inoculum enhanced NH_4^{+-N} uptake significantly at 7, 14, 21 and 42 DAI more than did *Azospirillum* inoculation. *Azospirillum* inoculation also increased significantly P uptake of rice. It is suggested that inoculation with diazotrophs promoted plant growth through processes, other than nitrogen fixation by increasing mineral uptake.

Straw yield was higher with ammonium sulphate followed by gypsum, elemental sulphur and urea. S. Bentonite was not as good as the others.

Results from 42 on-farm trials conducted from 1983 to 1985 in Sind-Pakistan showed that the adaptation of recommended practices increased farm yields by 2.5 t/ha on an average from a simulated farmer's yield of 6.2 t/ha to 8.7 t/ha. Fertilizer and tillage levels seem to be an important contributing factor.

The importance of environmental conditions in understanding the variability of adaptation rates of modern varieties (MV) across areas has shown that adaptation rates in India have been confined to the northern and southern regions which are mostly irrigated but account for only about 1/4 of the total rice area. In contrast eastern India which gets heavy rains during the growing season with poor water management has the lowest adaptation rate.

There is a chapter on machinery development and testing describing the results of ground driven rotory tiller, animal drawn cono puddler, drum seeder conical weeders with fertilizers applicator and a simplified axial flow pump. There are two chapters one on training programme and the other on cooperative programmes in different parts of the world.

The report is very useful for all those institutions which are engaged in Rice Research.

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SCIENCE NEWS

'CONCEPTS, LIMITS AND EXTENSION OF INDIAN GONDWANA'

The term Gondwana System was proposed by H. B. Medlicott in 1872 in his report on the Satpura Basin, but was omitted from the report when published (*Mem. geol. Surv. India*; Volume 10, part 1, pages 133–188). The term was revived by Ottokar Feistmantel in 1876 (*Rec. geol. Surv. India*, Volume 9, p. 28) and was adopted by the Geological Survey of India in 1879 (*Manual of the Geology of India* by H. B. Medlicott and W. T. Blanford). Since then it has been used in all official publications of the Survey.

The first available comprehensive definition is by Fox (1931). According to him (1931, *Mem. geol. Surv. India*, Vol. 58, p. 78) "The name Gondwana System was applied to the deposits of conglomerates, sandstones, shales and coal-measures of fluviatile or lacustrine origin which occur in the Indian Peninsula and whose geological age ranges from middle Carboniferous to upper Jurassic. The fauna and flora of these Gondwana sediments are largely of terrestrial forms and include some fresh water fishes and amphibians".

The term Gondwana acquired several meanings with the passage of time. Extrapeninsular co-eval sedimentary sequences were classified under the Gondwana due to mere presence of *Glossopteris* or *Ptilophyllum* floral associations, even if the sediments were primarily of marine origin. Similarly, the coastal sedimentary sequences with *Ptilophyllum* floral association were classified as Coastal Gondwana disregarding undoubted marine signatures.

The Geological Survey of India therefore organized a colloquium, in 1984, on Gondwana Stratigraphy for bringing a precision in the definition of the term. A revised definition of the Gondwana Sequence was proposed to include mainly terreginous facies with "Gondwanic" floral/faunal bondage.

The Birbal Sahni Institute of Palaeobotany invited a select gathering of Gondwana specialists to take stock of Gondwana related data generated so far, at a workshop on **'Concepts, Limits and Extension of the Indian Gondwana'** (November 14–18, 1987). State-of-the-art reports on key areas of Gondwana research were presented with a view to identify problems and areas that require immediate synergistic research. Inaugurating the

Workshop, Shri D. P. Dhoundial, Director-General of the Geological Survey of India observed that the term Gondwana, in its wide usage, often carries different connotations to stratigraphers, palaeontologists or workers in geotectonics and this has made its definition somewhat flexible. He advised that besides taking due note of terrestrial Lower Gondwana elements in Tibet, glaciomarine sediments in Burma, Thailand, etc. the possibility of Gondwana elements occurring in the Naga Patkai–Arakan–Andaman–Nicobar belt should be explored. Achievable short and long range programmes be formulated to develop a composite lithostratigraphic, palynostratigraphic and magneto- stratigraphic data base to complete sedimentary columns in representative basins.

Introducing the theme, B. S. Venkatachala observed that when first marine signatures were discovered in Indian Gondwana at Umaria, these were regarded as marine intercalations in predominantly freshwater facies. However, subsequent discoveries of marine signatures in the Talchir sediments of Son-Mahanadi, Satpura, Damodar and Pranhita-Godavari grabens, Palar and Rajasthan basins and in the Barakar, the Barren Measures and the Raniganj formations (B. S. Venkatachala and R. S. Tiwari; this workshop) necessitate a relook at the definition of the term Gondwana. Should it be restricted to continental facies *sensu stricto* or should it include both continental and marine facies sharing common biota? He emphasized that the mere presence of a Gondwanic flora does not make a sedimentary sequence the Gondwana *sensu stricto*. He exhorted the participants to examine if it was any more worthwhile to retain this term. In the latter case, the lower and upper boundaries have to be clearly defined and demarcated, though there does not seem to be much discrepancy about the lower limit. The glacial episode is mostly accepted to demarcate this limit. But, the reasons for fixing the upper limit of the Gondwana above Neocomian are obscure. If a typical floral assemblage characterizes the Gondwana, then the provincialism exemplified in the Permian floras is no more evident even in the Late Triassic.

R. Garg, K. Ateequzamman and K. P. Jain recommended that Late Triassic may be considered to mark the Upper age limit of Gondwana sequences. There being no definite evidence of non-marine Jurassic sediments in intracratonic Gondwana basins, the Neocomian non-marine deposits of peninsular India are a post-Gondwana event. Jai Krishna also suggested exclusion of marine and/or pericratonic units from Gondwana even if a characteristic Gondwana flora is found in them.

However, N. D. Mitra would restrict the term Gondwana to essentially terrestrial or deltaic sediments but having characteristic Gondwana flora and fauna. Accordingly, the open sea deposits such as Tethyan sediments or the *Gangamopteris*-beds of Kashmir are not to be included in the Gondwana. The Indus-Suture zone is the established northern limit of Indian plate. To extend the limit beyond this, more evidences are needed. R. S. Tiwari and Vijaya observed that the Permian and Triassic palynofloras of Tethyan Himalaya exhibit a major relationship with the Gondwana floras although Cathaysian and middle-east influence is noticeable. Again in the Jurassic, uniformity in assemblages is pronounced. They suggested the accretion of microplates in different times, a possible extension of the Indian Plate up to northern Tibet and a narrower Tethys. S. C. Srivastava, A. Prakash and T. Singh informed that palynofossils from the Permian of Eastern Himalaya depict an eastward extension of the Gondwana flora.

Taken in conjunction with geotectonic data, S. K. Acharya discussed the occurrence of tillite and cold water fauna in northern Tibet, peri-Indian ophiolite belts, and magmatic sections or oceanic pelagic sediments that suggest a larger Indian Plate in Permian and Triassic. The ophiolites of the Indus-Tsangpo and Naga-Chin Hills — Andaman belts respectively, delineate the northern and eastern continental margins of India. Most of the Tibet and Arabia was a part of Gondwana land during Permian and Triassic; Cathaysian domain was also not far away.

H. K. Maheshwari and Usha Bajpai analysed the floras that grew around the northern margin of eastern Gondwana assembly and concluded that, though some of the floral assemblages contain certain 'Gondwanic' elements, yet their overall composition, except of the one from Kashmir, is basically Cathaysian. This coupled with the occurrence of 'northern' Mesozoic flora at Fukche, Ladakh and near Lhasa, Tibet restrict the northern boundary of the Indian Gondwana along the Indus–Yarlung–Zangbo suture. H. M. Kapoor and G. Singh also observed that the Permian flora of North-West Himalaya is distinguished from the peninsular Gondwana flora by the presence of some northern elements. Palaeontologically, the Karakoram Basin has a matching with that region of southern Tibet which is situated north of the Indus Suture. On the other hand, F. Ahmad opined that

geological, faunal and floral evidences overwhelmingly suggest that Tibet was not separated from India in the Permian-Triassic time and hence the Indus-Suture zone concept is not valid.

The floras are the best indicators of palaeogeographic limits of any region. D. D. Pant remarked that coal-forming Gondwana flora thrived in a different set of climatic conditions than that of Euramerican and Angara floras. The Glossopteris flora developed from the Lower Carboniferous Rhacopteris–Lepidodendropsis flora by mutation probably brought about by sudden chilling through the widespread glaciation. Seasonal fluctuation is indicated by marked annual rings in the Permian wood. Shaila Chandra & Anil Chandra and R. S. Tiwari & Archana Tripathi enumerated the changing patterns of climate during the Gondwana period on the basis of mega- and micro-plant remains respectively. Palynologically a dry arid climate during the Barren Measures and the Panchet is not supported.

Commenting on the Gondwana palaeodrainage, S. M. Casshyap said that each basin grew in size to a unified longitudinal basin, broader than the existing one as sedimentation progressed through time. The river system drained from southeast to northwest and westnorthwest, following the northerly palaeoslope, into Tethyan Sea of Sikkim and Nepal. Post-Triassic fragmentation and drifting of India from Antarctica witnessed large scale eruption of Deccan Traps, palaeo-slope reversal and shifting of basins to the newly created southern margin of peninsular India. C. Tripathi pointed out that north-east Traps, Abhor Volcanics, Sylhet and Rajmahal Traps continuing into Tertiary Deccan Traps were responsible for breaking up and movement of the Indian Plate. He suggested a reclassification of Gondwana and use of the term "Gondwanozoic" for Palaeozoic ranging in age from basal Cambrian to Late Permian.

S. C. Ghosh and coworkers reviewed the morphography and distribution of various estherids from Gondwana sediments of peninsula as well as extrapeninsular equivalents with reference to biozonation on the basis of index taxa. The Permian-Triassic boundary can be demarcated in a number of Gondwana grabens by the appearance of typical estherids at the close of Permian. S. C. Shah pointed out that the Raniganj/Panchet boundary in the Raniganj Coalfield represents the P/T boundary although elsewhere the data are not yet complete to draw a clear picture. S. C. Srivastava strongly contended that *Dicroidium* and *Lepidopteris* establish a Triassic age for Nidhpur assemblage; palynology ascertains that the Nidhpur beds are younger than the Panchet. P. P. Satsangi felt that the area needs attention for more positive evidence regarding age.

H. P. Singh and B. S. Venkatachala demarcated the Upper Jurassic/Lower Cretaceous palynoassemblages of peninsular India on the basis of the appearance of a new set of cryptogamic spores which possess distinctive morphology and can be used effectively as boundary markers. They consider the palynoflora of the continental deposits of the Rajmahal Basin (Neocomian) compares closely with the palynoflora of the Great Artesian Basin of Australia. According to Sukh-Dev the Jurassic–Early Cretaceous flora of India contains a mixture of European as well as Gondwana elements. The late Cretaceous flora assumed a new dimension which continues to maintain its southern heritage till today.

R. V. Savanur and A. K. Roy informed that the Gondwana coals are bituminous and sub-bituminous in rank and contain high ash. The occurrence of cooking coal and superior grade non-cooking coals are very limited and are confined mostly to Damodar Valley coalfields. The total coal resources in the Gondwana are assessed at 1,57,623 metric tonnes. D. C. Bharadwaj suggested intensification of palynological correlation of coal seams by emphasizing the typification of coal seams on the basis of similarity in qualitative composition and also to some extent by quantitative assessment of palynoflora also. Utilization of megaspores for stratigraphic zonation of Gondwana sediments was demonstrated by H. K. Maheshwari and Rajni Tewari.

Valuable reviews on vertebrate faunal assemblages were presented, which mainly centred around the data from Pranhita-Godavari Valley. T. S. Kutty, S. L. Jain and T. Roy Chowdhury, P. Yadagiri and B. R. J. Rao and P. P. Satsangi gave an account of the recent discoveries of palaeontological remains and their significance in dating and palaeoecology of various strata in the peninsular India. The vertebrate bearing formations from Pranhita-Godavari Valley have been correlated with co-eval rocks elsewhere in the world. Overwhelming evidences of freshwater environment of deposition and a Liassic age for the Kota Formation were presented.

Manju Banerjee regards the Karharbari as a biozone, because its identification as a formation is not unequivocal. B. C. Pande presented his views on the concept of the Kamthi. B. S. Venkatachala and

A. Rajnikanth demonstrated that the occurrence of marine intercalations, earlier considered sporadic, is more of a rule than an exception in the East Coast 'Gondwana'. Therefore, they recommended the use of chronostratigraphic terms like Cretaceous to these sediments.

As a result of this effort the following problems and areas were identified for synergistic investigations:

1. Lower age limit of the Gondwana,
2. Nature and chronological development of Gondwana vegetation,
3. Permian/Triassic boundary in key areas,
4. Biological affinities of the Gondwana related extrapeninsular basins,
5. Triassic/Jurassic boundary,
6. Upper age limit of the Gondwana.

It was recommended that groups of specialists in different fields should simultaneously work on these problems to facilitate quick synthesis and collation of data generated through their efforts. The Geological Survey and the Birbal Sahni Institute would act as nodal agencies to coordinate the efforts of participating institutions.

Proceedings of the Workshop are being published in Volume 36 of *The Palaeobotanist*, Lucknow, (eds) B. S. Venkatachala and H. K. Maheshwari.

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