pattern, regardless of the variety and region-specific conditions. That is why this research suggested evaluating appropriate amounts of nitrogen fertilizer in each crop and region for proper growth and yield increasing. Huang et al. (18) also reported that the application of Nitrogen fertilizer had no significant effect on higher yield of hybrid rice under medium to high soil fertility conditions, indicated that the cultivars and region conditions could be effective in recommending fertilizer. For this purpose, the present study aims at investigating the effect of split application and the rate of nitrogen fertilizer on some of the yield traits and yield components to provide a management solution on Shiroudi high yielding cultivar.

Material and Methods

Samples and conditions

This study was conducted to appraise the yield and some of the components under different Nitrogen fertilizer managements in two cropping seasons of 2015 and 2016. The experiments were executed for both years in a farm located in Babol, Mazandaran Province with geographic coordinates of 36° 29 N, 52° 23 E, and an altitude of 23.7 meters. This province is one of Iran's best known and suitable rice cultivation regions. The climate of this region is Semi-Mediterranean with humid, warm summers and the lowest rainfall levels and also moderate winter with relatively high precipitation. In this area, the average temperature is 17.6 ° C for ten years (2006-2016), and the average rainfall is also 654.7 mm (19). The weather information from the time of planting to the rice harvest is shown Table 1.

Table 1: The weather features of the cultivated area in two cropping seasons 2015-2016.

Year	Month	Min-Temperature (°C)	Max- Temperature (°C)	Rainfall (mm)	Sun (h)
First Year	April	10.3	21.4	0.5	5.4
	May	18	26.4	0.3	7.1
	June	20.1	29.1	0.8	8.2
	July	22.4	29.4	1.5	3.2
	August	22.4	34.3	1.5	8.5
Second Year	April	9.5	20.5	0.4	4.7
	May	15.1	21.9	0.5	3.1
	June	20.9	28.3	1.1	5.3
	July	22.4	31.4	0.4	6.9
	August	23.3	32.7	2.1	5.8

Soil sampling was performed every two years before the start of the experiment and at a depth of 40 cm to determine the physicochemical properties. Based on the results obtained, the soil texture was loamy, and its pH in the first year was 6.42, and in the second year, 6.57 (Table 2). Shiroudi was picked for this analysis as High Yield (HY) cultivar. Shiroudi, recorded in Iran in 2007 (20) with a yield of 6.5-7 t ha^{-1}.

Table 2: Soil physicochemical information in two cropping seasons (2015- 2016).

Year	Texture	Exchanged P mg/kg	Exchanged K mg/kg	Sand (%)	Silt (%)	Clay (%)	PH	Nitrogen (%)	Organic C (%)
2015	Loam	21	147	31	47	22	6.42	1.63	2.1
2016	Loam	14.2	144.3	25.24	46.46	28.3	6.57	1.66	2.7

Experimental design

The experiment was conducted as a factorial based on Randomized Complete Block Design (RCBD) with two factors, 1: nitrogen fertilizer in 4 levels (50, 90, 130, 170 Kg N ha^{-1}) and 2: its method of splitting into 4 treatments (T1: 70% basal stage + 30% maximum tillering stage; T2: 1/3 basal stage + 1/3 maximum tillering stage + 1/3 panicle initiation; T3: 25% base + 50% maximum tillering stage + 25% panicle initiation; T4: 25% base + 25% maximum tillering stage + 50% panicle initiation). For each of Nitrogen amounts, a plot was considered as a control. Urea fertilizer was utilized as a nitrogen source. The plot size was 12 m^2 (3m ×4 m). Half-meter intervals were observed between plots to avoid lateral water and nutrient movement among treatments. Additionally, the use of plastic sheets at a depth of 40 cm prohibited the soil from shifting hydrological to the extent possible. Transplanting was performed in the first year on 25 of May, and in the second year on 29 of May. Three plants per hill were cultivated with a spacing of 25cm × 25cm. Three plants per hill, with a spacing of 25cm × 25cm, were cultivated. The harvest was carried out in late August in both cultivation years. Manual weeding was performed twice (25 and 50 days following transplantation). Subsequently, information related to yield and its components were investigated, including the panicle's length (cm), number of panicles per square meter, whole grain in a plant, filling grain (percent), and 1000 grain weight (gr). After removing the marginal effect, 50 plants were selected per plot, and then harvesting was done to determine the yield at the ripening stage. In addition, yield (kg /ha) was measured in terms of 14 percent of moisture content. The yield and its components were measured and recorded based on the Standard Evaluation System (SES) (21). Statistical Analysis System (SAS, Version 8) (22) was used to analyze the data. Duncan's multiple range tests were used for the comparison of data means at 95 percent probability level.

Results and Discussion

The results arising from the combined analysis of the data obtained in two cropping seasons showed that only the number of panicles per m^2 was influenced by the significance of the year (at the P-v of 0.01). None of the other measured factors were affected by the year. However, different amounts of nitrogen affected panicle length, Percentage of Filled Grain, (PFG), and yield at the 99 percent confidence level. Also, the whole grain in a plant was affected by the factor (amounts of N) at the probability of 5% (Table 3). Islam et al. (23) reported that nitrogen levels were effective on panicle length, grain in panicle and grain yield, but this factor didn't have a significant effect on PFG and 1000 grain weight. Because, according to the interpretation, two traits (PFG and 1000 grain weight) are influenced by the genetic characteristics of the cultivars. In this regard, Mannan et al. (13) reported that the weight of 1000 grains was not affected by the amount of nitrogen, but nitrogen amounts in 5 levels had a positive effect on many of the traits measured, including the number of panicle per square meter and the length of the panicle. In the study of Hirzel et al. (9), PFG was affected by different amounts of nitrogen fertilizer in Chile's Parral region in the first year of the experiment, which is consistent with the present result. Che et al. (24) also pointed to the effect of different rates of nitrogen fertilizer on grain yield.

Table 3: Compound analysis of yield and some yield Traits in Shiroudi cultivar in two cropping seasons 2015-2016.

S.O.V	Df	Panicle Length (cm)	No of Panicle (m^2)	Whole grain in a plant	Filling Grain (%)	1000 -grain weight (gr)	Yield Kg ha^{-1}
Year	1	ns	**	ns	ns	ns	ns
Year error	4	41.57	3.50	79.36	268.38	21.78	813659
Amount	3	**	ns	*	**	ns	**
Treat	3	**	ns	ns	**	ns	**
Amount ×Treat	9	**	ns	ns	*	ns	**
Amount ×Year	3	ns	ns	ns	ns	ns	ns
Year×Treat	3	ns	ns	ns	ns	ns	ns
Amount×Year ×Treat	9	ns	ns	ns	ns	ns	ns
Total Error	60	22.54	2.54	25.98	24.79	4.78	162447
CV (%)		15.91	7.68	3.79	6.65	7.45	6.34

ns is not significant, * and ** are significant at a probability level of 5% and 1%.

In the present study, N splitting had a significant effect over panicle length, PFG, and yield at the P-v of 0.01(Table3). The results of several methods of dividing N fertilizer on rice in India were also significant in most of the measured factors. Panicle length, 1000 grain weight, number of panicles per plant, filled grain, and yield was profoundly affected by nitrogen dividing. So that the amount of 120 kg N ha^{-1} and the splitting method of T_3 (1/4 N as basal, 1/4 at tillering stage, 1/4 panicle initiation, and 1/4 milking stage), for the cultivar understudy in India was recommended (25). In the study of Kavoosi and Allahgholipour (10), the splitting of 75 kg N fertilizer per hectare on Abjiboji cultivar in Tonekabon resulted in better rice yield. Also, nitrogen splitting on Gilaneh variety into both studied regions in Iran (Tonekabon and Rasht) was effective on the yield of this cultivar. Although Liu et al. (26) had a different suggestion that led to increase grain yield, they changed the current farmer fertilizer practice (225 kg ha^{-1} N: 40% as basal, 30% as tillering, and 30% as jointing) to one- time root-zone fertilization in southern China. They applied 225 kg ha^{-1} N into 10 cm deep holes positioned 5 cm from the transplanting rice root.

In the present research, the interaction of different amounts of N with nitrogen splitting methods, showed that these factors affect panicle length and yield at the CI of 0.99, while for PFG, a significant level was observed at the P-v of 0.05. However, the interaction of the year on different nitrogen amounts and splitting methods was not significant in any of the evaluated factors (Table 3).

According to the results obtained from the mean square of the yield and yield components for two years, (Table 4), the only number of panicle (m^2) was significant in two cropping seasons, and the highest was observed in the first year of cultivation. Furthermore, the highest number of panicle was found under the influence of different fertilizer levels at the consumption level of 130 kg ha^{-1}, while different splitting methods were not effective. According to Table 4, regardless of the effect of year, the amount of consumption of 130 kg N ha^{-1} on panicle length, number of panicle per square meter, whole grain per plant and yield was also affected, and N splitting by T_3 method in all indices except for panicle length showed the great effect.

Table 4: Mean squares of yield and some yield components in rice (Shirudi cultivar) in two cropping seasons 2015- 2016.

S.O.V		Panicle Length (cm)	No of Panicle (m^2)	Whole grain in a plant	Filling Grain (%)	1000 - grain weight (gr)	Yield Kg ha^{-1}
Year	**2015**	27.54 a	17.15a	110.78a	77.47a	27.58a	6574a
	2016	28.11a	16.13b	110.103a	78.35a	29.36a	6710a
Amount	**N_1**	24.66c	16.15b	102.21b	75.86c	27.35b	5661.25d
	N_2	28.68ab	16.71ab	104.87b	77.58b	29.07a	6592.4c
	N_3	29.11a	17.50a	123.85a	77.89b	28.12ab	7294.4a
	N_4	28.50b	16.20b	111.27b	80.21a	29.58a	6754.03b
	T_1	28.15b	16.57a	109.34b	75.69c	27.55a	6134.5c
Treat	**T_2**	27.54c	16.81a	110.82ab	78.49b	28.72a	6624.2b
	T_3	26.06d	16.76a	111.82a	80.42a	29.78a	6785.7a
	T_4	29.20a	16.81a	110.95a	77.08c	28.86a	6766.5ab

Nitrogen amounts are N_1:50, N_2: 90, N_3:130 and N_4:170 kg ha^{-1}. Splitting treatments at four levels: T_1: 70% basal stage + 30% tillering stage, T_2: 1/3 basal stage + 1/3 tillering stage + 1/3 panicle initiation, T_3: 25% basal stage + 50% tillering stage + 25% panicle initiation, T_4: 25% basal stage + 25% tillering stage + 50% panicle initiation. Means in the column with the same latter are not significantly different at the P-v of 0.05.

Considering the significance of the interaction between the amounts of N and nitrogen fertilizer splitting on the panicle length, PFG, and the yield, the comparison of the mean of interactions during the years of the experiment was also examined (Table 5). The most excellent effect on panicle length was observed in the consumption of 170 kg ha^{-1} and the division of T_4 (25% at basal stage + 25% at tillering stage + 50% at the panicle initiation). The percentage of filled grain on the consumption of 170 kg ha^{-1} of fertilizer had the highest effect; however, this difference was observed in the splitting method of T_3 (25% N at basal stage+ 50% at tillering stage + 25% at the panicle initiation). Comparison of mean interactions on rice yield showed that the highest yield was 130 kg ha^{-1}, and two methods of splitting T_3 and T_4 can be observed (Table 5), Whereas Nneke (27) recommended 150 kg N h^{-1} in Nigeria. Hirzel et al. (9) reported that the interaction between nitrogen amounts and their splitting methods on the grain-filled in each panicle and 1000 grains weight in any of the two years studied in Chile was not significant. The result is different from the findings of the present study. Thind et al. (28) announced that there was no significant interaction between N rate and different methods of splitting on grain yield.

Table 5: Mean comparison of interaction effects of N amounts × splitting treatments on yield and two yield components in the two years.

Amount × Treat	Panicle length (cm)	Filled Grain (%)	Yield (Kg ha $^{-1}$)
N_1× T_1	26 de	75.31 e	5389 e
N_1× T_2	26.25 cde	76.49 de	6149 d
N_1× T_3	22.89 e	77.29 cde	5667 de
N_1× T_4	25.87 cde	74.62 e	5654 de
N_2× T_1	28.69 c	76.42 de	5733 de
N_2× T_2	28.68 c	78.22 bcde	6868 bc
N_2× T_3	28.79 c	79.89 abc	6854 bc
N_2× T_4	28.80 c	75.19 e	6866 bc
N_3× T_1	32.79 ab	75.17 e	6640 c
N_3×T_2	29.38 bc	77.79 bcde	6790 bc
N_3× T_3	25.69 cde	80.49 abcd	7934 a
N_3× T_4	28.72 c	78.13 bcde	7512 a
N_4× T_1	27.29 cd	75.87 e	6592 c
N_4× T_2	26.19 cde	81.78 ab	7211 b
N_4× T_3	27.14 cd	82.85 a	6891 bc
N_4× T_4	33.69 a	80.34 abcd	6859 bc

Nitrogen amounts are N_1:50, N_2: 90, N_3:130 and N_4:170 kg ha^{-1}. Splitting treatments at four levels: T_1: 70% basal stage + 30% tillering stage, T_2: 1/3 basal stage + 1/3 tillering stage + 1/3 panicle initiation, T_3: 25% basal stage + 50% tillering stage + 25% panicle initiation, T_4: 25% basal stage + 25% tillering stage + 50% panicle initiation. Means in the column with the same latter are not significantly different at the P-v of 0.05.

Conclusions

The vital point in this research is ineffective in the factor of the year on most of the factors evaluated except the number of panicles (m^2) at the P-v of 0.01. It seems that the set of environmental factors, including the insignificant differences in data is related to soil analysis over two cropping seasons, also climatic changes, the use of a constant cultivar in the experiment, the use of the same technique in the planting process until the harvest and precise planning of sampling time can be the effective reasons for this issue. According to the results obtained in 2015 and 2016, the most suitable amount of nitrogen fertilizer for Shirudi cultivar (HY) in the study area is 130 kg N ha^{-1}. Informing the proper amount of recommended fertilizer in the area would reduce the cost and also reduce the damage caused by uncontrolled and inappropriate consumption of nitrogen fertilizer on the environment.

Conflict of interest

The authors expressed that there are no conflicts of interest associated with publication.

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Authors' declaration:

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are mine ours. Besides, the Figures and images, which are not mine ours, have been given the permission for re-publication attached with the manuscript.
- The author has signed an animal welfare statement.
- Ethical Clearance: The project was approved by the local ethical committee in Islamic Azad University.

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تقييم إدارة النيتروجين المختلفة على المحصول وبعض مكونات محصول الأرز (صنف شيرودي)

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الخلاصة

النيتروجين (N) هو عامل رئيسي للنمو(وللحد من الانتاج) في مناطق الأرز المزروعة. أجريت هذه الدراسة لتقييم آثار الظروف المختلفة اضافة Nعلى محصول الأرز ومكوناته (صنف شيرودي) في بابل (مازندران ، إيران) خلال موسم 2015-2016 نفذت تجربة عاملية ضمن تصميم القطاعات الكاملة المعشاة (RCBD) متضمنة ثلاث مكررات او تضمنت ثلاث مكررات. في العامل الأول استخدمت أربعة كميات من N وهي (50 و 90 و 130 و 170-kg N ha1) ، بينما في المعامل الثاني ، تكونت المعاملات من أربع طرق مختلفة لتقسيم الأسمدة ، بما في ذلك T_1: ٧٠٪ في المرحلة الحداثة + 30 ٪ في مرحلة تكوين الاشطاء القصوى ، T_2: ١/٣في المرحلة القاعدية + ١/٣ في مرحلة الحراثة القصوى + ١/٣ في مرحلة بدء تكوين السنبلة ، T_3: ٢٥٪ في المرحلة الحداثة+ 50 ٪ في الحد الأقصى لمرحلة مرحلة تكوين الاشطاء القصوى+ 25 ٪ في مرحلة بدء تكوين السنبلة ، وT_4 : ٢٥٪ في المرحلة القاعدية + 25 ٪ في مرحلة الحرث القصوى + 50 في مرحلة بدء تكوين السنبلة. اوضحت لنتائج عدد السنابل (m^2)هي فقط التي تأثرت بشكل كبير بالسنة (at the CI of 0.95). كان لمستويات مختلفة من N تأثيرات على طول السنبلة ، والنسبة المئوية للحبوبالممتلئة (PFG) ، والحبوب الكلي في النبات ، والحاصل (at the CI of 0.95). كما تأثر طول السنبلة ، PFG، والعائد بشكل كبير بطرق مختلفة من تقسيم (at the P-v of 0.01). كان للتفاعل بين كمية النتروجين وتقسيم النتروجين تأثير كبير على طول السنبلة ، PFG، والعائد (at the CI of 0.95). بشكل عام ، فإن التأثير الأكثر أهمية في طول السنبلة ، و عدد السنابل (m^2) ، وحبوب النبات الكلي ، والحاصل لوحظ بعد استخدام 130 كجم N ها -1. علاوة على ذلك ، أظهر T_3 التأثير الأكثر وضوحا على جميع المؤشرات التي تمت دراستها باستثناء طول السنبلة.

الكلمات المفتاحية: تقسيم N ، طول السنبلة ، النسبة المئوية للحبوب الممتلئة ، الحاصل.