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

Table 1 *Effects of high levels of N, P and Cd on rice physiology*

Treatment	Variety	RH (%)	PAR ($\mu E\ m^{-2}\ sec^{-1}$)	Stomatal conductance (cm/sec)	Chlorophyll Total (mg/g)	Chlorophyll *a/b* ratio	photosynthetic rate (mg CO_2 $dm^{-2}\ h^{-1}$)
Control	CV. 1	59	720	0.690	3.68	3.6	19.4
	CV. 2	58	750	0.561	2.92	3.8	17.7
Urea (U)	CV. 1	60	720	0.772	4.35	3.3	18.7
	CV. 2	50	680	0.665	3.65	4.3	16.1
Phosphorus (P)	CV. 1	57	695	0.618	4.01	3.9	20.8
	CV. 2	56	780	0.639	2.48	3.9	19.4
Cadmium (Cd)	CV. 1	52	760	0.525	2.67	2.7	15.4
	CV. 2	51	740	0.502	2.51	2.2	14.6
U+P	CV. 1	49	680	0.711	4.21	3.8	22.2
	CV. 2	52	710	0.666	3.90	3.2	18.8
U+Cd	CV. 1	60	810	0.642	2.82	2.9	18.4
	CV. 2	58	830	0.626	2.68	2.7	16.4
P+Cd	CV. 1	57	840	0.515	2.58	3.1	11.0
	CV. 2	56	790	0.510	2.32	3.0	11.3
U+P+Cd	CV. 1	57	820	0.505	2.33	3.1	10.1
	CV. 2	58	810	0.512	2.29	2.3	8.8
C.D. 5%							
Treatment (T)		3.2	24.3	0.04	0.62	0.4	2.1
Variety (V)		NS	NS	0.02	0.43	NS	1.7
T × V		2.6	34.3	NS	NS	NS	NS

CV. 1, Swarnaprabha; CV. 2, IR36.
PAR, Photosynthetically active radiation.
NS, Not significant.

antenna molecules more conspicuously engaged in harvesting photons and are less prone to adverse situations. But the degradation of chl *a* molecules is indicative of profound damage to the photosynthetic apparatus. Root and Miller[4] found that Cd-induced chlorosis might be due to changes in Fe:Zn ratios in corn leaves.

The correlation study revealed a close positive association of photosynthetic rate with stomatal conductance ($r=0.750$) and chlorophyll content ($r=0.631$). The rate of stomatal conductance (CO_2) is so closely associated with assimilation rate that it might be inferred that adversely acting treatments like Cd, P+Cd or U+P+Cd had some stress effects on the opening and closing of stomata, thus governing the rate of conductance of CO_2. Huang *et al.*[5] reported almost complete absence of CO_2 assimilation in soybean receiving 900 μM Cd in a sand culture experiment. Further, they also observed a depression in photosynthesis to the extent of 60% on the day of peak photosynthetic activity when the plant was subjected to 450 μM Cd treatment. Evidently, Swarnaprabha is more adaptable to such stress environments than IR36. The benefit of U+P treatment can be related to higher photosynthetic rate as well as higher chlorophyll content under this treatment.

Injury to plants due to exposure to heavy metals may arise from replacement of another metal in an enzyme, causing interference in a specific metabolic process[6]. The present study suggests that the inhibitory effect of Cd can be checked to some extent by urea but not by phosphorus.

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OCCURRENCE OF HITHERTO UNKNOWN INSECTS OF MAIZE IN INDIA

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This paper 'Occurrence of hitherto unknown insects of maize in India' by L.M.L. Mathur, M.C. Joshi and M. Arif, has been withdrawn by the authors. The intimation came to us after this issue was printed.

-Ed.

Decachaetophora aeneipes (de Meijere) (Diptera: Sepsidae)

Maize seeds damaged by the maggots was first noticed in heavily manured fields at Auli (Joshimath, 3000 MSL) during May–June. The eggs were laid on the soil and the newly hatched maggots made their way into the seed. The infested seeds either did not germinate at all or bore with weak seedlings which did not persist much longer. Preliminary observations had shown that the infestation due to these maggots varied from 7 to 15% in each row of a 6-row plot compared to those sown 10 and 20 days thereafter.

The full-grown maggot is cream-coloured and measures about 4.5 mm in length. The apodous worm has a pair of dark hook-like mandibles at its pointed end and the body segments are indistinct. The grey-bodied fly measures 5 mm in length. The second antennal articulation bears no angular projection, the metatarsi of hind legs are slender, the anal cell and lower cross-veins of the wing are present, the costa remains unbroken, and the metastigmatal bristles are present. Hypandrium and aedeagal apodemes are completely fused and the ovipositor is non-piercing type.

Agrotis c-nigrum Linnaeus (Lepidoptera: Noctuidae)

The cutworm remains active during May–June at high altitudes where summer maize is grown as food and fodder. As many as 6 larvae of variable size and growth were found associated with roots of each infested plant. As a consequence of their feeding on the root hair and primary rootlets of one-month-old seedlings, the plants either showed sickly appearance or lay on the earth surface. The infestation in a 10 × 3 m plot was about 32%.

The greasy, mature larvae measure 35 mm long and the general appearance of the body is red to olive-green. The head is red-brown, the lateral yellow bands along the spiracles are mixed with brown spots, and the transverse band at the junction of the third thoracic and first abdominal segments is more prominent. The medium-built adults are dark or red-brown and the wing expansion is almost 44 mm (ref. 2). The collar has whitish scales. Each forewing bears a double sub-basal and antemedial unevenly curved lines, triangular black patches before and after a pale triangular patch emerging from the middle costa, the post-medial line bears a series of dark specks, and the sub-marginal line is indistinct. The hind wings are slightly pale and their underside bears an indistinct post-medial line and a cell spot.

Popillia pulchrips Arrow (Coleoptera: Rutelidae)

The adults were seen feeding on the silk during September 1987 at Nagenahalli, Mysore. The extent of damage was such that not a single ear remained untouched by the insect in the locality. As a result of such feeding the emerging silk was badly damaged and the grain-filling was adversely affected.

The metallic green, blue or coppery adults measure 10–12 mm long and 6–7 mm broad[3]. The body is elongate-oval in shape, very smooth and shining with a small but compact tuft of greyish hair on each side of the pygidial base, and a thin clothing of hair on the underside of the body. The clypeus is rugose, forehead and pronotum finely punctured, and scutellum almost smooth. Each elytron bears a deep transverse impression behind the scutellum, a finely punctured striae, a much wider row of striations, and a last row of few punctures. The pygidium is coarsely transversely punctured and the mesosternal process is compressed, curved and almost blunt. The foretibia of the male is armed with two sharp teeth, the lower lobe of the inner front