identified quinone compound, extracted for the first time from the lichen species *Pyxine pefricola* Nyl., following the method described earlier[1,5,6]. In squash preparations the authors noticed some chromosomal aberrations and mitosis-inhibitory action of the compound.

Germinating bulbs of *Allium cepa* L. with 2–3-cm-long roots were kept in 0.01, 0.02, 0.05 and 0.1% of the compound in 1% aqueous NaOH (cytological study was made in alkaline medium as the compound was insoluble in water) for 6 h at 28 ± 2°C. Controls, in 1% NaOH solution, were also kept. After the treatment the root tips were fixed in a mixture of absolute alcohol and acetic acid (3:1), hydrolysed in N HCl at 60°C for 3–5 min, and squashed in haematoxylin. Nearly 10,000 cells (dividing and non-dividing) were screened in each experiment. In every slide the numbers of cells in prophase, metaphase, anaphase and telophase, and aberrant phases were counted. Mitotic index (MI) was calculated on the basis of number of dividing cells per 100 observed, while phase indices were calculated on the basis of ratio of number of cells observed in a given phase to total number of dividing cells. The χ^2 test was employed to find the significance of differences between control and treated plants.

The effect of the compound on cell division can be recognized by its reduction of MI and inhibition of anaphase. The decline in MI (except at 0.02%) is concentration-dependent (MI values: control (1% NaOH), 7.837; 0.01% quinone compound, 6.793; 0.02%, 7.228; 0.05%, 4.174 and 0.1%, 2.685). The proportions of cells in various phases were determined and the data suggest that the compound causes concentration-dependent inhibition of anaphase (anaphase index values: control, 162.116; 0.01%, 121.321; 0.02%, 91.425; 0.05%, 27.227 and 0.1%, 4.978).

Laggards and sticky chromosomes, bipolar and tripolar unequal sister nuclei, stickiness and clumping of nuclei and chromosomes (figures 1–5), bridges, split spindles, and c-mitotic cells and binucleate cells were also noticed. Root tips treated with 1% NaOH solution (control) showed very few aberrations. However, total per cent aberrations varied with concentration of the compound (per cent chromosome aberration: control, 0.910; 0.01%, 3.117; 0.02%, 4.959; 0.05%, 6.538 and 0.1%, 5.255). MI and per cent chromosome aberrations at 0.05 and 0.1% concentrations were significantly different.

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COMPETITIVENESS OF HOMOLOGOUS AND HETEROLOGOUS *RHIZOBIUM* FOR NODULATION AND GROWTH OF PIGEONPEA [*CAJANUS CAJAN* (L.) MILLSP]

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CULTIVATED soils in many parts of India are known to contain diverse groups of rhizobia that infect and produce nodules on a large number of species of the family Leguminosae. Thus a legume growing in such a soil is nodulated by all those rhizobia that can infect the host regardless of their effectiveness, unless the host is highly specific in its *Rhizobium* requirements. Besides, high competitive ability of *Rhizobium* is an important criterion for strain selection[1].

Failure of inoculation response could be due to either the presence of adequate population of efficient native rhizobia capable of nodulating the legume or failure of the inoculant strain to compete out native inefficient strains[2]. The present experiment was conducted to study the competitiveness of a homologous (effective) strain in the presence of a heterologous (ineffective) strain and the effect on nodulation and growth of pigeonpea [*Cajanus cajan* (L.) Millsp], an important pulse crop.

Competitiveness of homologous *Rhizobium* strain UASB 722 in the presence of heterologous strain UASB 11 was studied using Leonard jar technique[3]. The experiment involved inoculating host plants with the two strains in various proportions: (i) Control (uninoculated), (ii) UASB 722 only, (iii)

Table 1 *Competitiveness of homologous (UASB 722) and heterologous (UASB 11) Rhizobium for nodulation of pigeonpea*

Treatment	No. of nodules/plant		Total no. of nodules	Nodules formed by UASB 722 (%)	Nodule dry wt (mg/plant)		Total nodule wt (mg/plant)	Weight of nodules formed by UASB 722 (%)
	UASB 722	UASB11			UASB 722	UASB 11		
Control	0 (1)	0 (1)	0	0	0 (1)	0 (1)	0	0
UASB 722	90 (9.53)*	0 (1)	90	100	372 (19.3)	0 (1)	372	100
UASB 11	0 (1)	32 (5.7)	32	0	0 (1)	138 (11.7)	138	0
UASB 722+UASB 11 (8:2)	48 (6.9)	14 (3.8)	62	77	212 (14.5)	80 (8.9)	292	77
UASB 722+UASB 11 (6:4)	31 (5.6)	23 (4.8)	54	57	212 (14.5)	58 (7.6)	270	78
UASB 722+UASB 11 (5:5)	37 (6.1)	48 (6.9)	85	43	200 (14.1)	61 (7.8)	261	77
UASB 722+UASB 11 (4:6)	51 (7.2)	46 (6.8)	97	52	215 (14.6)	65 (8.1)	280	77
UASB 722+UASB 11 (2:8)	51 (7.2)	57 (7.6)	108	47	115 (10.7)	65 (8.1)	180	64

*Data in parentheses are transformation of $\sqrt{X}$.

	No. of nodules	Nodule wt
CD (5%)	0.17	0.28
SE	0.08	0.13
CV (%)	0.80	2.40

UASB 11 only, (iv) UASB 722+UASB 11 (8:2), (v) UASB 722+UASB 11 (6:4), (vi) UASB 722+UASB 11 (5:5), (vii) UASB 722+UASB 11 (4:6), (viii) UASB 722+UASB 11 (2:8). Each had four replications. Competitive ability was determined as per cent nodules formed by the two strains, which were typed on the basis of nodule morphology. Since the two strains formed morphologically distinguishable root nodules on pigeonpea, it was possible to identify the nodules by visual observation. The identification was confirmed by serotyping. Observations were made of nodule number, nodule dry weight, shoot dry weight, root dry weight and total biomass. The nodule number and nodule dry weight for each strain were recorded separately under mixed inoculation. The age of the crop at harvest was 50 days and the pigeonpea variety used was Hy-3C.

The nodules formed by UASB 11 were small and devoid of leghaemoglobin in contrast to the bigger, leghaemoglobin-containing nodules formed by UASB 722. The heterologous strain UASB 11 produced fewer nodules and lower nodule dry weight than the homologous strain UASB 722 in the single inoculation situations (table 1). With increasing proportion of UASB 11 (20–80%) in the mixed inoculum the number of nodules formed by it also increased from 14/plant to 57/plant, resulting in reduction in the infectivity of the homologous strain UASB 722 (77–47%). The nodule mass produced by UASB 722 was always higher compared to UASB 11 in both pure and mixed inoculations. However, nodule dry weight produced by UASB 722 was reduced in the presence of UASB 11. While the number of nodules produced by UASB 722 in mixed inoculation always decreased with decrease in its proportion in inoculum, the strain UASB 11 sometimes formed more nodules in mixed inoculations than in single inoculation. Total nodule dry weight was highest (372 mg/plant) in inoculation with only UASB 722. Total nodule dry weight formed by UASB 722 was reduced by 36% when UASB 722 was only 20% in a mixed inoculation.

Maximum plant dry weight and shoot dry weight were recorded in plants inoculated with only UASB 722, while the plants inoculated with UASB 11 recorded the lowest shoot, root and total plant weight (table 2). In mixed inoculations, increasing proportion of UASB 11 decreased shoot, root and total plant dry weight, but the magnitude of decrease was smaller in comparison to the decrease of nodule number and nodule dry weight.

Most pulse crops grown in India are nodulated by rhizobia of the cowpea miscellany group including pigeonpea. Thus it is important to know the effect of nodulation by a nonhomologous *Rhizobium* on symbiotic N_2 fixation by effective and compatible strains. The soybean *Rhizobium* UASB 11 ineffectively nodulated pigeonpea (table 1). This further supports the view that cross-inoculation groups were not discrete and many cases of boundary jumping occurred between these groups[4]. Nodulation of pigeonpea by *Rhizobium japonicum* has been reported earlier[5]. The heterologous strain UASB 11 occupied proportionately fewer nodule sites than the homologous strain UASB 722. In Australia the introduced effective *Rhizobium* strain TA-1 dominated the ineffective native rhizobia in clover but not in sub-

Table 2 *Competitiveness of homologous (UASB 722) and heterologous (UASB 11) Rhizobium assessed by dry matter production in pigeonpea*

Treatment	Shoot wt (g/plant)	Increase in shoot wt due to UASB 722 over UASB 11 (%)	Root wt (g/plant)	Increase in root wt due to UASB 722 over UASB 11 (%)	Total plant wt (g/plant)	Increase in total plant wt due to UASB 722 over UASB 11 (%)
Control	3.39	—	2.47	—	5.86	—
UASB 11	1.05	—	0.50	—	1.55	—
UASB 722	3.91	272	2.42	384	6.13	295
UASB 722+UASB 11 (8:2)	3.05	190	1.22	144	4.25	174
UASB 722+UASB 11 (6:4)	2.01	91	1.92	284	3.93	153
UASB 722+UASB 11 (5:5)	2.61	148	1.40	184	4.01	158
UASB 722+UASB 11 (4:6)	2.20	109	1.31	162	3.51	126
UASB 722+UASB 11 (2:8)	2.06	96	1.04	108	3.10	100

	Shoot	Root	Total biomass
CD (5%)	0.17	0.12	0.26
SE	0 08	0.06	0.12
CV(%)	3.10	3.90	3.00

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)