恰「稻」好處 － 應用高效還田之富鐵脆桿

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水稻為世界上主要的糧食作物之一。台灣稻作以水田栽培方式為主，大量的灌溉水為此栽作方式所必須。然而在有限的水資源分配下，農業用水逐漸受到民生及工業用水所排擠，如合適當調度水資源維持農業活動的穩定性，以達到國家糧食安全存量及滿及人民食品健康安全的需求，是農業永續發展的重要課題。目前透過水稻節水栽培技術可提高作物水分的利用效率，此栽培法如同種植玉米或小麥所進行的旱作栽培，僅需相對少的用水量。但在水田轉旱作耕作模式的轉變下，會改變土壤中營養元素的植物可利用性。初步觀察發現，旱作栽培發生水稻開花時間的延遲，可能是鐵營養素缺乏所造成。為解決此一問題，必須著重增加旱作栽培下鐵的營養循環。依此，我們研究團隊將選育富鐵之水稻轉植株，並於稻米生成後，利用廢棄稻桿還田方式，達到涵養稻田生機之目的。

於本計畫中，我們除評估富鐵稻稈還田對土壤肥培的改善作用外，也期展現富鐵脆桿水稻再利用之獨特性與永續價值。水稻稻稈中含有大量植物生長必須元素，其還田對於提高土壤肥力及有機質含量有重要作用，可以做為環境友好型肥料。然而，稻稈還田後，其降解速度慢，不利於後季作物播種和生長，尤其在一年三作集約耕作制的台灣。

針對此一問題，本計畫將選育脆稈抗病突變株（**子計畫 1**），該突變株的主要特徵為稻稈由韌變脆，此脆稈相較於野生型稻稈具有較快的分解速度。增快稻稈的分解速度，將可實現稻稈完全還田，培肥地力，解決農業廢棄物等問題，有利於後續作物之生長。此外，為改善節水栽作所造成鐵營養素植物有效性低之衍生問題，藉由水稻基因的突變有望增強水稻鐵缺乏的耐受性，以及增加脆稈中鐵的累積，以提高脆稈作為天然肥料之營養價值(**子計畫 2**)。預期效益將有助於水稻節水栽培技術之實踐。同時，本計畫將探討不同脆性(**子計畫 1**)以及高鐵積累 (**子計畫 2**)之脆稈還田，對土壤肥力和作物產量之影響 (**子計畫 3**)。本計畫將進一步了解稻稈-土壤-農作物這個複合系統中，養分釋放、累積、和循環的過程，對於脆稈還田之應用以及未來發展之方向提供一定的理論依據。

New Strategies for improving Rice Nitrogen Utilization Efficiency (NUE)

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Subtitle 1. Enhancing Nitrate Remobilization and Identifying New Markers for NUE

To improve plant NUE by enhancing nitrate remobilization, we introduce a hyperactive chimeric nitrate transporter NC4N driven by the promoter of *NRT1.7*, a nitrate transporter gene for source-to-sink nitrate remobilization. This strategy was successfully applied in Arabidopsis, tobacco and rice. The improvement in rice is less than that in Arabidopsis. Therefore, this strategy is further improved by using the promoter of rice *YSL16*. In addition, we also introduced *NC4N* driven by the promoter of another nitrate transporter *AtNRT1.11* that is responsible for nitrate remobilization at high nitrate condition. In addition, to identify new markers for NUE, we analyzed three mutants (AZ1108, AZ283, AZ1306) showed the N-dependent phenotype. AZ1108 has lower NUE under high N condition, and altered expression of *OsNRT2.3* and *OsNPF2.*2 might be responsible for shoot-to-root nitrate ratio phenotype of AZ1108. AZ283 showed superior ammonium uptake, which is correlated well with up-regulation of *AMTs*. AZ1306 shows interesting U-shaped response to N concentrations with higher shoot nitrate content and better yield under low and high N concentrations. Cloning and mapping these genes is under process.

Subtitle 2. Perturbation of nitrogen-responsive genes to enhance NUE in rice

In the primary nitrogen (N) assimilation pathway, nitrate taken up by plants will be reduced to nitrite and ammonium, which is then assimilated into glutamine (Gln) and glutamate (Glu) via the Gln synthetase/Gln oxoglutarate aminotransferase (GS/GOGAT) cycle. Gln and Glu, the first organic N synthesized in the cell, are the major N donors for the synthesis of amino acids, purines, pyrimidines, and other N-containing compounds in plants. Thus, improvement in Gln/Glu use efficiency may result in better N use efficiency in plants. We have previously used transcriptome analyses to identify Gln- and Glu-responsive genes in rice. Here, we focus on characterizing the knockout mutants of the *ZOS5-02* (*Os05g0114400*) gene encoding a C2H2-type zinc finger protein, and the *bHLH35* (*Os04g0301500*) gene encoding a basic helix-loop-helix protein. The expression of *ZOS5-02* and *bHLH35* was rapidly and strongly induced by Gln and Glu, respectively. The growth of *zos5-02* CRISPR mutants was significantly reduced when grown in hydroponic solution containing Gln as the sole N source. The expression of some Gln-responsive genes was impaired in the *zos5-02* mutants, indicating that ZOS5-02 is involved in the regulation of these Gln-inducible genes. By contrast, the growth of *bhlh35* mutants was not affected when grown in hydroponic solutions. The expression of Glu-responsive genes, including *GLUTAMATE DECARBOXYLASE1* (*GDC1*) and *GLUTAMATE DEHYDROGENASE2* (*GDH2*) was impaired in the *bhlh35* mutant, indicating that these genes may be the downstream targets of *bHLH35* in the Glu signaling pathway in rice. In addition to mutants, we have obtained *ZOS5-02* and *bHLH35* overexpression lines. Characterizations of these overexpression lines are currently underway.