Comparison of Young Seedling Growth under Lower Nutrient Concentrations in Culture Solution among Rice Cultivars

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Summary

The growth of rice seedlings under lower nutrient concentrations was compared among 12 cultivars. The seedlings were cultured under 3 levels of nutrient concentration of Kimura B solution. The results showed various responses of cultivars in total dry matter weight (TDW) and relative growth rate (RGR). Therefore, they were classified into 4 groups based on RGR change: group A (IR 28, Dular, Toyonishiki, Akebono and Owarihatamochi), B (Koshihikari), C (IR 60, Pokkali, Kasalath, Rikuto norin 21), and D (IR 42 and IR 50). To analyze the cause of variations in growth rate among them, the correlation between leaf area ratio (LAR) and net assimilation rate (NAR) was investigated. Total nitrogen concentration in plant tissue and nitrogen content per unit leaf area were also examined. Under moderate nutrient concentration (50% strength), physiological response was regarded more crucial in determining growth rate in this level. Then, Pokkali, Kasalath, Dular and Rikuto Norin 21 were considered as the best cultivars attributed to their ability in maintaining NAR and the amount of nitrogen accumulated in their leaves. However, when the nutrient concentration decreased to 25% strength, morphological characteristics had more influence to the seedlings growth. Therefore, Dular and Owarihatamochi then were considered as good cultivars in this level.

Introduction

The use of fertilizer in rice cultivation has been widely applied by the farmers in order to produce higher yield to meet the increasing demand. However, not all fertilizer given can be absorbed and utilized efficiently by plants. Generally, plant can only make use of 30 – 50 percent from the applied fertilizer (Muurinen and Sainio, 2004) and the rest will loss through leaching, volatization, and by microbial action. Furthermore, yield can even decrease as the result of lodging and also an increasing disease occurrence when the fertilizer was applied exceeding crop demand (Fischer, 1998). The loss of fertilizer will certainly bring a bad impact on environment as well as economic loss from the saturated crops' production. Therefore, the need for alternative agriculture based on lower fertilizer input has been an increasing issue and the efficiency between rice cultivars in utilizing the given nutrient should also be reconsidered. Thus, this study was aimed to investigate and compare the growth of typical rice cultivars selected from former experiments grown under lower nutrient concentration in culture solution.

Materials and methods

Twelve rice cultivars, IR28, IR42, IR50, IR60, Pokkali (PK), Dular (DL), Kasalath (KL), Koshihikari (KH), Toyonishiki (TN), Akebono (AB), Rikuto Norin 21 (R21) and Owarihatamochi (OH) were cultured with Kimura B solution. The seeds (2 seeds/hill) were sown into each hole in a styrofoam board placed over the top of plastic container. Twenty five percent strength of culture solution was first applied to maintain the condition of young seedling. After 21 days, 3 levels of culture solution (25, 50 and 100%) then were applied. The solutions were well aerated and

exchanged every two days, while pH was adjusted to 5.5. Samplings were conducted every 10 days for growth analysis. Transpiration rate and nutrient uptake for 6 hours during mid day were measured. Nitrogen analysis was also carried out in laboratory to examine total nitrogen concentration in plant and nitrogen content per unit leaf area.

Results and Discussion

The results showed various responses of cultivars in total dry matter weight (TDW) (Fig. 1). TDW would generally decrease along the decrease of culture solution level since the nutrient supply was considerably had a linear relationship with plant growth. However, in this experiment, most cultivars showed the opposite response where in total dry weight in 100 % level was lower than either in 50% or even in 25% culture solution level. Only KH and R 21 decreased the total dry weight with the same pattern as the decrease of culture solution concentration, while the rests showed a various pattern of total dry weight change. In IR 48, DL, AB and OH, both 25% and 50% level had higher total dry weight than in 100%. PK and IR 50 showed the highest total dry weight in 50% concentration level, but then decreased drastically when the nutrient concentration decreased into 25%. Small change in total dry weight found in 3 cultivars including IR 28, IR 60, and KL. TN had the lowest total dry weight in 50% level and only slight change between 25% and 100% concentration level.

This result showed that there was a cultivaral difference in total dry weight as a response to lower nutrient condition. Similar to this result, Namai *et al.* (2009) also reported wide variations of dry matter weight among landrace and improved rice varieties grown under different nitrogen concentrations.

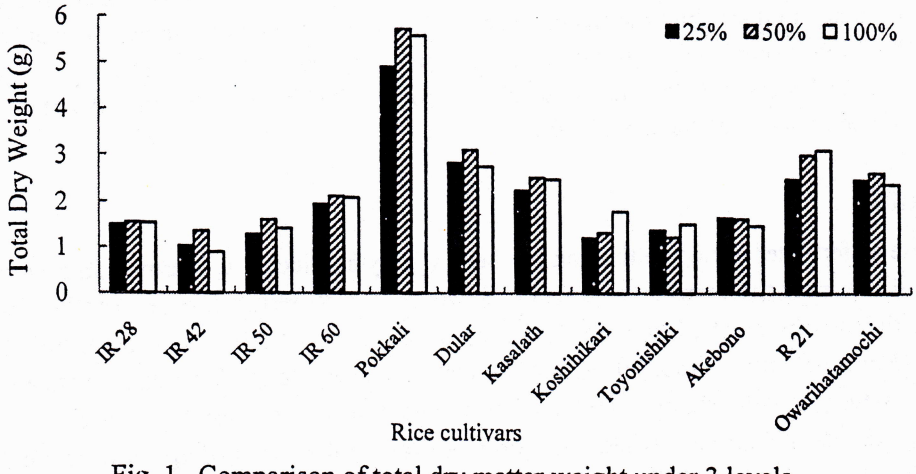


Fig. 1. Comparison of total dry matter weight under 3 levels of nutrient concentrations

The cultivars used then were classified into 4 groups based on RGR change to the decrease in nutrient concentration: group A (IR 28, DL, TN, AB and OH), group B (KH), group C (IR 60, PK, KL, R 21), and group D (IR 42 and IR 50) (Fig. 2). To explain the variations among them, the relationship between leaf area ratio (LAR) and net assimilation rate (NAR) was investigated (Fig. 3).

Group A showed only slight difference in RGR value in 25% and 100%. This might be influenced by the negative correlation between LAR and NAR. This negative relationship between LAR and NAR was regarded as a compensatory response between these two variables. Some reports also supported the occurrence of compensatory effect in rice. Yan and Wang (2009) reported the compensatory effect in rice seedling induced by water deficit. Compensatory effect on yield was also found in rice planted at different seedling densities (Ehara *et al.*, 1998). In exception for OH where only small change found both in LAR and NAR.

RGR in group B decreased following the decrease of nutrient concentration. The decrease from 100% to 50% was determined by the decrease of NAR, while the decrease of LAR from 50% to 25% was the major factor of the RGR decrease. In group C, RGR decrease in lower concentration was caused by the decrease of LAR. The increase of NAR from 100% to 50% had caused the increase of RGR in group D. However, in 25%, RGR decreased caused by the decrease of LAR.

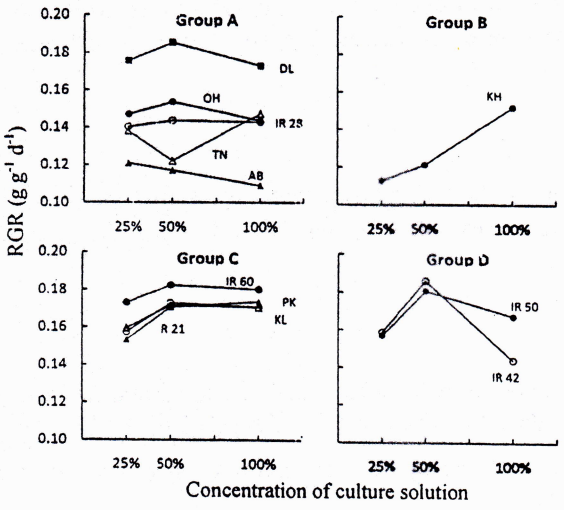


Fig. 2. Change in RGR to nutrient concentration in 4 groups of rice cultivars

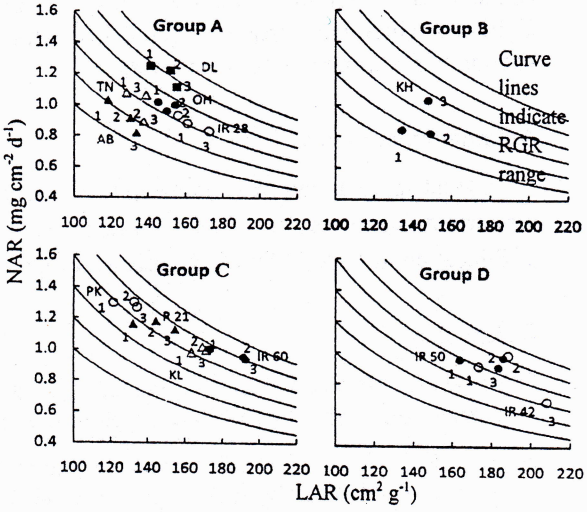
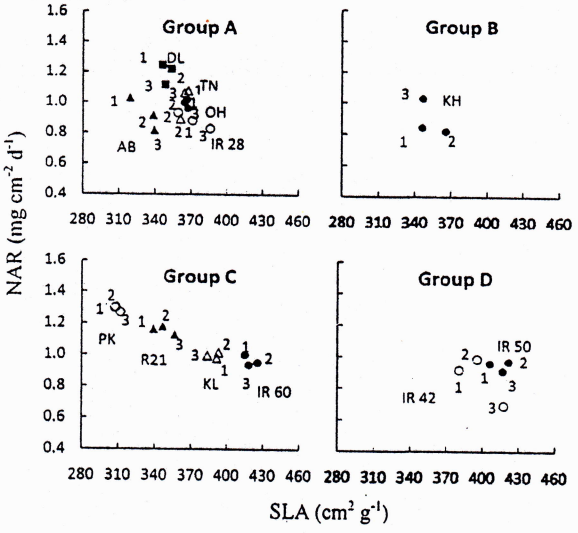


Fig. 3. Relationship between LAR and NAR in 4 groups of rice cultivars (1: 25%, 2: 50%, 3: 100%.)

Furthermore, in this experiment, it was also found a highly negative correlation between NAR and SLA (specific leaf area) indicating the influence of morphological characteristics in physiological activity of the seedlings (Fig. 4).



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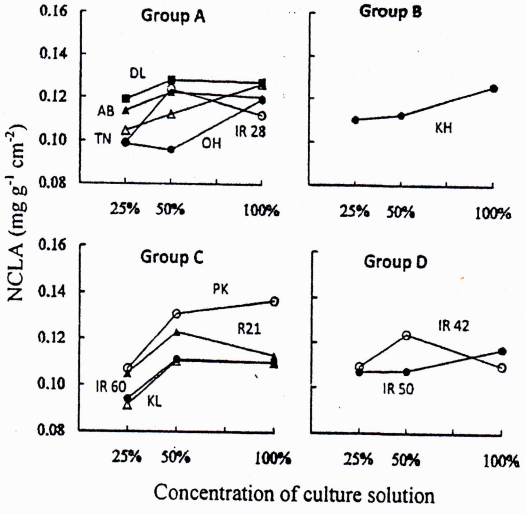

Fig. 5. Comparison of nitrogen content per unit leaf area in 4 groups of rice

Nitrogen content per unit leaf area (NCLA) in most cultivars generally decreased under lower nutrient concentrations (Fig. 5). This result was in accordance to the finding by Rupp and Hubner

(1995) reporting an increasing level of leaf N with applied N. The role of genetic factor in controlling NCLA was also noticed by Ray *et al.* (2003) confirming genetic variability in leaf nitrogen status in 38 germplasm lines of rice.

Observing the trend from all parameters, it was considered that under moderate nutrient concentration (50% strength), morphological character had insignificant influence to rice growth expressed by relatively unchanged LAR in most cultivars. NAR representing physiological response was regarded more crucial in controlling the growth in this level. Thus, Pokkali, Kasalath, Dular and Rikuto Norin 21 were considered as the best cultivars attributed to their ability in maintaining NAR value and the amount of nitrogen accumulated in their leaves. However, when the nutrient concentration decreased to 25% strength, LAR started to decrease and caused slower growth rate. Cultivars which could sustain their LAR value then were considered to have a better growth rate as shown by Dular and Owarihatamochi.

Acknowledgements

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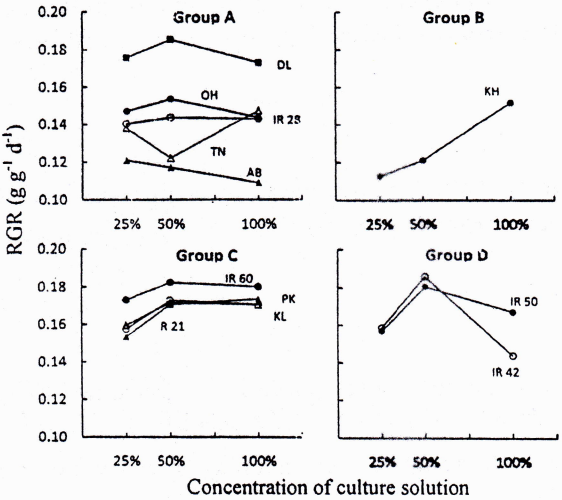

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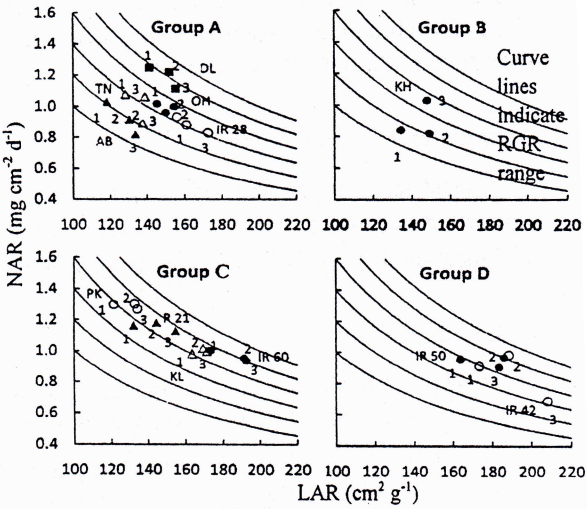

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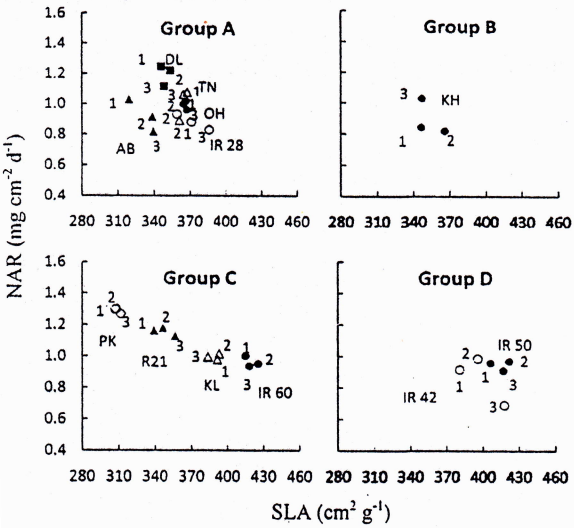

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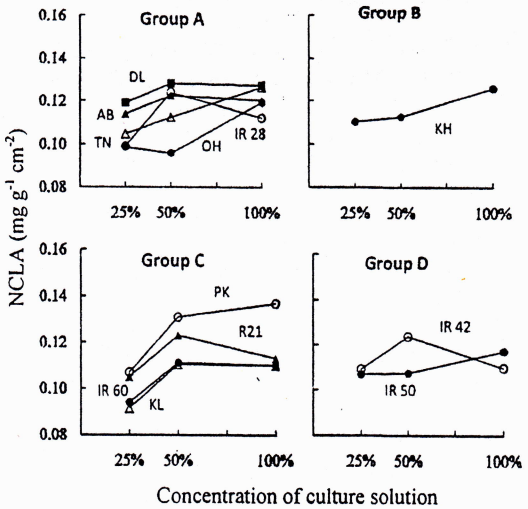

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