4th RMUTIC 2013 organized by Rajamangala University of Technology Phra Nakhon, Bangkok-Thailand

JOURNAL OF APPLIED SCIENCES RESEARCH

JOURNAL home page: http://www.aensiweb.com/jasr.html 2013 Special, 9(12) pages: 6140-6145

Published Online :15 January 2014 **Research Article**

Effects of chitosan application before being subjected to drought on physiological changes and yield potential of rice (*Oryza sativa* L.).

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Received: 12 November 2013; **Revised:** 14 December, 2013; **Accepted:** 20 December 2013.

ABSTRACT

Drought stress is one of the serious problems limiting yield potential in rice production. This work aimed to investigate the effective method of chitosan application for maintaining growth and yield potential under drought stress. Complete randomized design (CRD) with four application methods (treatments) including Tr1.no chitosan application, Tr2.seed soaking before planting, Tr3. foliar spray before subjecting to drought and Tr4.seed soaking before planting + foliar spray later before subjecting to drought, was performed with five replications and conducted in an open-ended outdoor greenhouse of Rajamangala University of Technology Suvarnnabhumi, Phra Nakhon Si Ayutthaya province from October 2012 to February 2013. The results indicated that various methods of chitosan application significantly affected leaf greenness and grain yield of rice plants, application of chitosan by foliar spray and seed soaking +foliar spray showed the best effects on leaf greenness and grain yield respectively. While plant height and yield components under drought stress were not significantly improved by chitosan application. However, application of chitosan by foliar spray and seed soaking +foliar spray tended to improve growth and yield components better than the other methods. In regard with proline and soluble sugar, they were not significantly affected by various methods of chitosan application. Nevertheless, the best trend of proline and soluble sugar content were mostly detected from seed soaking before planting +foliar spray and mere foliar spray respectively. In this present study, it might be possible to maintain growth and yield potential of rice plants encountering drought stress by applying chitosan by soaking the seeds before planting followed by foliar spray later or mere foliar spray.

Key words: rice plant, drought stress, chitosan application

INTRODUCTION

Rice production is affected by numerous environmental factors both biotic and abiotic stress, including drought, flooding and insect or disease infection. In Thailand, rice is very important economic crop because it is largely exported per year with high values of 4700 million US$ in the year 2012. Therefore, drought stress in rice production in Thailand is one of serious problems to be solved urgently. Each year numerous rice fields are damaged by drought, particularly in-season rice fields, Drought is considered to be one of the most important factors seriously affecting rice yield potential. It directly affects both vegetative and reproductive growth. The severity of drought depended on plant growth stage and drought duration. Therefore, the finding of method to solve this problem is urgently considered. Chitosan, natural biopolymer, can be used as elicitor for stimulating plant immune system under unfavorable condition, i.e. drought, flooding and insect and disease infection. There were many academic papers reporting about application of chitosan in many plant species such as eliciting immune system of plants under both biotic and abiotic stress condition [4,14,13,17], promoting seed germination percentage and seedling growth [16,6,10,20,19] and enhancing growth and yield of many crop species [3,9,5,1]. In this present study, our objective was to determine the appropriate method of chitosan application to rice plants before being subjected to drought on some physiological changes and yield potential

Materials And Method

The experimental design was Complete randomized design (CRD) with four treatments and five replications. The treatment details are as follows: Tr1. no chitosan application, Tr2.seed soaking before planting,Tr3.foliar spray before subjecting to drought and Tr4. seed soaking before planting + foliar spray before subjecting to drought. Ten rice seeds cv. Pathum Thanee1 per experimental

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unit (1 tank) were planted in 60-cm diameter cement tank containing clay soil having chemical properties as follows: pH= 7, % OM = 2.35 (moderate), aval. P = 88 mg/kg (very high), exch. K = 230 mg/kg (very high). Rice seeds of Tr2 and Tr4 were soaked in chitosan solution at the concentration of 40 ppm whereas seeds of Tr1 and Tr3 were soaked in water for 8 hrs. before planting. After that foliar spray of chitosan at the same concentration used for soaking the seeds was performed when the ages of rice plants were 14, 21, 28 and 35 days after planting. Three days after finally being sprayed, drought stress was imposed by withdrawing irrigation from the cement tank until rice leaves showed shallow V-shape (score 3) according to standard evaluation system (SES) [7]. After that re-irrigation was normally performed until harvesting time. This experiment was conducted from October 2012 to February 2013 at Rajamangala University of Technology Suvarnnabhumi, Phra Nakhon Si Ayutthaya province. All data were subjected to analysis of variance (ANOVA) by MSTAT. Standard deviation (SD) was performed to compare data distribution whereas treatment means were compared by Least significant difference (LSD).

Results And Discussion

Plant height:

Plant height of rice plants applied chitosan with various methods and then suffered by drought was not significantly different ($p>0.05$). Height of rice plants applied chitosan by foliar spray tended to be higher than those of the other methods. Soaking the seeds with chitosan solution before planting had poor effect on rice height (Figure 1a). This finding was closely to the work of Lizarrage-Paulin *et al.* [9] who found that chitosan at the rate of 2% did not increase stem length of maize subjected to alkaline soil.

Leaf greenness:

Application of chitosan by foliar spray 4 times before being subjected to drought stress significantly promoted ($p<0.05$) leaf greenness of rice plants greater than the others , however it did not differ from those that soaking the seeds with chitosan solution before planting followed by foliar spray. Leaf greenness value was the lowest in treatment that soaking the seeds in chitosan solution (Figure 1b). This result was in line of the result of LiQiang *et al.* [8] who revealed that the chlorophyll content of cucumber seedlings was increased by 6.7% after chitosan application under drought stress.

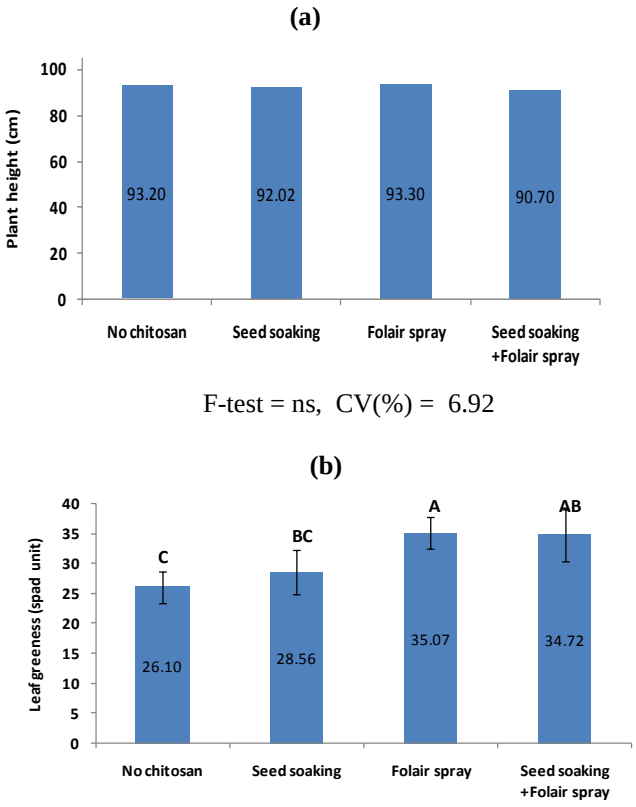
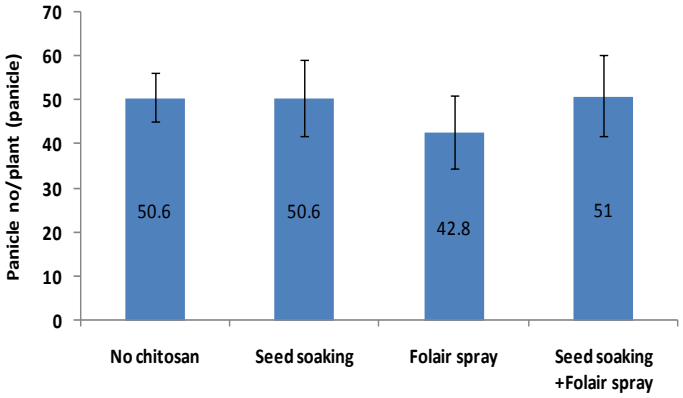


Fig. 1: Effect of various applications of chitosan before being subjected to drought stress on plant height (a) and leaf greenness (b) of rice plants.

Panicle numbers:

Panicle numbers of rice plants subjected to drought were not significantly different ($p>0.05$) after application of chitosan with different methods. However, higher panicle numbers per plant tended to obtain by seed soaking followed by foliar spray. Chitosan application increased number and weight of strawberry plants [1]. Chitosan solution at the concentration of 0.15% (w/v) induced a significant increase in the number of pods per plant of *Phaseolus vulgaris* L. The lowest panicle numbers were observed in foliar spray method (Figure 2).



F-test = ns, CV(%) = 16.6

Fig. 2: Effect of various applications of chitosan before being subjected to drought stress on panicle numbers of rice plants.

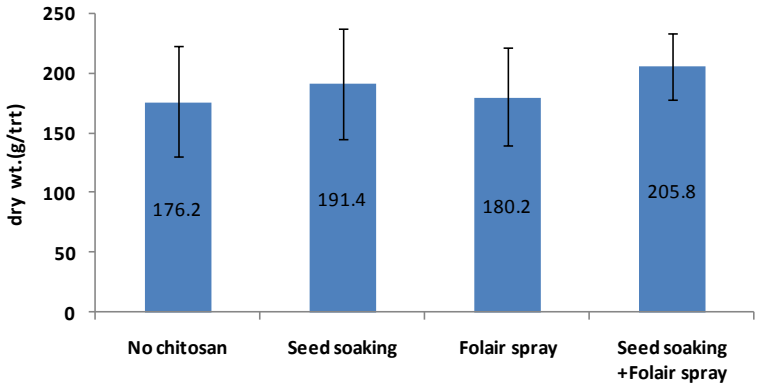
Dry weight:

Dry weight of rice plants was not significantly ($p>0.05$) influenced by various applications of chitosan before being subjected to drought. However, the highest dry weight tended to obtain from application by seed soaking before planting and foliar spray later. The similar result reported by Shehata *et al.* [15] found that foliar application with chitosan at rates of 4 mlL^{-1} recorded the best treatment to obtain the highest vegetative growth in cucumber. The lowest dry weight tended to obtain from application by foliar spray (Figure 3a).

Grain yield:

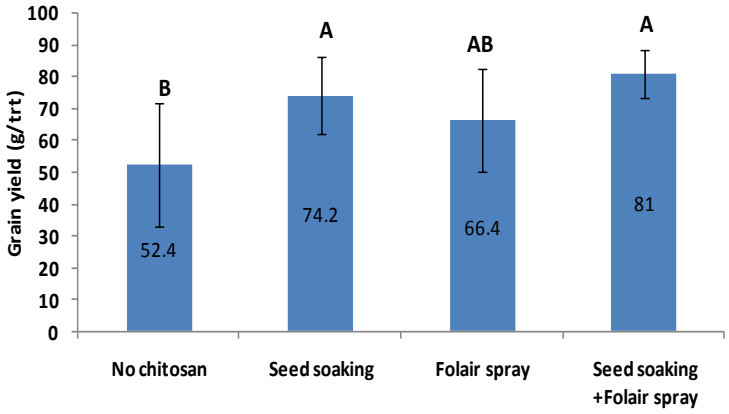
Grain yield of rice plants applied various applications of chitosan before being subjected to drought was significantly different ($p<0.05$). Seed soaking before planting followed by foliar spray later showed the best effect to increase grain yield whereas the lowest grain yield was observed from the control (no chitosan). About 20% of soybean yield was increased over the control when applied chitosan at the concentration of 5% [19]. Foliar application of chitosan at the concentration of 20 ppm, four times throughout cropping season slightly increased grain yield of rice cv. Suphan Buri 60 [2].

(a)



F-test = ns, CV(%) = 21.73

(b)



LSD (0.05) = 19.48, CV(%) = 21.22

Fig. 3: Effect of various applications of chitosan before being subjected to drought stress on dry weight and grain yield of rice plants.

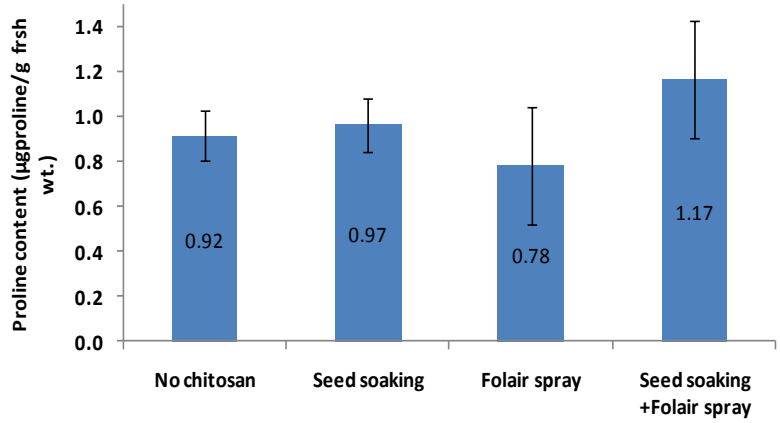
Proline content:

Various applications of chitosan to rice plants before being subjected to drought did not significantly ($p>0.05$) influence proline content in rice leaves. The best trend having high proline content was detected from application by soaking the seed before planting followed by foliar spray. It can be explained that foliar chitosan spray might contribute to proline synthesis for sustaining water potential in rice plant resulted in reduction of drought injury. Karimi *et al*. [11] reported that the severity of castor bean plants damaged from drought was reduced by chitosan application. (Figure4a).

Soluble sugar content:

The highest soluble sugar content was obtained from application of chitosan by foliar spray, nevertheless it did not show any significant difference from the other applications including the control. This result implied that foliar chitosan spray tended to stimulate soluble sugar synthesis which was related to osmotic potential adjustment in rice plants resulted in drought tolerance. Solute accumulation was one of the mechanisms for drought tolerance in rice [12]. The lowest soluble sugar content was detected from the control (no chitosan) (Figure4 b).

(a)



F-test = ns, CV(%) = 24.84

(b)

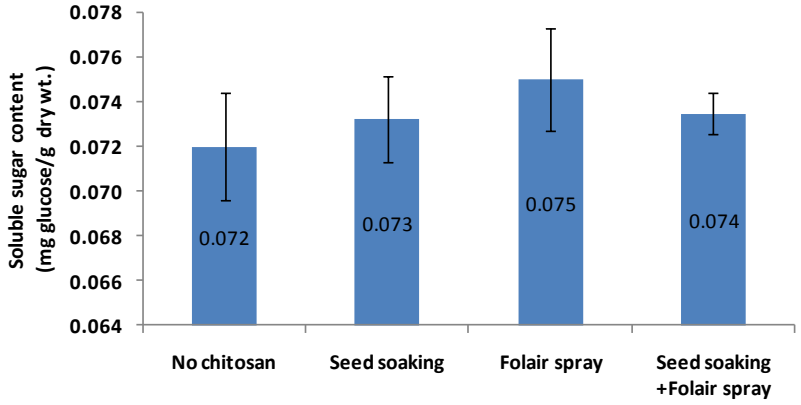


Fig. 4: Effect of various applications of chitosan before being subjected to drought stress on proline content and soluble sugar content of rice plants.

Conclusion:

Application of chitosan by foliar spray to rice plants before being subjected to drought had potential to stimulate solute accumulation during drought stress resulted in maintaining growth and yield potential of rice plant under drought period.

Acknowledgement

We would like to appreciate Rajamangala University of Technology Suvarnnabhumi for financial support.

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