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Research Article

Effects of Irrigation and Nitrogen Fertilization on Rice Physiological Characters and Yield and Quality

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Abstract: The effects of irrigation model and Nitrogen (N) fertilization on rice evapotranspiration and yield were studied in an experiment of pool culture with in rain-proof shelter. Results showed that irrigation model and nitrogen fertilization had significantly influence on rice growth and photosynthetic capacity and yield and quality. Compared with the conventional irrigation, the plant height, rice water consumption, water requirement intensity and valid panicle number decreased and while water use efficiency, grain number perspike and seed setting rate in creased under control irrigation. With the in cement of N application rates, rice water consumption, water requirement intensity, effect panicle number and grain number per spikein creased, while setting-seed rate and 1000-grain weight decreased. Use the controllable irrigation technology, which had obvious effects of yield and quality on rice with the raise of N fertilizer rate. The yield reached 11489 kg/hm^2 and 10126 kg/hm^2 when the treatments was with 180 kg/Nhm^2 and 270 kg/Nhm^2, which was significantly higher than the treatment of CIN1and C2N1. The determination results showed that the palatability value of C1N2 was highest to 79.3, the cooking quality was improved. Then analyzed water and nitrogen fertilizer, yield and water use efficiency were highest at 180 kg/hm^2 of N applied. We concluded that control irrigation model combined with suitable N application rate (180 kg/hm^2) could benefit for rice production by reducing cost and gaining high yield.

Keywords: Irrigation model, nitrogen application, quality, rice, yield

INTRODUCTION

Nitrogen and water are the two most important factors that affect rice growth. In recent years, Chinese scholars have done a number of studies regarding the interaction rice yields, nitrogen uptake, physical shape, quality, nitrogen metabolism enzyme activity, etc. (Sun *et al*., 2009; Zhang *et al*., 2013; Yao *et al*., 2006). A lot of researches manifest that suiFigure irrigation management, fertilizer application rates and methods, water and fertilizer interaction control measures have significant influences on improving the photosynthetic performance of rice as well as increasing rice yield and improve rice quality. With the rapid development of China's water-saving agriculture, rice control irrigation, intermittent irrigation, rainfed and other other models are also gradually being promoted and applied in rice production (Pan *et al*., 2009). However, currently the researches on water control and nitrogen management in rice are mostly about single nitrogen or water-saving measures, few studies focus on the combined influences of water-nitrogen interaction on photosynthetic characteristics, yield and quality. Therefore, this research analyzes the influence of water-saving irrigation and nitrogen fertilizer on photosynthetic characteristics of rice fields, stress tolerance characteristics, yield and quality by anti-canopy pool culture experiment and aims to provides a theoretical basis for deciding the best water and nitrogen use mode in quality and efficient rice production.

MATERIALS AND METHODS

Test design: Since 2007, tests have been done for seven consecutive years in Anhui University of Science and Technology Park in Fengyang County, Anhui Province. This test takes the average statistics of 2013 and 2014 as the object data. This place, located in the northeast of Anhui Province and the south bank of the middle reaches of Huaihe River, belongs to the typical Seasonal Drought Area (Liu, 2012). The soil tested is Yellow-brown soil, whose physical and chemical properties are as follows: pH 6.21, the quality of available phosphorus scores 32.80 mg/kg, mass fraction

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of potassium 64.90 mg/kg, organic matter content 9.87 g/kg and alkali-hydrolyzable nitroge 68.10 mg/kg.

The test include two irrigation methods (C1-control irrigation and C2-traditional irrigation), three nitrogen application rates (90 kg/hm^2, 180 kg/hm^{2}and 270 kg/hm^2, namely N1, N2, N3) and six treatments, each treatment is repeated for three times and there are total 18 districts. Each district covers an area of 3.75 m^2 (3 m×1.25 m) with a depth of 1.2 m. The districts are arranged randomly. There are brick concrete isolation cell between districts to prevent moisture exchange. Each district is covered by canopy.

C1-control irrigation: In green stage (June 10-June 13), the water level in the field keeps at 10~20 mm and dry off in ripening period (Sept. 18-Oct. 9). Except these, no water layer is established in other growing period after irrigation. Saturated moisture content means soil moisture saturation limit, which includes early tillering (June 14-June 23), mid-tillering (June 24-July 9), late tillering (July 10-July 20) jointing booting stage (July 21-August 10), heading and flowering (August 11 - August 25), filling (August 26-September 6) and milk stage (9 July 7-September 17).

The lower limit of soil moisture takes 70, 65, 60, 80, 80, 80 and 70%, respectively of the saturated moisture content. C2-traditional irrigation: Irrigation system refer field irrigation by the local farmers, a shallow water layer of 10~60 cm is established except for field drying in late tillering and ripening period.

Experiment material: The rice tested, Gangyou527, was transplanted on June 10th and was harvested around October 9th. Tillering and panicle were applied on June 22nd and July 19th, The amount of nitrogen fertilizer used was at a ratio of basal: tillering: panicle, 5: 2: 3. And the varieties of N, P and K was urea (containing N 46%), superphosphate (including P2O5 12%) 75 kg/hm^2 and potassium chloride (including K2O 60%) 150 kg/hm^2 respectively. Cultivation and management such as pest control and weeding are the same as local rice production.

Test items and methods:

SPAD values determination: Use SPAD-502 chlorophyll Tester that is producted by Japan to test the SPAD values of rice blades once every 10 d from tillering stage to the milk stage. Select the top leaves that is completely out of the representative plants to make the leaf color observations. Test the SPAD value of the central and two 1/3 vertical points of the blade and take the average SPAD value. Measure 10 points and take the average value.

Flag leaf transpiration intensity: Photosynthesis rate, stomatal conductance, intercellular CO2 concentration and single leaf water use efficiency: use LI-6400 porFigure photosynthesis system analyzer (produced by LI-COR in America), the system will directly show the Photosynthetic rate Pn (μmolCO_2/m^{2}s), transpiration intensity Tr (mmolH_2O/m^2.s), Stomatal conductance Cond (mmoLH_2O/m^2.s) and Intercellular CO2 concentration Ci (μmolCO2/mol). The above indicators takes the flag leaf of the stem in the early filling measurements before and after rehydration, ten flag leaves are selected at random at each test and the average value is taken finally.

Leaves resilience physiology indexes: Take one totally spread out leave when the test is over and test its MDA, soluble sugar and proline, etc. The specific water method refer to "Plant Physiology Test Guideline".

Output indicator: When the rice is ripen, take 5 points (given acupuncture) at every mature cell, examine the influenceive spikes, the grains of each spike, the actual grains of each spike and the grain weight spike traits; calculate the actual yield of each district.

Grain quality: Use the DA7200 NIR rice grain quality analyzer produced by the Perten Ruihua Scientific Instruments (Beijing) Co., Ltd. to calculate the 12 traditional indicators of the rice (namely, brown rice rate, milled rice rate, milled rice rate, grain length, aspect ratio chalky grain rate, chalkiness, transparency, gelatinization temperature, gel consistency, amylose content and protein content).

Data analysis and processing: Analysis data by Excel 2 003 and SP ASS17.0.

RESULTS AND ANALYZE

Influence of irrigation and nitrogen fertilizer on rice growth period, plant height, tillering dynamics and chlorophyll value (SPAD):

Influence of irrigation and nitrogen application rate on the developmental stages of rice: Using traditional irrigation, the total fertility treatment period of rice under traditional irrigation is 5-8 d longer than the rice using control irrigation, among which the tillering ratio of C2N2 is14 days later than C1N1 and the milking stage is 2 d later than the full heading stage. Under the same water treatment, rice growing in low Nitrogen treatments (N1) and Nitrogen (N2) are shortened by 2-5d, while rice growing in Nitrogen (N3) is extended by 2-4 d, control irrigation and conventional watered are the same for rice growing period under the same nitrogen levels (Fig. 1).

The test results of the treatment during reproduction period in 2013 is similar to this. The two-year experiment shows that control irrigation and low nitrogen shortens fertility period (Table 1).

The influence of irrigation and nitrogen fertilizer on rice plant height: Figure 1 shows that using control irrigation (C1), as the Nitrogen increases, the height of the rice also increases significantly. C1N3increased by

Table 1: The growth stage of rice under treatments of water and nitrogen interaction

Treatments	Tilling	Panicle initiation	Heading	Maturity
CIN1	7/20	8/1	8/14	10/7
C1N2	7/27	8/3	8/16	10/9
C1N3	7/27	8/8	8/20	10/12
C2N1	7/20	8/5	8/14	10/7
C2N2	8/3	8/6	8/16	10/9
C2N3	7/27	8/8	8/18	10/12

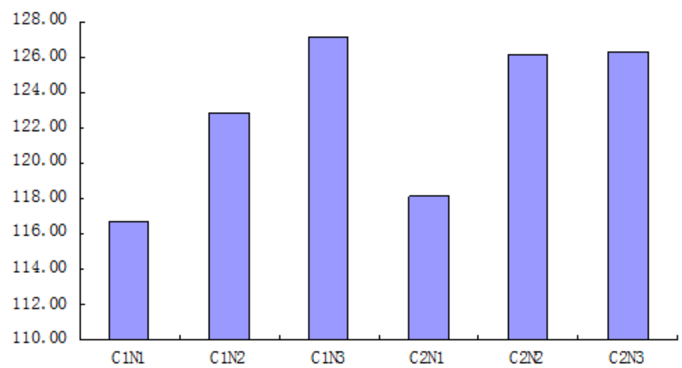

Fig. 1: The different height of rice (cm)

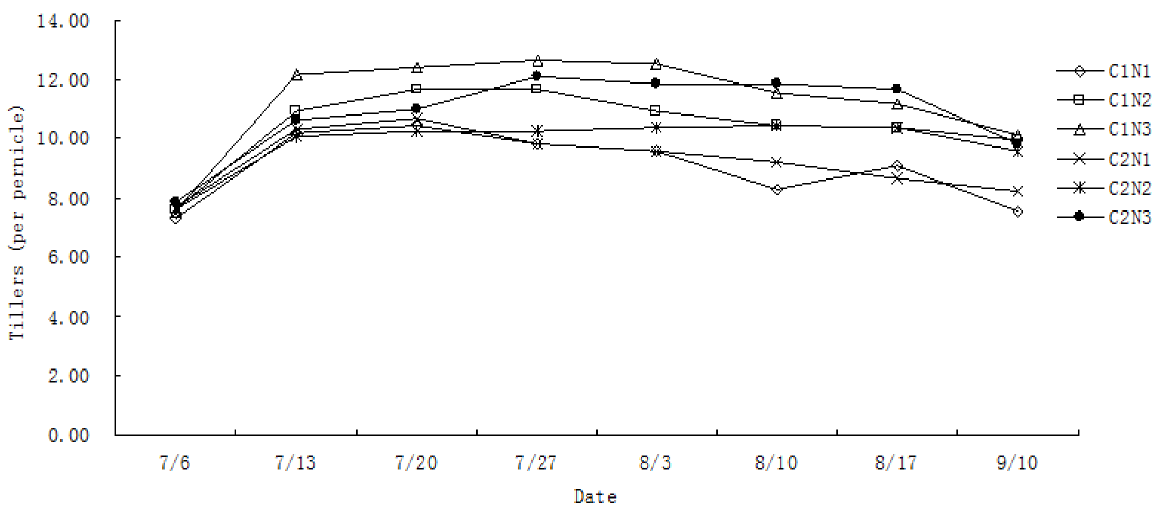

Fig. 2: The influence on tillers of rice

8.9% compared with CIN1; Under traditional irrigation (C2), there is a significant difference between C2N2, C2/N3 and C2N1. But the difference between C2N2 and C2N3 is not too significant. With the same Nitrogen fertilizer, different irrigation methods have no significant difference, this shows that using the method of traditional irrigation, over use of Nitrogen fertilizer has no positive influence on rice height increase, Nitrogen fertilizer dosage and water management has obvious interaction influences. With reasonable control of water, adding Nitrogen fertilizer dosage will have a positive influence on rice growth.

The influence of irrigation and nitrogen fertilizer dosage on dynamic tillers of rice: The influence of Nitrogen fertilizer dosage on rice under different irrigation method on the tillers of rice are shown in Fig. 2. In the test done on July 6th, the differences between different basic tillers treatment is not very significant. While the test on July 13th and the following tests shows the tillers of those with more Nitrogen is more than those doesn't. Also, as the amount of Nitrogen dosage increases, the speed of tiller will also increase and peak number of seedlings will increase, too. C1N3 has the largest number of tiller stems and has significant difference with other treatment methods at the same period. The tests on August 3rd, August 10th and August 17th also indicate Nitrogen fertilizer dosage increases and increases of the significance of the differences among the treatments. However, over use of Nitrogen fertilizer will not get the largest number of tiller stems. Among the six treatment,

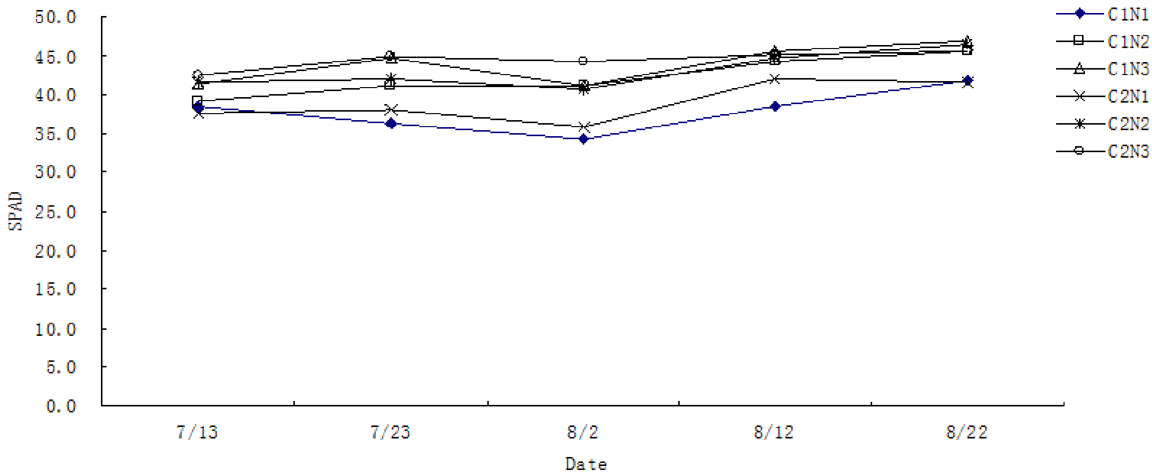

Fig. 3: The influences of different treatments on SPAD value of rice leaves

Table 2: Effects of leaf photosynthesis under different water-nitrogen treatments

Treatments	Pn/(μmol/m²/s)	gs/(mmol/m²/s)	Ci/(μmol/m²s/)	Rate Tr (mg/L)
C1N1	16.23±2.12e	72.01±22.5f	151±29f	2.18b
C1N2	18.02±1.28d	85.62±12.4e	178±18e	2.23b
C1N3	22.58±1.72c	112±24.6d	197±17d	2.34b
C2N1	26.23±1.12b	103±14.6c	238±25c	3.52a
C2N2	28.02±2.28a	122±14.9b	246±8b	3.68a
C2N3	32.58±3.72a	136±22.8a	263±14a	4.86a

C1N2 has the largest number of tiller stems, followed by C2N2 and the difference significance is much higher than that of other treatments. Under different irrigation systems, with the same amount of control Nitrogen fertilizer dosage, the control irrigation has relatively larger number of effective panicles than the traditional irrigation. Timely control of water, Nitrogen fertilizer can make up for the impact of water deficit will help to improve water use efficiency.

The influence of irrigation and Nitrogen dosage on rice chlorophyll value (SPAD): As can be seen from Fig. 3, in the early growth stage of rice, the SPAD value of the flag leaf with water Nitrogen joint regulation maintains at a low level. All the rice has once off the yellow in late tillering (August 2nd). This period is also the critical period of heading and jointing, which helps to control ineffective tillers and thus form a suiFigure vegetative. If increase Nitrogen fertilizer dosage at this period, all the SPAD values will increase, which means keeping relatively higher Nitrogen level will promote spikelets differentiation and prevent degeneration of spikelets. While in C1N3 treatment, as the Nitrogen fertilizer dosage is high in the early growth stage of rice, the SPAD value in the last phase is higher than that of other treatments. This not only increases the ineffective tillers but also prolongs the first phrase, which will lead to the lodging in the latter phrase; In the late rice growth, due to the lack of Nitrogen of C1N1, C2N1 treatment, their SPAD values also decrease significantly, especially the SPAD are lower than all other treatments in the heading of rice.

The influence of Irrigation and Nitrogen Fertilizer dosage on rice leaf photosynthetic performance: Figure 1 shows that, under traditional irrigation conditions, with the increasing amount of applied Nitrogen, flag leaf photosynthetic rate appears to be C2N3> C2N2> C2N1. Under the control irrigation, the photosynthetic rate changing trend is consistent with that of the traditional irrigation. Among each treatment combination, C2N3 has the maximum flag leaf photosynthetic rate. The influence on stomatal conductance, intercellular CO2 concentration and transpiration rate are almost the same. Under control irrigation, the intercellular CO2 concentration and transpiration rate values are greater than that of traditional irrigation conditions and with the increase of the amount of applied Nitrogen, it shows an upward trend. There are significant differences between stomatal conductance and intercellular CO2 concentrations among different treatments under different irrigation systems. Under the same irrigation conditions, the difference between different application Nitrogen is not significant (Table 2).

Influence of irrigation and Nitrogen dosage on some stress physiological index of rice Leaves: The content of Malondialdehyde (MDA) is an indicator for the plant cell membrane in vivo conditions in adversity. As is shown in Fig. 2, MDA content in the rice leaves at different times of different treatments varies significantly. In tillering stage, when measure the first leaf fully open, both in Control Irrigation (C1) and

Table 3: Effect of different treatments on Water Use Efficiency (WUE) and rice yield

Treatment	Valid panicle /(104/hm^2)	No. of total grainper spike	Seed-setting rate/%	1000-grain weigh/g	Yield/(kg/hm^2) Yield	Water consumption /(m^3/hm^2)	WUE/(kg m^3) WUE
C1N1	204.2d	161.2b	76.5a	28.8a	9247.0c	4542.7e	2.03ab
C1N2	289.5b	172.1a	67.4b	28.5a	11489.0a	5336.0d	2.15a
C1N3	302.9a	174.3a	64.2c	25.7b	10126.0cd	5734.4cd	1.77bc
C2N1	222.9c	153.4c	74.4a	28.8a	8914.0c	6138.6bc	1.42d
C2N2	297.4ab	171.2ab	66.7bc	28.5a	11528.0a	6806.4ab	1.69c
C2N3	301.3a	175.1a	64.3bc	25.9b	10255.0b	7035.5a	1.46d

traditional irrigation (C2), the the amount of Nitrogen will increase. When MDA content increases, difference between different Nitrogen Fertilizer is significant under Controlled Irrigation (C1). Under traditional irrigation (C2), differences between different Nitrogen dosages are not significant. Judging from the content of soluble sugar and proline, soluble sugar content of boot stage is less than that in tiller stage, which also illustrates that the water content of tillering leaf is high, the growing conditions are favorable and the physical growth ability is strong. With larger Nitrogen fertilizer dosage, the variation of soluble sugar and proline content is not obvious. In both irrigation methods, almost single leaf area increases substantially with the increase of Nitrogen dosage. The single leaf area of the control irrigation (C1) is generally smaller than the area under traditional irrigation (C2). With the increase of Nitrogen dosage, the amount of leaf area becomes more significant, which means the plant population increases. This will favor the formation of high-yield, but will increased water consumption and result in big water transpiration, which is one of the reason of the low water use efficiency.

The influence of irrigation and Nitrogen dosage on the component factors of rice yield:

The influence of irrigation and Nitrogen dosage on the component factors of rice yield: Figure 3 we can see with the increase in the amount of applied Nitrogen, effective panicles and grain number increase, while setting rate and thousand grain weight decrease. Compared with C1N1, C1N2, C1N3, panicles increases by 41.5, 48.3%, grain number increased by 6.8, 8.1%, setting rate decreased by 11.8, 16.1%, thousand grain weight decreased by 1.0, 10.8%; compared with C2N1, panicles of C2N2, C2N3 increased by 33.4, 35.2%, grain number increased by 11.6, 14.1%, lower seed rates decreased by 10.3, 13.6% thousand grain weight decreased by 1.0%. Taking account of the influence of irrigation on the factors for rice yield, compared with that of traditional irrigation, under control irrigation, the rice effective panicles shows a downward trend and the grain number and setting rate are tend to increase (Table 3).

The influence of irrigation and Nitrogen dosage on rice yield: As is shown in Fig. 3, with same irrigation method, increasing Nitrogen dosage can to some degree increase rice yields. The yield increase is effected by the irrigation method. Using traditional irrigation, C2N2 has the highest yield, reaching 11528.0 kg/hm^2; using control irrigation, C1N2 has the highest yield, reaching 11489.0 kg/hm^2. Using the same irrigation method, over dose of Nitrogen fertilizer cannot continue to increase the yield. The dosage of N2 (180 kg/hm^2) can offer favorable condition for high yield and all the rice shows high yield indications. Using the same irrigation method, with different Nitrogen dosages, yield difference are significant ($p<0.05$). N2 treatment has the highest yield, followed by the N3 treatment, but the difference is not significant compared with that of N2. And then comes the N1 treatment and N1 has a significant difference compared with N2 treatment. This shows that within a certain range, rice yield increase as Nitrogen fertilizer dosage increases. When Nitrogen fertilizer dosage reaches a certain amount, yield decreases as Nitrogen fertilizer dosage increases. In irrigation comparison test, the difference between C1 and C2 is not significant. Considering the interaction effects of irrigation and Nitrogen fertilizer dosage, we can see from Fig. 3 the rice yields of each treatment shows in the following decreasing order: C2N2, C1N2, C2N3, C1N3, C1N1, C2N1, C2N2, among which C2N2 treatment rice yield is 11528 kg/hm^2, but compared with C1N2, the difference is not significant.

The influence of irrigation and Nitrogen dosage on water use efficiency: The results (Fig. 3) shows that the water use efficiency of rice are in the following decreasing order: C1N2, C1N1, C1N3, C2N2, C2N3, C2N1. Compared with the traditional irrigation method, control irrigation can increase water use efficiency by 21.2~43.0%, with the increase Nitrogen dosage, water use efficiency in rice shows an trend of first increase and then decrease. Compared with C1N1 treatment, C1N2 treatment increases water use efficiency by 5.9%, while C1N3 treatment reduces water use efficiency by 17.7%, indicating that adopt water-saving irrigation method and rational Nitrogen fertilizer dosage can effectively improve water use efficiency in rice and the cost saving and effectiveness increasing effect is significant.

The influence of irrigation and Nitrogen dosage on rice quality: As can be seen from Table 4, with the same Nitrogen fertilizer dosage, the brown rice rate, milled rice rate, milled rice rate with control irrigation (C1) are higher than that of traditional irrigation

Table 4: Effect of the interaction between nitrogen rates and irrigation regimes on grain qualities

Treatment	Brown rice (%)	Milled rice (%)	Head rice (%)	Chalkiness (%)	Chalky kernel (%)	Protein content (%)	Amy lose content (%)	Setback	Gel consistency (mm)	Food stuff value
C1N1	82.3b	46.7e	49.2c	19.3a	32.8d	9.7c	21.4a	432.5a	38.4e	78.6a
C1N2	84.4b	51.2c	57.3a	19.1a	37.2b	10.8b	20.5a	305.2b	48.9c	79.3a
C1N3	85.2a	55.9a	58.7a	12.4b	42.9a	11.9a	19.7a	287.4c	56.7a	76.2b
C2N1	79.7c	49.1d	48.9d	10.6d	29.2e	9.8c	20.8a	277.6cd	43.3d	70.5c
C2N2	78.8c	53.2b	52.3b	13.2c	35.4c	10.7b	20.4a	206.1d	50.2b	69.9c
C2N3	75.2d	52.8b	51.4b	19.4a	42.1a	11.9a	19.2a	255.3bc	55.7a	67.2c

condition (C2); under controlled irrigation (C1) , as the dosage of Nitrogen fertilizer increases, brown rice rate, milled rice rate and milled rice rate show an upward trend; while in traditional irrigation treatment (C2), brown rice rate decreases as Nitrogen fertilizer dosage increases, while milled rice rate and milled rice rate increase. But the N2 is higher than that of N3, which means under conventional irrigation method, over dose of Nitrogen fertilizer can not get a high brown rice rate, milled rice rate and milled rice rate, but proper control of irrigation can increase favor rice rate under low Nitrogen fertilizer dosage processing conditions. Under traditional irrigation (C2), chalkiness rate and chalkiness of rice performance appear in the following trend, CN3> CN2> CN1 (Fig. 3), under the control of irrigation (C1), chalky grain rate and chalkiness of rice appear in the following trend, CN1> CN2> CN3 and there are significant differences between various treatments. In each treatment group, C2N1 has the lowest chalky grain rate and chalkiness. C2N3 has the highest chalkiness and C1N3 has the highest chalkiness rate. Irrigation methods and Nitrogen dosage have had no significant effect on the amount of rice amylose content. With the same irrigation method, rice gel consistency and protein content increase as the amount of applied Nitrogen increases. In each treatment combination, C1N3 has the largest protein content and gel consistency while C1N1 has the minimum.

The value of rice flour digestion of rice using traditional irrigation (C2) is significantly less than that of control irrigation (C1). The difference between the different treatments appears significant with C1N1 has the highest setback, reaching 432.5. Taste value decreases as the dosage of Nitrogen fertilizer increases. The taste value of the control irrigation is more than that of the traditional irrigation with C1N2 has the processing taste value reached a maximum of 79.3.

DISCUSSION

To reduce the environment pressure, save water resources and reduce Nitrogen fertilizer dosage, more and more attention have been paid to humid irrigation, alternate wet and dry irrigation and other water-saving irrigation techniques and optimization of Nitrogen fertilizer management etc. But most of the previous studies focused on a single factor effect and few studies focused on the influence of interaction of relevant irrigation methods and Nitrogen fertilizer on rice growth, physiological characteristics, yield and quality and the conclusions varies significantly. Lin Wenxiong, *et al*., studied the MDA, SOD and CAT change of flag leaves with the three Nitrogen dosages (75 kg/Nhm^2, 150 kg/Nhm^2 and 300 kg/Nhm^2). In the early grain filling stage the accumulation of MDA decreases; but in the middle and late grain filling stage, the vitality of three kinds of enzymes appears in the following trend, middle Nitrogen dosage> low Nitrogen dosage>high Nitrogen dosage. Under irrational Nitrogen fertilizer dosage, (low Nitrogen dosage and high Nitrogen dosage), enzyme activity appears defensive, which is an abnormal performance reaction. This results in a significant increase in the accumulation of MDA and faster leaf senescence. Arnon and Lahiri hold the view that in the dry soil, increasing Nitrogen fertilizer dosage can promote the usage of water in deep soil and thus increase yield. However, Bhan and Begg point out that when soil moisture is limited, increasing Nitrogen fertilizer dosage will increase crop water stress, which will have an adverse impact on yield. Researches done by You *et al*. (2006), shows that after adoption of water saving irrigation, rice yield and rice milled rice, amylose content and gel consistency show a decreasing trend, while chalkiness rate and chalkiness increase significantly, so he think there is no interaction effect between irrigation mode and Nitrogen fertilizer dosage. Cai *et al*. (2006) reports that under mild water stress, normal Nitrogen fertilizer dosage can increase rice milled rice and chalkiness rate and chalkiness also increase significantly. In addition, under whatever Nitrogen fertilizer dosage, mild pressure dry wet alternate irrigation has no effect on the amylose content.

The research shows that with the same agronomic and meteorological conditions, compared with using traditional irrigation method, plant height difference of rice using control irrigation is not significant, effective panicles increases and the water use efficiency increases by 21.2~43.0%. With increased Nitrogen fertilizer dosage, rice water use efficiency increase at first and then decrease. This manifests taking water-saving irrigation and rational application of Nitrogen fertilizer can effectively improve water use efficiency in rice. Both rice using control irrigation and traditional irrigation show as the Nitrogen fertilizer increases, MDA of flag leaf in tillering and jointing booting period increase. And under control irrigation, MDA varies significantly with different amount of Nitrogen fertilizer. In traditional irrigation, the differences of MDA between different Nitrogen fertilizer is not so significant. In terms of the content of soluble sugar and proline, the soluble sugar content in booting period is lower than that of tillering stage. This test supports the views of Liu (2012) which is that increasing Nitrogen fertilizer dosage is meaningless for increasing production. And the larger the dosage of Nitrogen is, the lower the Nitrogen utilization will be. Under the conditions in this experiment, control irrigation production decreased, but did not reach significant level. And from the analyse yield component factors we can know compared with traditional irrigation, rice panicles of the rice under controlled irrigation decreased, but grain number seed rate increased, which make up for the defect of decreased effective ears, thus production changes were not significant.

This study shows that controlled irrigation method can conserve water while not reduce rice yield and has a high water use efficiency, which is consistent with previous studies. The reason is mainly that control irrigation method can reduce soil evaporation and transpiration rice field leakage in most growth stages and the limited water depth layer and dry layer management offer a good environment that is conducive to rice root growth and maintains a high root activity. This helps to enhance the root's ability of using nutrients and water. It will improve the root's ability of offering the necessary nutrients that the plant need. Controlled irrigation can meet the physiological water need in pre seedlings period and can effectively inhibit ineffective tillers, increase tillering rate, anti-aging of functional leaves; while traditional irrigation is not conducive to the growth of rice and it is easy to make rice premature aging, resulting in grain number and seed rate decrease. Nitrogen fertilizer dosage and irrigation amount has a significant amount complementary effect, especially in the seasonally arid areas, it can improve water and Nitrogen fertilizer use efficiency and thus achieve a "fertilizer supplement water" and "water couple fertilizer".

The mechanism for Nitrogen fertilizer's influence on rice yield and quality under different irrigation method is yet unclear. Zhang *et al*. (2013) studied the influence of the interaction of Nitrogen fertilizer dosage and irrigation method on the yield and quality of rice, irrigation methods and concluded that Nitrogen fertilizer dosage and irrigation method has an obvious interaction between grain yield quality. Jin Zhenxun *et al*. (2014), holds that although increasing Nitrogen will have a positive effect on increasing the nutritional quality and appearance quality of rice. It will have negative effect on improving the cooking and eating quality, which means Nitrogen fertilizer have both positive and negative effect on rice quality. Studies done by Yang *et al*. (2002) suggest that, Nitrogen nutrition is negatively correlated to grain quality and increasing Nitrogen fertilizer dosage will reduce cooking and eating quality. Many studies also show that increasing the amount of Nitrogen fertilizer can increase the protein content of rice, reduce gel consistency and amylose content of rice, thereby affect the eating quality of rice (Yang *et al*., 2005; Ye *et al*., 2005). Study on rice quality in this research indicates that, as the Nitrogen fertilizer dosage increases, rice protein content increases; under the same Nitrogen fertilizer treatment, the brown rice rate, milled rice under controlled irrigation are higher than that under traditional irrigation; under traditional irrigation conditions, brown rice rate decreases as the Nitrogen fertilizer dosage is reduced, while rice rate and milled rice rate increase. There are significant differences between different irrigation methods and different Nitrogen fertilizer. But the differences of the rice with single different factor but with same irrigation method and the same Nitrogen fertilizer dosage is not significant. This means that irrigation methods and Nitrogen fertilizer dosage have obvious interaction on rice quality. Under the conditions in this experiment, high quality results can be gain under the controlled irrigation and 180 kg/hm^2 Nitrogen dosage.

CONCLUSION

In this experiment, using control irrigation, increasing Nitrogen fertilizer dosage (N2, N3) can reduce the negative influence of insufficient water to rice quality. Using traditional irrigation, when the Nitrogen fertilizer dosage is 180 kg/Nhm^2, 270 kg/Nhm^2, the yield will reach 11489 kg/hm^2 and 10126 kg/hm^2, which is obviously higher than that of CIN1 treatment and C2N1 treatment. The comprehensive quality index of rice is high with the C1N2 has the highest taste value of 79.3. Making a comprehensive consideration of water and fertilizer factors, under control irrigation and C1N2 treatment, when the Nitrogen dosage is 180 kg/Nhm^2, the synergistic effect is the best and it can initial realize water by fertilizer and promote fertilizer by water and enhance the water and fertilizer use efficiency, thus promote agricultural production efficiency.

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