Responses of Rice (Oryza sativa L.) Varieties under Drought and Cold Stresses at Vegetative Stage

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Title : Responses of Rice (*Oryza sativa* L.) Varieties under Drought and Cold Stresses at Vegetative Stage
(イネ栽培品種の栄養成長期での乾燥ストレスと寒冷ストレスへの応答)

Category：Kou

Thesis Summary

Drought is the major constraints to rice production worldwide and is becoming a severe problem in recent years. In this study, several experiments were conducted to evaluate morphological, physiological and biochemical characteristic of different rice varieties under drought stress and re-watering conditions. Moreover, the expression of genes related to drought tolerant traits also analyzed. In the first experiment, 172 rice varieties were used for screenings at seedling stage. Leaf rolling index (LRI) and drought resistance index (DRI) were used as selection parameters. The results indicated a large variation in LRI among experimental varieties. Shoot and root growth of genotypes were severely depressed under drought conditions, but shoot was more severely affected than root. There were large variations in drought resistant index (DRI) among experimental varieties. Based on DRI values, DA8 and Thierno Bande were selected as drought tolerant varieties while Malagkit Pirurutong and Pate Blanc MN1 were drought sensitive varieties.

Four above varieties accompany with two other varieties (Kinandang Patong and Moroberekan) were used for further experiment. In addition to dry weight accumulation, this experiment analyzed physiological characteristics of rice varieties under drought stress and re-watering conditions. The results showed that DA8 and Thierno Bande accumulated higher dry weight than other varieties. DA8 and Thierno Bande also exhibited bigger root systems other varieties. Root dry weight was less affected than that of shoots under moderate drought, in contrast, roots were more severely affected than shoots under severe drought. After re-watering from moderate drought, Kinandang Patong showed the highest recovery ability while Malagkit Pirurutong expressed the poorest recovery ability among varieties, in term of dry matter accumulation.

Under drought stress, proline in leaves of all varieties was highly accumulated compared to control condition, and more severe drought stress resulted to more proline accumulation. DA8 and Thierno Bande expressed higher proline accumulation ability than other varieties. After re-watering, leaf proline content of all rice varieties decreased rapidly, reaching values similar to those under the control condition. Under moderate and severe drought conditions, DA8 and Thierno Bande expressed higher sheath soluble sugar contents than the other varieties. Starch content in leaves and sheaths of varieties were significantly decreased under moderate drought compared to control condition, except for DA8 and Malagkit Pirurutong. Severe drought significantly decreased starch content in leaves of all varieties, except for DA8 and Kinandang Patong.

Another experiment was conducted using three varieties (DA8, Malagkit Pirurutong and Kinandang Patong) to intensively analyzed the changing of proline, soluble sugar and starch

content under different drought stresses and subsequent recovery conditions. Consistent with results from our previous experiment, findings in this experiment suggested that drought tolerant variety expressed higher proline accumulation ability compared to susceptible ones. We suggested that proline accumulation ability under drought stress condition can be used as a useful indicator for drought tolerant potential of rice varieties. This study found that the changing of soluble sugar and starch content in rice were affected by not only drought stress conditions, but also daily changing of environmental condition and experimental variety characteristics. In addition, soluble sugar and starch content were not reliable indicators for drought tolerant potential in rice.

In order to understanding the mechanism of proline biosynthesis and degradation, the expression of genes related to proline metabolism in rice were analyzed under drought stress and re-watering conditions. The results of gene expression suggested that the high levels of proline under drought stress condition were due to the higher expression of genes involved in the proline biosynthesis, when compared with genes that code for catabolism enzymes. Our study showed increased expression of both *P5CS1* and *P5CS2* under drought condition. In this experiment, high expression levels of the *P5CS2, P5CR* and *OAT* genes, particularly at SWC 10%, are in line with the high concentrations of proline in this period. It proposed that proline biosynthesis by glutamate and ornithine pathways prevails under drought stress condition in rice varieties. After re-watering, the expression of *P5CS1*, *P5CS2*, *P5CR* and *OsOAT* in both rice varieties significantly decreased compared to drought stress period.

In North of Vietnam, low temperature often appears at both germination and seedling stages of rice cultivation. In addition to drought experiments, we conducted some experiments to test the responses of rice varieties over the world to low temperature. The results from experiments suggested that low temperature severely affected germination ability and the growing of coleoptile, radicle of rice varieties. There was a great variation among experimental varieties in response to cold stress at germination stage. In average for all varieties, the reduction percentage of coleoptile length under cold stress was at 97.59% compared to control condition. Under cold stress condition, radicle length of varieties was severely depressed with the average reduction percentage of 96.80% compared to control. Generally, low temperature negatively affected the growing of rice varieties under seedling stages. Interestingly, there were 30 varieties expressed no symptom of cold damage (leaf color score = 1) and defined as cold tolerant varieties. To test the effect of warming treatment to growing of rice seedlings compared to natural low temperature, warming sheet was used to increase soil temperature up to 5°C higher than natural temperature. The result indicated that warming treatment significantly increased shoot dry weight, shoot length and root length of rice varieties compared to natural condition. From results of experiment in both germination and seedling stages, two rice varieties Hei-Chiao-Chui-Li-Hsiang and Ta-Mao-Tao were selected as highest cold tolerant varieties.