Advance Journal of Food Science and Technology 4(6): 413-416, 2012
ISSN: 2042-4868; E-ISSN: 2042-4876

Submitted: September 11, 2012 Accepted: October 09, 2012 Published: December 20, 2012

Effects of *Pirformaspore Indica* on Cotton Resistance to Waterlogged Stress

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Abstract: In this study, Xiangzamian F7 was as experimental material and four experimental treatments were made. Which are: *Pirformaspore indica* to be as base fertilizer (0P), *P. indica* to be added into soli respectively before and after cotton seedlings suffering from subsurface waterlogging (+P, P+) and cotton seedlings merely encountering subsurface waterlogging (CK). This study aimed to study the influence of *P. indica* to cotton growth and the main enzyme activity under the waterlogged stress condition. The results showed that: the leave area and height of 0P, +P were higher than that of CK and P+ obviously during the waterlogged stress and the recover after waterlogged stress. The Chlorophyll and sugar content of 0P and +P leaves were higher than P+ and CK leaves after removing from the waterlogged stress. The MDA content of 0P and +P increased slowly during waterlogged stress and the recover after waterlogged stress. The SOD activity of 0P and +P seeding went quickly up under 15 days waterlogged stress. The POD activity of 0P and +P went down during 15-day waterlogged stress, but the POD activity of CK and P+ increased. The above results showed that *P. indica* could improve cotton resistance to waterlogged stress. In order to improve cotton resistance to waterlogged stress, suggesting *P. indica* as base fertilizer, at the same time, adding *P. indica* into soli before cotton seedlings suffering from subsurface waterlogging, the effect of cotton resistance to waterlogged stress will be better.

Keywords: Enzymatic activity, morphological index, *Pirformaspore indica*, waterlogged disaster, xiangzamian F7

INTRODUCTION

Cotton is an important economic crop in China. Yangtze basin has been the important commodity Cotton area. Affected by the subtropical monsoon climate, rainy weather happened frequently in July and August. It often causes cotton suffering from waterlogged disaster periodically and causes cotton output and fiber quality reducing sharply (Bange *et al*., 2004; Zhang *et al*., 2001). So, improving the cotton resistance to waterlogged stress and post-disaster recovery is needed to resolve urgently in the Yangtze cotton basin. Predecessors had done many researches in characteristics of waterlogging disaster, determining the method of waterlogging disaster, loss evaluation of waterlogging disaster. They had established many quantitative index and model (Grichk *et al*., 2001; Pezeshki *et al*., 1997; Varrna *et al*., 1999), formed the farmland drainage technique, crop cultivation technique, fertilization regulation and control technology, as well as selection and cultivation varieties of resistance to waterlogging in the practice. However, at present, using microbial to prevent waterlogged disasters was seldom-reported. *P. indica* is an endophytic fungi, it was founded by Varma from the desert of northwestern India. It could colonize in a variety of crop roots (Song *et al*., 2011) promote plants growth (Lou *et al*., 2007; Ralf *et al*., 2005) and speed up the absorption of nitrogen, phosphorus and mineral (Wang *et al*., 2011; Kumari *et al*., 2003) improve the resistance to bad environment of crops (Wang *et al*., 2011). But it had not been reported about *P. indica* of resistance to waterlogged stress at home and abroad. In this study, *P. indica* to be as base fertilizer, to be added into soli before and after cotton seedlings suffering from subsurface waterlogging, respectively. The cotton seedling growth and the antioxidant enzymes activity of the leaves were researched during and after the waterlogged stress. This study can reveal the physiological mechanism about cotton seedlings' recovery growth added with *P. Indica* fertilizer and provide the basis theory for cotton' comprehensive prevention from the waterlogged disasters and cotton' resistance cultivation.

MATERIALS AND METHODS

Xiang F7 was used in this study. The seeds were sown in the square plastic plates filled in sandy soil on March 27, 2012 and cultivated in the illuminating incubator. The Vigorous seedlings were transplanted in plastic pots (35 cm in diameter and 50 cm in height) as the second true leaf expanded fully, each pot had one plant and each treatment had 10 plants. Four treatments

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were set up which are: treatment 1 as Control test (CK) that cotton plants only encountered waterlogging, treatment 2 marked as 0P that *P. indica* was as base fertilizer and added on 27 March and after that cotton plants suffered from waterlogging, treatment 3 marked +P that as manure *P. indica* was added at 10^{th} day before water logging (on 25 April), treatment 4 marked as P+ that topdressing was added after water logging stress (on 20 May).

The amount of *P. indica* was 0.125% without organic fertilizer and chemical fertilizer. The cotton seedlings were processed under waterlogged stress from May 5 to 20. The water depth was 2 cm during the waterlogging treatment. The growth indexes of cotton seedlings were investigated respectively before, after and at 15 days after waterlogging treatment.

In the day before waterlogged stress, the 15^{th} day separately under and after waterlogged stress, taking fresh functional leaves of cotton plants were used to determine chlorophyll, soluble sugar, MDA, SOD and POD etc., 3 replicates per index. Data analysis were carried out using excel and with SPSS software for significant analysis.

RESULTS AND DISCUSSION

Analysis of cotton leaf area and height variation: Each experimental treatment had a different effect for cotton growth (Fig. 1). Table 1 showed that the leaf area and cotton height of 0P and +P were larger than that of CK and +P obviously. In addition, the leaf area of 0P was 720.83 cm^2, it was the largest of all on 20 May and there was a significant difference between them. It indicated that *P. indica* as the base fertilizer benefited to the growth of cotton leaves and height under waterlogged stress for 15 days. At the same time, the leaf area of +P reached to 923.37 cm^2, it was the largest of all on 4, June and there had a significant difference from the others. It indicated that *P. indica* as the topdressing before waterlogging stress benefited to the recovery growth of cotton leaves after waterlogging damage. But, the leaf area of P+ was no significance before and after waterlogging disasters on 5/20/4, June and even lower than that of CK. It showed that the *P. indica* had no obvious effects on the growth of cotton leaf after water logging removal.

Changes of content of chlorophyll: The content of chlorophyll of 0P, +P, P+ increased more quickly than that of CK during the waterlogged stress. Especially, the rise rate of +P reached to 106.20%. In addition, the content of chlorophyll of P+ was the highest among four treatments from May 20 to June 4 under the recovery growth of cotton after waterlogging damage (Fig. 2). The above results showed that *P. indica* used as bacterial manure benefited to the accumulation of the content of chlorophyll.

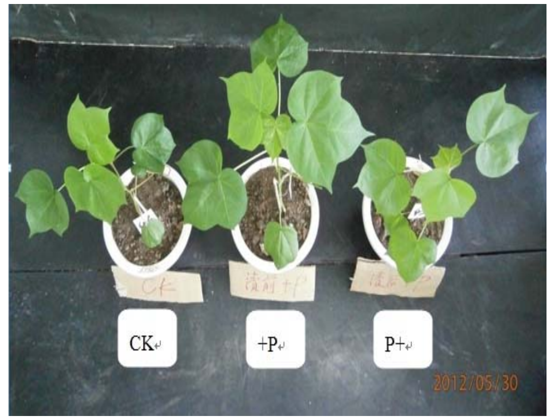

Fig. 1: Cotton plants at 10^{th} day after waterlogging elimination (May 30)

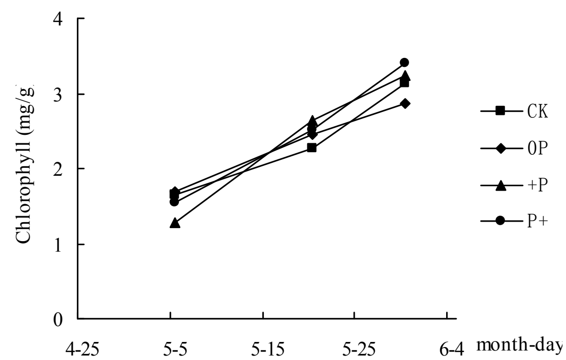

Fig. 2: Chlorophyll dynamic each treatment

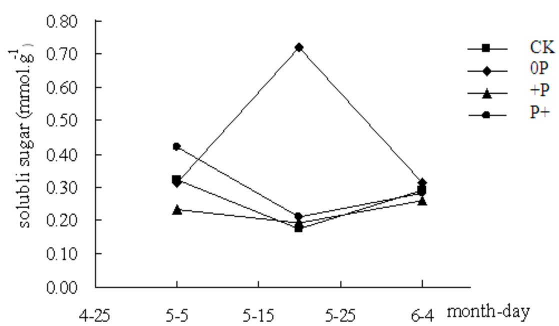

Fig. 3: Soluble sugar each treatment varying with time

Changes of soluble sugar in leaves: During the 15 days that cotton plants was under waterlogged stress, the soluble sugar content of 0P increased from 0.31 to 0.72 mmol/g, but which of the others went down. After removing from the waterlogging stress, the

Table 1: Changes of leaf area and plant height of cotton

Treatment	The day before waterlogged stress (May 5)		15^{th} day under waterlogged stress (May 20)		15^{th} day after waterlogging elimination (June 4)	
	Leaf area (cm^2)	Cotton height (cm)	Leaf area (cm^2)	Cotton height (cm)	Leaf area (cm^2)	Cotton height (cm)
CK	324.39 a	18.92 a	453.34 a	25.80 ab	561.42 a	30.30 a
0P	520.36 b	18.95 a	720.83 c	26.10 b	787.39 b	31.57 ab
+P	402.22 a	21.50 a	649.73 b	26.80 ab	923.37 c	31.85 ab
P+	314.91 a	20.00 a	406.56 a	23.80 c	447.46 a	30.65 bc

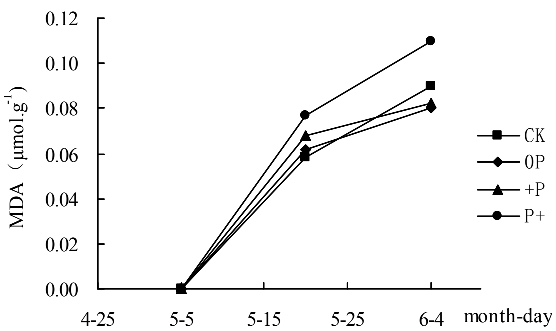

Fig. 4: MDA dynamic each treatment

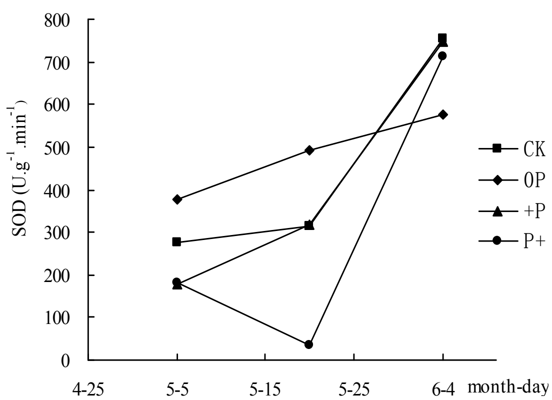

Fig. 5: SOD activity each treatment varying with time

soluble sugar content of 0P went down quickly and that of other treatment went up, respectively (Fig. 3). (Table 1) The above results indicated that *P. indica* used as base fertilizer was beneficial to increasing the soluble sugar content under waterlogging condition.

Changes of the MDA from leaves: During 15-day waterlogging treatment, the content of MDA of all the treatments increased. The content of MDA of 0P and CK went up slower than the other treatments. After waterlogging treatment, the increase of MDA content of all the treatment was slower than that of during the waterlogged stress (Fig. 4). The content of MDA of 0P and +P was the minimum. The results showed that *P. indica* was effective to reduce the membrane lipid peroxidation degree of cotton, if it added as base

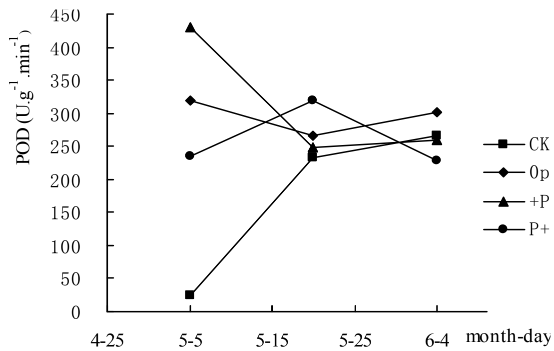

Fig. 6: POD dynamic each treatment

fertilizer or added before cotton seedlings suffering from subsurface water logging.

Changes of the activity of SOD from leaves: During 15 days of cotton plants under waterlogged stress, the SOD activity of 0P and +P went up obviously, that of CK had little changes and that of P+ went down inversely. These results indicated that *P. indica* may induce the SOD activity to enhance the defense of cotton seeding to waterlogging damage. After removing from the waterlogging damage, the SOD activity of all treatment went up and that of P+ increased dramatically (Fig. 5). These result showed that the usage of *P. indica* after removing waterlogging damage may induce the SOD activity to get rid of a large number of reactive oxygen radicals of cotton seedling and avoid suffering from waterlogged damage.

Changes of the activity of POD from leaves: During 15 days of the waterlogged stress, the POD activity of 0P and +P decreased, however, the POD activity of CK increased. After removing from the waterlogging damage, the POD activity of CK, 0P and +P had no changes, but that of P+ descended (Fig. 6). The results showed that *P. indica* was effective to reduce the membrane lipid peroxidation degree of cotton and could avoid cotton suffering from waterlogged damage.

CONCLUSION

The usage of *P. indica* before waterlogged damage may improve growth of cotton seedling and enhance the resistance of cotton seedling to waterlogged stress.

The usage of *P. indica* after removing from the waterlogged stress may increase the reaction of repairing of cotton seedling to waterlogging damage.

In order to prevent and relieve waterlogging damage at cotton seedling stage, *P. indica* may be used as seed coating agent or base fertilizer. In addition, it may be used as topdressing after waterlogged damage.

ACKNOWLEDGMENT

This study was supported by the Key Project of Hubei Provincial Department of Education (Z200712002), Hubei Province Natural Science Fund (2011CDB010) and Special Fund for Agro-scientific Research in the Public Interest (201203032).

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