terraneum[6]. There are also reports where ineffective or less-effective rhizobia are known to be more competitive than effective rhizobia. In midwestern USA the ineffective *Rhizobium* USDA-128 is known to dominate over the effective *Rhizobium* USDA-110. The competitiveness and symbiotic effectiveness of homologous strain UASB 722 were markedly altered in the presence of heterologus *Rhizobium* UASB 11. These results suggest that nonhomologous (ineffective) nodulation could result in reduced $N_2$ fixation.

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## VARIATION IN ANTHER CULTURE EFFICIENCY AMONG DONOR PLANT TILLERS IN RICE

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GROWTH conditions, in particular the physiological state of the donor plant at the time of anther excision, are known to affect anther callusing response in a large number of plant species including rice[1–4]. The present study was undertaken to examine callusing response and subsequent plant regeneration potential of the calli of anthers of different tillers of rice plants.

Young panicles from the main culm and primary, secondary and tertiary tillers of rice cultivar Wu-10B were withdrawn separately. In each case, samples of anthers were taken from different sites along the length of the panicle. Smear preparations of the anthers were stained with propionocarmine and examined microscopically to determine the developmental stage of the microspores. Anthers from florets of the region with microspores at mid-to-late-uninucleate stage were excised separately from different tillers and plated on $N_6$ medium[5] supplemented with 2 mg/l 2,4-dichlorophenoxyacetic acid and 30 g/l sucrose and gelled with 10 g/l agar. Immediately after inoculation, the cultures were subjected to a cold treatment of 8°C for 10 days in the dark. Then they were transferred to low light intensity of about 600 lux at 25 ± 1°C. Observations for visible callus induction were recorded till 60 days. For plant regeneration, the calli were transferred, after a week of their emergence from the anther lobes, to Murashige and Skoog's (MS) medium[6] supplemented with 1.0 mg/l kinetin and 0.5 mg/l 6-benzylaminopurine. Cultures showing shoot initiation were transferred from low light conditions to a regime of 4000 lux, 12 h photoperiod.

Ample variation for callusing and regeneration response was noticed in anthers from different tillers (table 1). Callusing response was the highest in anthers obtained from the main culm, and showed a steady decline in anther cultures from primary, secondary and tertiary tillers, in that order. However, regeneration frequency, calculated on the basis of calli subcultured, did not differ much for calli from the main culm, primary and secondary tillers, but was very low for calli from tertiary tillers.

**Table 1** *Anther culture efficiency of different donor tillers of rice cultivar Wu-10B*

| | Anthers | | | Calli | | Regeneration frequency | |
|---|---|---|---|---|---|---|---|
| Donor tiller | Number inoculated | Number showing callus | Callusing frequency (%) | Number subcultured | Number regenerating | on the basis of calli subcultured (%) | on the basis of anthers inoculated (%) |
| Main culm | 685 | 168 | (24.5) | 168 | 42 | (23.2) | (6.13) |
| Primary | 1065 | 131 | (12.3) | 131 | 36 | (27.5) | (3.38) |
| Secondary | 1700 | 151 | (8.9) | 151 | 47 | (31.1) | (2.76) |
| Tertiary | 1370 | 21 | (1.5) | 21 | 3 | (14.3) | (0.22) |

Thus, while callus induction frequency showed a distinct drop from main culm to tertiary tillers, there was no corresponding decline in regeneration response except in the case of tertiary tillers where both callusing and regeneration response were very low. The overall culture efficiency, worked out on the basis of anthers inoculated, was the highest for main culm and lowest for tertiary tillers.

These results indicate that the main culm is the most suitable source of anthers for high culture efficiency; primary and secondary tillers are likely to give appreciably lower response, while tertiary tillers are perhaps unsuitable for anther culture. It seems that the anthers drawn from the main culm offer a physiological state that is more amenable to *in vitro* manipulations. Further investigations leading to the understanding of the causes of this variation in response should afford some manoeuvrability for improvement of anther culture efficiency not only in rice but in many other systems as well.

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## INFLUENCE OF N AND P ON CADMIUM TOXICITY ON PHOTOSYNTHESIS IN RICE

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CADMIUM, a non-essential metal, is considered potentially hazardous to plants and animals[1]. Rock phosphate constitutes one of the sources of Cd pollution. It is reported[2] that Cd content of P fertilizers varies from 2 to 200 ppm. Effluents from fertilizer industries contain Cd along with high levels of urea-N and P as pollutants. Photosynthetic ability of green plants provides an important physiological criterion to assess pollution stress. Photosynthetic ability of two physiologically different rice cultivars under conditions of cadmium toxicity was studied.

Twentyfive-day-old seedlings of the high-yielding semidwarf IR36 and the photosynthetically efficient, tall Swarnaprabha of identical duration were used for the study. Two seedlings of each cultivar were transplanted to nutrient culture solution[3] contained in 5 l capacity porcelain pots. The various treatments, viz. 3 ppm Cd as $CdCl_2$, 150 ppm each of urea-N and P as $KH_2PO_4$, began after a week. Control pots received only nutrient solution. The culture solution was maintained at pH 4.5 and renewed once every week. The treatments were arranged in a factorial design with two replications. Photosynthetic rate of the intact leaf *per se*, photosynthetically active radiation and stomatal $CO_2$ conductance were measured using a portable IRGA (ADC, UK). Chlorophyll content[3] (*a*, *b* and total) was also determined. The investigations were carried out about 15 days prior to flowering.

Since all the observations were made under least variation of relative humidity (2–4%) and photosynthetically active radiation (8–15%), the two varieties were compared for each treatment independently.

Overall photosynthetic rate was found to be highest under urea + P treatment, followed by P alone, and lowest under U + P + Cd treatment (table 1). In general, the cultivar Swarnaprabha showed higher photosynthetic rate than IR36.

The deleterious effect of Cd on photosynthetic rate was quite evident because Cd alone was found to be impairing carbon assimilation, which was further aggravated when Cd was combined with P. The decrease under the latter treatment was 40% compared with control. The decrease in photosynthetic rate was about 19% in the case of Cd treatment, while it was only 7 to 8% in urea + Cd treatment. The deleterious effect of Cd was further aggravated when it was combined with either P or P + U, although the P + U treatment resulted in the highest photosynthetic rate in both varieties. Of the two varieties, Swarnaprabha was found to be more sensitive to Cd toxicity than IR36.

The reduction in photosynthetic rate was evident from the concurrent reduction in chlorophyll content under Cd or Cd + P treatments. Apparently, chl *a* was more adversely affected than chl *b* owing to Cd toxicity. Chl *b* molecules serve mainly as