Advance Journal of Food Science and Technology 11(8): 537-544, 2016
DOI:10.19026/ajfst.11.2698
ISSN: 2042-4868; e-ISSN: 2042-4876

Submitted: July 19, 2015 Accepted: September 3, 2015 Published: July 15, 2016

Research Article

Effect of Water Stress on Growth and Yield of Rice

[1, 2]Duan Su-Mei, [1]Huang Yi-De, [2]Yang An-Zhong, [3]Wu Wen-Ge, [2]Xiao Xin,
[3]Xu You-Zun and [3]Chen Gang
[1]Anhui Agricultural University, Hefei, 230031, China
[2]Anhui Science and Technology University, Fengyang 233100, China
[3]Rice Research Institute Anhui Academy of Agricultural Sciences, Hefei, 230031, China

Abstract: The main research objective of this study is drought resistant mechanism of rice. Using Xinliangyou6 rice as materials, the effects of stress on models growth and physiological characteristic and yields are studied. The results indicate that the plant height were decreased, the crop-stem lodging resistance was effectively increased, the physiological index changes occured, the content of Methane Dicarboxylic Aldehyde and proline and total soluble sugar marly all increase, which compared with the treatment of all the water (CK) was applied always, the reduction was significant. Compared with the CK, the yields of the short time water stress treatment in tilling stage (3d) increased 9.2%. With long time water stress by -75 Pa in booting stage, the yield decreased and it will be decreased about 42% in the treatment for the 7-day drought period.

Keywords: Growth stages, rice, water stress, yield

INTRODUCTION

Drought will be one of the worst natural disasters that human beings have to face for a long time. Frequent droughts and long-term sustainability of the national economy will especially impose huge losses on agricultural production (Zou and Zhang, 2008). China is the largest rice producer in the world and rice is the crop that has the largest water needs (Ding *et al*., 2014). Therefore, how to solve drought's negative impact on rice yield is a very serious agricultural production problem we are facing and is waiting to be solved. Anhui Province is one of the major rice producing provinces, Jianghuai hilly region is an important rice production center and commodity grain base (Huang *et al*., 2005). This region, which belongs to the subtropical to temperate transitional climate zone, is suitable for the growth of season rice. However, the north-south gas flow intersects here and this leads to uneven distribution of rainfall temporal, thus the evaporation distribution is not synchronized, resulting in often seasonal drought. Combined with other reasons such as complex hilly topography, aging irrigation project and backward irrigation techniques, drought stress is still the bottleneck that constrains high rice yield in this area (Xiao *et al*., 2008).

Most of the researches in recent years are focused on the single factor of duration of drought stress. By analyzing the physiological characteristics, yield and agronomic traits and drought tolerance of rice in different growth stages, the studies try to provide a reference for the cultivation of drought-resistant rice and rice water saving cultivation (Li *et al*., 2013; Zhao *et al*., 2012). But few researchers can taking view of both rice growth stages and drought duration to discuss the rice's physiological mechanisms for dealing with drought stress under continues drought stress. Based on the current status quo of a few study of the relationship between different degree of drought stress and rice growth, coverage, physiological traits and yield, in order to find out the influence of drought and drought duration in different rice growth stages on the growth traits and physiological characteristics of rice, this study makes a systematic study on the influence of different duration of drought stress in different growth stages on plant height, tiller number, lodging resistance, stress tolerance index of leaves and yield, so as to study rice water-saving mechanism, fully tap their own water conservation and drought-resistant potential and take advantage of self-compensation effect of rice, to promote agricultural water saving and rice yield increase, which will has a great significance for agriculture water-saving cultivation and yield increase as well as provide a theoretical basis for the anti-drought cultivation measures of Medium Hybrid Rice along Huaihe River.

MATERIALS AND METHODS

Test material: The test seed used is Xinliangyou No. 6. Provided by Anhui Rice Research Institute of Agricultural Sciences. This kind of rice belongs to

Corresponding Author: Duan Su-Mei, Anhui Agricultural University, Hefei, 230031, China

indica hybrid rice. It has an average growth period of 130.1 days growth period and features high yield, high grain quality and is one of the major rice cultivated in Anhui Province. The soil used in the test is from the wheat filed in Qiancha. The soil has a organic matter content of 11.98 g/kg, nitrogen of 71 mg/kg, soil available phosphorus of 28 mg/kg, quick-acting potassium of 136 mg/kg. The fertilizer used are urea (46% N), superphosphate (12% P2O5) and potassium (60% K2O) purchased from Fengyang County fertilizer market.

Treatments design: Tests were conducted from April to October of two consecutive years, 2013 and 2014, in the movable planting pot with rain shed in Anhui University of Science and Technology Park in Fengyang. With dry nursery, transplant the rice plants into the prepared plastic pots on June 5, the 35 d seedling age. The plastic pot is 27 cm (internal diameter) ×26 cm (height) and contains 12.5 kg of dried and smashed soil taken from Rice Test Field of Anhui University of Science and Technology (the water content of the soil is around 18%), each pot plants two rice plants.

Apply Nitrogen fertilizer by 15 kg/667 m^2, phosphate 7.5 kg/667m^2, potash (K2O) 12 kg/667 m^2, which are conventional dosage. Calculate the amount used in each pot and fertilize by a single basin as a unit. Apply all basal fertilizer at once.

The test has ten kinds of treatment, namely tillering stage (21d~30 d after planing) with drought duration of 3d (T1), 5d (T2), 7d (T3), tillering stage (21d~30 dafter planing) +booting stage (61d~70dafter planing) with drought duration of 3d (T4), 5d (T5), 7d (T6), booting stage (61d~70dafter planing) with drought duration of 3d (T7), 5d (T8), 7d (T9) and take conventional water management CK (T0) as the comparison, a total of ten treatments. In different growth stages, water potential control is kept at around -75 kPa (0~10 cm of the soil has only 20% moisture content. The soil surface cracks and root water uptake will be trapped, rice leaves wilt temporary at noon). 7d to 10 d before treatment, the rice plants are protected by anti-canopy and is offered water when there is a lack of water. After treatment begins, when water is bellow-60 kPa, monitor soil moisture with soil water tension meters (negative pressure vacuum gauge type tension meter produced by CAS Nanjing Institute of Soil, each treatment three meters), record the moisture value at 8:0 to 8:30 and 16:00 to 16:30 every day and take the average value of the two values as the moisture value of the soil moisture and record the lowest moisture value during the treatment. If the water is below -80 kPa during the treatment, add water to around -75 kPa, repeat for three times, so the total are 30 pots.

Test items and method:

Height After the harvest: Tile all rice plants, take average value of the length from the stem base to the top of the ear (without Mount).

Tiller dynamic: Start from one week after planting (June 15^{th}), record the tillers of two pots of rices, test tillers amount once every 7 d until the tiller amount does not increase (August 1^{st}).

Leaf water potential: On 4 d after the treatment, at 11:30 every Sunday noon, measure the leaf moisture of the first fully expanded leaf on the top of the main stem by US water potential dew point measurement system. Each pot choose two plants and each leaf tests for six times and take the average value.

Drought resistance physiological indicators of the leaf: At the end of the day of the treatment, take the uppermost functional leaf and measure its MDA, solube sugar, Proline. The specific method refer to "Plant Physiology Test Guideline" (Li, 2000).

Stem coefficient Take sample when the rice is ripen: Choose two plants of each pot and measure the weight of the first and the second stem (g), measure the length (m), calculate the stem coefficient = the total weight of the first and the second stems (g) /the height of the first and the second stems (cm) (Duan *et al*., 2014).

Yield index: After the rice is ripen, take out all the rice with all treatments and rinse with water. Air dry the plant indoor and measure the plant height, effective panicles, grain number, panicle grain weight, thousand seed weight and yield (economic grain yield).

RESULTS AND ANALYZE

The influence of drought treatment on rice shape dynamic:

The influence of drought treatment on rice height: As can be shown in Fig. 1, drought treatment has a restrain on rice height. Booting stage drought has greater restrain on rice height than tillering stage, the height of tillering stage+booting stage drought treatment has the most significant reduction when compared with CK. In the same period of drought treatment, as the drought period becomes longer, the height reduction is more significant. The height reduction in booting stage drought treatment reduced by 17.56 cm, the height inhibition rate reaching 15%.

The influence of drought treatment on tillering dynamic: Figure 2 shows that rice tiller in different physiological stages of drought treatment basically reach a peak on July 25, among which T6 treatment has the largest number of tillers of 30.67/pot and T3 has the least tiller, only 22.33/pot, 8.34/pot less than the highest. And after July 25, the number of tillers

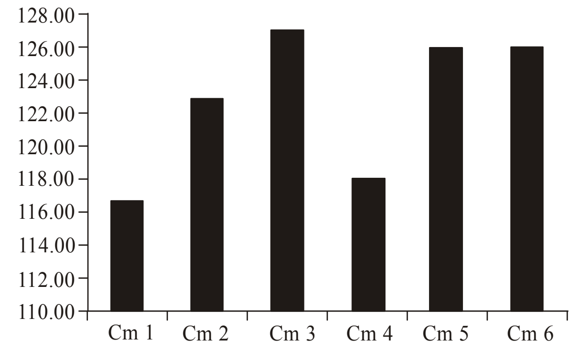

Fig. 1: The different height of rice (cm)

decreases. By August 1st, there is no significant change of tillers in different treatment.

The tiller number in peak time of tillering stage drought treatment is almost the same as that of CK, while both the tiller number in peak time of booting stage drought treatment and tillering stage+booting stage drought treatment are larger than that of CK. After July 25th, the reduction of tillers in tillering stage drought treatment, booting stage drought treatment and tillering stage+booting stage drought treatment are more significant that that of CK. This means that water control may increase rice tiller amount but the tiller reduces fast in the late stage of tillering; as drought period becomes longer, the ineffective tiller will increase and effective tiller will decrease.

The influence of drought on stem coefficient in different physiological stages: As is shown in Table 1, except the three-day drought treatment in booting stage, the weight with drought treatment in the first two sections are significantly higher than that of CK, among which the tillering stage maintains a largest gap of 7 d and dry weight between sections reaches 13.80 g/pot, followed by 5 d in tillering stage drought treatment, with other treatment periods between 10.85-12.51 g/pot. Drought treatment makes the section between the first two periods smaller than that of CK. Wherein each drought treatment period, the longer the duration is, the shorter the length of the sections between the first and second period will be, with the shortest section in tillering stage being 7 d, only 12.22 cm. Therefore, drought can effectively enhance plumpness between rice sections and its effect enhances as the drought duration extends, with the largest being 7d in the tillering stage, reaching 0.99 g/cm. Making a comprehensive comparison of drought treatment in different stages, conducting drought treatment in tillering stage and tillering stage to booting stage, substantial increase are more obvious between sections, while drought treatment in booting stage has a relatively small impact on enhancing inter-section stem coefficient. Thus, drought can increase the straw accumulation, inhibit elongation and improve lodging resistance. The effect of this treatment on height is in consistent with that of the drought.

The influence of drought treatment on rice leaves resilience index: Test the water potential of rice flag leaf on the third day, fifth day and seventh day of the drought treatment in tillering stage, booting stage. The water potential can be show in Fig. 3 to 5. Drought treatment can reduce water potential rapidly and the water potential reduction of tillering stage drought treatment is more significant than that of the booting stage. Restore water supply of rice on 3 d and 5 d in tillering stage drought treatment, the water potential of the leaves can restore to normal level. When drought continues to 7 d, water potential of flag leaf decline sharply and is irreversible. Water potential change in booting stage drought treatment is more significant than that of tillering stage drought treatment.

The influence of drought treatment on the leaf MDA content: Malondialdehyde (MDA) is a cell membrane peroxidation index. It is a peroxidation product that can strongly react with the various components within the cell occurs and will severely damage a variety of

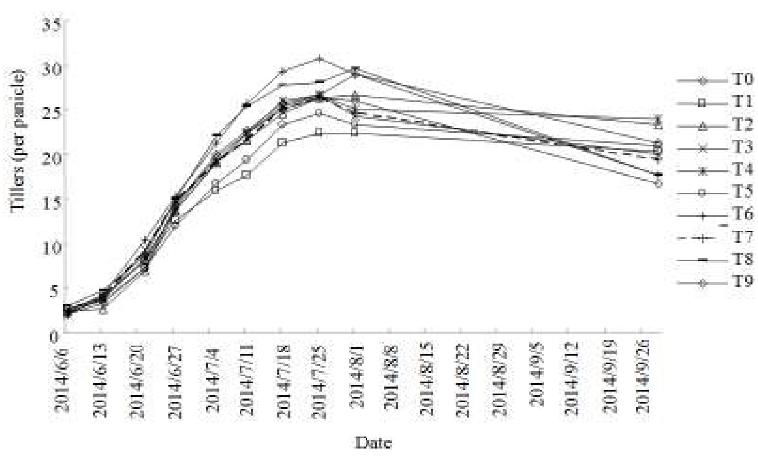

Fig. 2: The influence on the tillering dynamics

Table 1: The stem coefficient and test results of each treatment

Treatment		Weight (g) in the first and second section	Length weight (g) in the first and second section	Stem coefficient (g/cm)
Comparison	T0	10.53	15.34	0.69
Drought treatment in tillering stage	T3	10.85	13.51	0.80
	T5	13.34	13.65	0.98
	T7	12.63	12.77	0.99
Drought treatment in tillering stage+booting stage	T3	11.79	14.16	0.83
	T5	12.51	13.18	0.95
	T7	11.5	12.58	0.91
Drought treatment in booting stage	T3	10.04	14.16	0.71
	T5	11.92	14.47	0.82
	T7	12.29	13.69	0.90

Table 2: The test results of MDA, solube sugar, proline test results after drought stress at different growth stages

Treatment		MDA content /(10^{-3}mol/g) MDA activity	Solube sugar content/% solube sugar	Free Proline/10^{-3}%	Leaf relative water content/%
Comparison (tillering stage)	T0	1.11 Bb	2.39 Bbc	1.48 c	31.88
tillering stage drought	T1	1.18Bb	3.68Aab	2.11Bb	29.59
	T2	2.00Aa	4.75Aa	3.65 Aa	27.79
	T3	1.97 Aa	4.48Aa	1.86 d	26.95
Comparison (booting stage)	T0	1.40 cd	7.04 bc	1.28 d	31.22
tillering stage+booting stage drought	T4	1.49 cd	8.79Aa	2.28 b	30.65
	T5	1.92 Bb	7.90 Aab	1.32d	29.73
	T6	2.19 Aa	6.42 bc	1.70 c	28.36
Booting stage drought	T7	1.76c	7.91 Aab	3.47 Aa	28.86
	T8	1.94 Bb	7.45 Aab	1.63 c	27.18
	T9	2.29Aa	6.77abc	1.04 d	27.02

Small letter means significant at the 0.05 probability levels and the capital letter means significant at the 0.01 probability levels

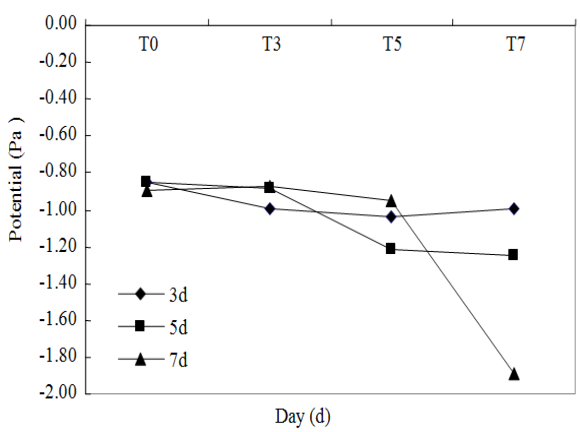

Fig. 3: The leaf water potential at rice tillering

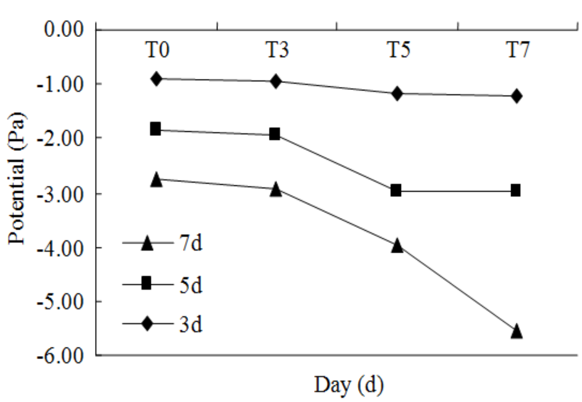

Fig. 4: Leaf water potential tillering stage and booting stage

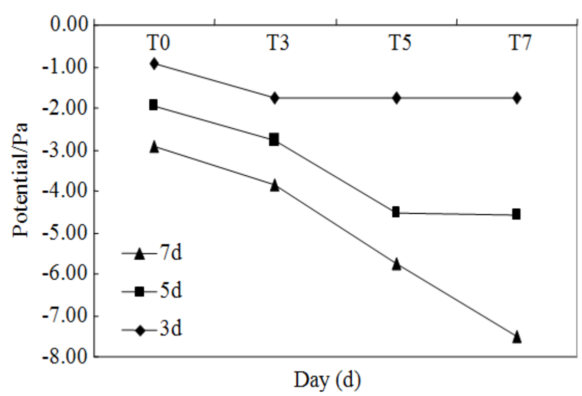

Fig. 5: The leaf water potential at rice booting stag

enzymes and membrane system. The MDA contents show the blade height membrane lipid peroxidation. As can be shown in Table 2, compared with that of CK, the MDA of each treatment are much higher and there are significant difference between different treatments; during the same treatment time, the MDA content change of leaf in tillering stage drought treatment is the most significant, while the MDA content change of leaf in booting stage+tillering stage drought treatment is the minimal. On 3 d in tillering stage treatment, the MAD content of the leaf is a little higher than that of the comparison group, with the MDA of leaf on 5 d drought increasing sharply to 2.00 umol/g; comparing booting stage drought treatment and booting stage+tillering stage drought treatment, the increase of leaf MDA content is higher than that of CK.

The influence of drought treatment on solube sugar content: As can be shown in Table 2, the solube sugar content in tillering stage+booting stage drought treatment is the highest and then comes the booting stage drought treatment. In the same period, leaf of shorter drought treatment has a more significant increase of solube sugar. Five days after the treatment, the solube sugar decrease; solube sugar of both tillering stage drought treatment and tillering stage+booting stage drought treatment increase and have a trend of increase first and then decrease. Therefore, under drought stress, the leaf solube sugar content increase has a threshold value, if exceeds this threshold, the value will decrease. Leaves on 3 d of tillering stage+ booting stage drought treatment has the highest solube sugar content of more than CK24.9%, when it is on 7 d in drought treatment, the solube sugar content in the leaves drops to 6.42%, down by 8.81% than CK.

Proline content measure: Table 2 shows that the leaf Proline content will increase in tillering stage and booting stage drought treatment and it has a significant increase trend compared with that of CK; in tillering stage drought treatment, viewing from drought duration, the Proline content first increase rapidly and then decreases; leaf on 5 d in tillering stage drought treatment has the largest amont of Proline content increase, reaching 3.05×10^{-3}%, when drought duration reaches 7 d, the Proline content decreases to 1.86×10^{-3}%; the Proline content of the tillering stage+booting stagedrought treatment is the lowest and the increase and decrease of the Proline content of the leaf in booting stage drought treatment are more significant and dramatic. When drought duration reaches 3 d, the Proline content increases rapidly to 3.47×10^{-3}%, 1.71 times higher than that of CK. When drought duration reaches 7 d, the Proline content decreases by 19% compared with CK and there are significant differences between different treatments.

The influence of drought treatment on yield components:

The influence of drought treatment on effective panicles: As can be shown in Table 3, except for 5 d in tillering stage drought treatment and 3 d in tillering stage+booting stage drought treatment has more effective panicles than that of CK, other treatments are all less than that of CK. Therefore, short term drought in tillering stage and drought in tillering stage+booting stage at the same time have positive impact on the effective panicles of rice. But if the drought time reaches 7 d or longer, it will reduce the effective panicles significantly and the more significant the reduction of tillers will be compared with CK. In all the treatments, the 3 d in tillering stage drought treatment+booting stage drought treatment has the largest number of effective panicles, reaching 24.00/pot, followed by 5 d in tillering stage drought treatment, being 23.34/pot and the lowest is 7d in booting stage drought treatment, being only 16.67/pot. The difference of effective tillers in booting stage drought treatment and 7 d in tillering stage+booting stage drought treatment reaches a significant level compared with that of CK. While tillering stage drought treatment has an insignificant influence on the number of effective panicles. By comparison, only booting stage drought treatment has a bigger comprehensive influence on the effective panicles than tillering+booting stage drought treatment. This is related to that after the drought training of the rice in tillering stage, the rice has bigger adversity tolerance, which needs further study.

The influence of drought treatment on grains per spike and grain numbers per ear: As can be seen from Table 3, the grains per spike amount on 3 d in tillering stage drought treatment and 3 d in booting stage are larger than CK, among which the 3 d in tillering stage drought treatment has the largest amount, reaching 221.01/ear, followed by 3 d in booting stage drought treatment, being 214.51/ear, which has a significant difference compared with that of CK; there is also significant differences in different time of booting stage drought treatment. Drought treatment significantly reduces the seed rate and the longer the period of drought is, the more obvious the reduction

Table 3: The yield components of each treatment

Treatment		Effective panicles	Grains per spike	Grain numbers per ear	Percentage of filled grains (%)	Thousand seed weight (g)	Yield (g/pot)	±CK/%
Comparison	T0	21.34ab	192.84Bb	168.68Bb	87.47a	25.50Aa	90.6Bb	
Tillering stage drought treatment	T1	20.34bc	221.01a	189.59a	85.78b	25.75Aa	99.30Aa	9.21
	T2	23.34a	182.28bc	131.71c	72.26c	25.07Aab	76.81bc	-15.22
	T3	20.00ab	180.58bc	136.15e	75.40c	25.02Aab	68.03e	-24.91
Tillering stage dought +booting stage drought	T4	24.00a	187.63bc	126.42f	76.79bc	24.43Aabc	75.8bc	-16.34
	T5	21.00ab	186.05bc	142.86d	73.62c	24.44Aabc	74.94bc	-17.28
	T6	17.67abc	197.30Bb	145.25d	67.38cd	25.04Aab	64.18Ab	-29.16
Booting stage drought	T7	19.34abc	214.51Aa	175.33c	67.75cd	25.20Aab	72.02bcd	-20.51
	T8	17.67abc	193.58Bb	122.31f	63.18cd	24.53Aabc	53.96f	-40.44
	T9	16.67abc	194.06Bb	128.33f	66.13cd	24.72Aabc	52.37f	-42.20

will be. Except on the 3 d of tillering stage, the grains per spike amount in drought treatment is larger than that of CK, the grain numbers per ear in other treatments are all less than that of CK. All the treatments have significant differences with CK and the amount also varies in different period and different treatment duration. Among all the treatment, 3 d of tillering stage drought treatment has the highest grain numbers per ear, reaching 189.59/ear, followed by 3 d in tillering stage+booting stage drought treatment, reaching 175.33/ear and the 5 d of booting stage drought treatment has the least, being only 122.31/ear. Further study is needed to explain whether rice plant after short drought rewatering will be more sensitive to moisture and can can quickly restore or stimulate higher growth performance and accumulation of dry substance. Long period of drought stress will lead to irreversible damage and directly reduce yield.

The influence of drought treatment on thousand seed weight and yield: As can be shown in Table 3, among all the drought treatments. The thousand seed weight of 3 d in tillering stage drought treatment is the highest, being 25.75 g, followed by that of the 3 d in booting stage drought treatment, being 25.20 g and the weight on 7d in tillering stage+booting stage drought treatment is the lowest, being only 24.43 g. Drought stress leads to the decrease of thousand seed weight and the increase of the long drought, increasing decline. The highest yield of drought 3 d tillering stage, reaching 99.30 g/pots, increasing 9.2% by comparison with the difference, reaching a very significant level; the yields of other drought stress treatment are lower than that of CK and there are significant differences among different treatments; the yield of booting stage drought treatment decreased significantly compared with CK, among which the yield of 7 d in booting stage being the lowest, only 52.37 g/pot, reducing by 42.2% by comparison. Drought in booting stage has a greater impact on yield than tillering stage drought treatment and tillering stage+booting stage drought treatment. Further study is needed to find out whether tillering stage drought treatment has any exercise stress effect on booting stage drought treatment and whether after going through a tillering stage drought treatment can improve or stimulate the tolerance for drought damage.

DISCUSSION

The influence of drought treatment on height, tiller and lodging capacity of rice: A lot of researches have been done on the influence of drought on the growth, physiology, yield and quality of rice. This study researches and analyzes the influence of drought stress on the height, tiller, lodging resistance, leaf physiological characteristics and yield of rice in different growth stages. And reaches the conclusion that the drought treatment will inhibit plant height and there are different growth inhibitory effect in different period of drought stress, which are consistent with previous findings.

Booting stage drought treatment has a greater inhibition on plant height than that of tillering stage drought treatment (Ge *et al*., 2012). Conducting drought treatment in tillering stage+booting stage at the same time can attain the most significant reduction on rice height. Drought treatment can effectively enhance the plumpness of inter-section of rice and as the duration of the drought treatment becomes longer, this influence will also become stronger. Drought stalks by increasing dry matter accumulation, inhibition between elongation improve lodging resistance, this treatment effect on plant height is consistent with the drought. Controlling water also increase tillering trend, but with the extension of drought duration, ineffective tillering increase, reducing the effective tillers. Drought can inhibit stem growth and improve lodging resistance by increasing dry matter accumulation, which is in consistent with the drought. Controlling water will also increase tillering trend, but as drought duration extends, ineffective tillering will increase and effective tillers will decrease.

The influence of drought treatment on resistance physiological indexes of rice leaves: Increasing the amount of plant MDA, solube sugar and Proline is widely seen as plants' adaptation mechanism to water stress. This test further proves that a certain number of solube sugar accumulation is likely to be the plant's emergency response to water osmotic stress and is one behavior of adaption to adversity. Wang Xia *et al*. (1999) and Bao Siwei *et al*. (2001) hold the view that osmotic adjustment has some limitations. Severe droughts will cause plants to reduce or loss osmotic adjustment ability. Under the experimental conditions in this test, with sustained water stress, the amount of MDA, solube sugar content and Proline content of rice leaves shows the trend of first decline sharply and then slowly, which means when drought duration exceeds the limit, plant will lose osmotic adjustment ability of MDA, solube sugar content and Proline. But this test also proves that under short drought stress duration, rice has very strong resistance. And if restore water supply in time, the drought will not have significant influence on rice growth and yield. Researches done by Zhang Meiyun *et al*. (2001) point out that viewing from Proline biosynthesis, water stress will prevent Proline formulation and finally result in the Proline accumulation stop in the last stage of stress treatment. The tests showed that for both solube sugar accumulation and the accumulation of free Proline, when water stress reaches 5 d or 7 d, the contents will decline sharply, indicating that water stress has a limited influence on solube sugar and free Proline content. Exceeding the limit, the cumulative effect will disappear and it will impose irreversible harm on the growth and metabolism of rice. It is reported that during the entire drought treatment process, the accumulation processes of Proline and solube sugar are different, Proline content has a lower accumulation speed in the late drought, while solube sugar has a large accumulation in the late stage of the drought. The test shows there's no obvious law in the synchronicity and sequence of MDA, solube sugar and Proline accumulation. At the beginning of the stress, solube sugar will accumulate immediately. After some time of stress, the amount of Proline accumulation amount will increase. Further study is needed to find out the role of mutual compensation of MDA, Proline and solube sugar under different stress and different duration of streets.

The influence of drought treatment on yield and yield factors: This test shows that although rice has self adjustment function, the loss bring by drought is much higher than that of self-adjustment. This will definitely have influence on the yield and quality of rice in later stage, which will result in substance reduction and reduction of economic yield. Research done by Yu Xuezhi *et al*. (2001) shows that booting stage is the critical period of rice. During this period, there will be yield reduction if there is water stress or drought. If there is successive drought, the yield will plummet. The longer the drought lasts, the more reduction will the yield suffer, or the rice even be killed. The yield reduction was mainly that drought in the booting stage suppress the development of sex organs. Researches done by Chen Xiaorong *et al*. (2013) suggest that, under drought conditions, there is a significant and highly significant positive correlation between soil moisture and yield. This test further verifies these views. The difference in the 3 d in tillering stage has the highest yield and reaches a very significant level; with booting stage drought treatment having a big reduction by comparison. The test also found that only booting stage has a greater impact on yield than tillering stage and tillering stage+booting stage drought treatment.

Yields of rice under other drought stress treatment reduce compared with that of conventional water management and there are significant differences among different treatments; booting stage drought treatment compared with the control large yield reduction. The experiment also found that only booting stage of drought impact on yield greater than tillering stage and tillering stage+booting stage drought treatment. Whether tillering stage drought treatment has a stress exercise effect on booting stage drought treatment and whether going through tillering stage can enhance or stimulate drought stress tolerance of harm of rice in booting stage call for further study.

CONCLUSION

The study finds that in tillering stage, short-term mild drought has the most optimal performance, drought treatment has negative effect on plant height and can also stimulate tillering potential, increase certain tillering ability, cultivate reasonable plant type, enhance lodge capacity and there are positive response in the plant physiological indexes. MDA concentration, proline and solube sugar content all have varying degrees of change by compare and the differences reach a significant level; the plants are sensitive to moisture after drought stress rehydration and can be quickly restore and is even able to stimulate higher growth. Therefore, in tillering stage, timely and reasonable control of water can achieve good water-saving effect on the basis of not affecting the yield of rice. Drought duration reaches 7 d will result in serious injury of plant physiological mechanism, causing irreversible damage. Especially in jointing-booting stage, which is a crucial period for rice yield, if soil water potential continuous to be around 75 Pa, the 7 d has the most significant cuts of yield reduction of 42%.

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