

PIGEONPEA (*CAJANUS CAJAN*)— A UREIDE PRODUCING GRAIN LEGUME

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A NUMBER of grain legumes such as adzuki bean (*Vigna angularis*), soybean (*Glycine max*), cowpea (*Vigna unguiculata*), rice bean (*Vigna umbellata*), wing bean (*Psophocarpus tetragonolobus*), mung bean (*Vigna radiata*), black gram (*Vigna mungo*), cluster bean (*Cyamopsis tetragonoloba*) and horse gram (*Macrotyloma uniflorum*) are now known to synthesize ureides (allantoin and allantoic acid) from currently fixed N_2 in nodules and use these compounds for transport and storage of nitrogen¹⁻⁶. In these crops, the ureides are most prominent in nodulated plants than in plants grown with NO_3 or NH_4 salts^{3,5,6}, indicating a special association between N_2 fixation and ureide formation¹⁻⁶, and the possibility of using ureide levels in plant tissues or transport fluids to determine the extent to which a field-grown crop is relying on symbiosis as opposed to combined forms of nitrogen from soil or fertiliser⁶. We, hereby, report pigeonpea (*Cajanus cajan*), another grain legume, also producing ureide from symbiotically fixed N_2 in nodules and further transporting the same to aerial parts.

Pigeonpea crop (cv. UPAS-120) was raised in earthen pots (30 cm dia) on N-free culture solution in sand culture in a naturally lighted net-house. The seeds before sowing were inoculated with an effective *Rhizobium* culture (strain IPH-159). At weekly intervals, each pot was supplied with 250 ml of N-free nutrient solution⁷. Irrigation was done daily by providing 500 ml of tap water to each pot. Xylem sap, at three different growth stages, viz., vegetative (30 days), flowering (70 days) and pod-filling (90 days), was collected from 7.00 a.m. to 9.00 a.m. as described by Pate *et al.*⁸. Total nitrogen in the sap was determined by conventional micro-Kjeldahl's method. Amide nitrogen was estimated employing the method of Pucher *et al.*⁹. Ureides (allantoin and allantoic acid) were measured colorimetrically¹⁰.

Xylem sap total nitrogen increased during growth till 70 days and then declined during pod filling (Table I), mainly because of reduced nitrogen fixing efficiency of root nodules (Luthra, Y. P., unpublished). Similarly, ureides, which accounted for 45 to 55% of the total nitrogen of the sap at different stages of growth, increased till 70 days and then decreased, indicating a direct association of ureide formation with symbiotic N_2 fixation. However, the amide nitrogen content, accounting for about 3 to 10% of the total sap nitrogen at various growth stages, increased during

TABLE I
Changes during growth in nitrogen solutes of xylem sap of nodulated pigeonpea plants*

Growth stage	Total nitrogen ($\mu\text{g/ml}$)	Amide nitrogen ($\mu\text{g/ml}$)	Ureide nitrogen ($\mu\text{g/ml}$)	Others including free amino acids ($\mu\text{g/ml}$)
Vegetative (30 days)	367	17	166	184
Flowering (70 days)	729	23	400	306
Pod-filling (90 days)	350	35	163	152

* Each value is the mean of six estimations.

all phases of growth. At all stages, the principal non-ureide constituents were mainly amino acids and other unidentified nitrogen containing substances. Their concentration again increased till 70 days and then decreased during pod-filling stage. However, their absolute amount, except at 30 days, was less in comparison to the amount of ureides present at corresponding stage, indicating ureides to be the major fraction of xylem sap total nitrogen. The earlier studies on other ureide-producing crops have also shown ureides to be the major component of xylem sap^{1,4,6}.

The above results showed that nodules of pigeonpea incorporated a major proportion of their fixed nitrogen into ureides and further exported the same to the shoot. The presence of appreciable levels of glutamate dehydrogenase, glutamine synthetase, xanthine oxidase, uricase and allantoinase in pigeonpea nodules (Sheoran, I. S., unpublished) further established that similar pathways as described by Rawsthorne *et al.*¹¹ for ureide metabolism in other legume species might exist in this crop also. However, this needs detailed investigations in pigeonpea. These findings suggest that the pigeonpea be classified as a species with a ureide-based nitrogen metabolism similar to that recorded from other grain legume species^{1,4,6}.

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CONNARDITE FROM CARBONATITE COMPLEX OF TIRUPPATTUR, TAMIL NADU

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CONNARDITE, a rare zeolite, has been identified by optical, X-ray, chemical, DTA and infrared spectral analyses during the detailed investigation of carbonatite complex of Tiruppattur, Tamil Nadu. The mineral was collected from a cavity amidst a basic xenolith found in the syenite masses exposed at 3 m depth from the surface in a well section located 300 m south of Korati Village, North-Arcot District, Tamil Nadu. The mineral is fibrous and radiating. The spherulites of connardites are pale pink to white in colour and measure upto 2 cm in diameter. The mineral, found as thin films with a maximum thickness of 1 to 2 cm, extends along the cracks, cavities and joint planes. Rhombohedral calcite intergrows along its peripheral portions. Phillipsite forms as interpenetration twins and chabazite occurs as lenticular crystals. But connardite is the dominant zeolite found in this area. The other associated minerals are the members belonging to the host rock, namely, oligoclase (An 24%), perhite, diopside augite, hornblende and biotite. In thin section it is colourless and exhibits low order interference colour with a birefringence of $(\gamma - \alpha) = 0.002$. R.I. is $N_\alpha 1.500$, $N_\gamma 1.502$, 2V low, length slow or positive elongation. A pure sample of connardite was separated and analysed chemically following the method of A. W. Groves¹. Its chemical analysis shows: SiO_2 43.14%, TiO_2 0.03%, Al_2O_3 24.25%, Fe_2O_3 0.20%, MnO 0.03%, MgO 0.25%, CaO 13.00%, Na_2O 4.06%, K_2O 0.09%, H_2O 14.68%, total 99.73%. X-ray powder

diffraction was carried out for the identification of the mineral and the data are given in Table I.

TABLE I

$d \text{ \AA}$	I/I_0	$d \text{ \AA}$	I/I_0
9.118	10	3.175	12
6.707	81	3.054	100
5.945	11	2.897	39
4.745	44	2.680	4
4.406	9	2.578	5
4.172	15	2.479	4
2.423	4	1.877	7
2.289	4	1.812	12
2.201	19	1.751	7
2.181	12	1.720	6
2.099	3	1.475	6
1.916	5	1.237	6

The powder diffraction data of 3.054 (100), 6.707 (81), 4.745 (44), 1.812 (12) and 5.945 (11) matches with the X-ray data for connardite². Connardite from Punchbowl (Hawaii)³ and from Maze (Japan)³⁻⁴ show four endothermic peaks at 70°, 385°, 450° and 770°–760° C and an exothermic peak at 150° C (Maze, Japan) as well as at 950° C (Punchbowl, Hawaii) all agree well with the connardite of Korati subjected to differential thermal analysis (Fig. 1). Infrared spectral diagram (Fig. 1) indicates the presence of Si–OH bondings at the wave number of 950 cm^{-1} which confirms the zeolite structure. However the presence of CO_3 indicates calcite impurities. CO_2 determination was made following the method of Shapiro and Brannock⁵ and the chemical analysis was corrected for the impurities of calcite present in the analytical sample. Available analyses of connardites are listed in Table II.

Connardites from: 1. Punchbowl, Hawaii³; 2. Aci Trezza, Sicily²; 3. Punchbowl, Hawaii³; 4. Keloch, Styria²; 5. Maze, Japan⁴; 6. Aci Castella, Sicily²; 7. Chaux de Bergonne, France²; 8. Chaux de Bergonne, France²; 9. Korati, India. The table exhibits that connardite of Korati lies as the end member of the solid solution series of isomorphous minerals, owing to the replacement of $\text{Ca Al} \leftrightarrow \text{Na Si}$ or $\text{Ca} \leftrightarrow \text{Na}_2$ similar to thomsonite minerals⁶. The mineral reported from Korati consists of very low values of Na with high Ca. Structural formula of the mineral with a number of ions and the basis of 80 oxygens, according to the Deer *et al.*⁷ is $(\text{Ca}_{5.07}\text{Na}_{3.23}\text{K}_{0.48}\text{Mg}_{0.16})_{9.53}(\text{Si}_{17.64}\text{Al}_{11.03}\text{Fe}^{'''}_{0.06})_{28.73}\text{H}_2\text{O}_{39.88}$. The occurrence of connardite in the carbonatite complex of Tiruppattur indicates subvolcanic nature of the emplacement of alkaline rocks in this area. The mineral assemblage of totally silica poor species of calcite, phillipsite, chabazite and connardite indicates that silica activity of the magmatic solution from which these minerals developed was notably low during