4. Matsumura, S., Die schadlichen und nutzlichen insecten von Zuckerrohr Pflanzen Formosas. Keiseisha, Tokyo, 1910, pp. 52–86.
5. APPP, Insect pests of economic significance affecting major crops of the countries in Asia and the Pacific region. Technical Document No. 135, Regional FAO office for Asia and the Pacific, Bangkok, 1987, p. 66.
6. Ishida, M., The sugarcane woolly aphid and its control in *Formosa. J. Formosan Sugar Planters Assoc.*, 1928, **6**, 1–28.
7. Uye, T., On three aphids in Kiushya. *Insect World*, 1924, **28**, 14–15.
8. Lim, G. T., Pan, Y. C. and Pang, K. S., Seasonal collections of alate sugarcane aphids in yellow pan water traps in Gula Perak Berhad Plantations, Malaysia. *Proc. Int. Soc. Sugar Technol.*, 1977, **16**, 561–564.
9. Arakaki, N., Flight periodicity and the effect of weather conditions on the take-off of *Ceratovacuna lanigera* Zehntner (Homoptera: Aphididae). *Appl. Entomol. Zool.*, 1989, **24**, 264–272.
10. Saxena, A. P., Biology of *Campyloneurus mutator* (Fabricius) Hymenoptera: Braconidae. *Tech. Bull. CIBC*, 1967, **9**, 61–72.
11. Phukan, E., Comparative response of certain sugarcane varieties to *Ceratovacuna lanigera* Zehntner (Hemiptera: Aphidoidea: Pemphigidae) and effect of meteorological factors on the natural population build up of the pest. M Sc thesis, Assam Agricultural University, Jorhat, Assam, 1978.
12. Phukan, E., Datta, S. K. and Sharifullah, Md., Population build up of sugarcane aphid, *Ceratovacuna lanigera* Zehntner. *Co-Op. Sugar*, 1988, **19,** 311–312.
13. Gupta, M. M. and Goswamy, P. K., Incidence of sugarcane woolly aphid and its effect on yield attributes and juice quality. *Indian Sugar*, 1995, **44**, 883–885.
14. Ghosh, A. K., Aphids (Homoptera: Insecta) of economic importance in India. *Indian Agric.*, 1974, **18**, 135.
15. Tripathi, G. M., Biology of *Conobathra aphidivora* Meyr. Pyralid predator of sugarcane woolly aphid in Nagaland. *J. Appl. Zool. Res.*, 1992, **3**, 99–100.
16. Report on woolly aphid, *Ceratovacuna lanigera* Zehntner (Homoptera: Aphidiidae: Harmaphidinae) on sugarcane in northern Karnataka, University of Agricultural Sciences, Dharwad, 2002.
17. Patil, N. G., Spread of sugarcane woolly aphid, *Ceratovacuna lanigera* Zehntner (Aphididae: Homoptera), in western Maharashtra. *Insect Environ.*, 2003, **9**, 74–75.
18. Nerkar, Y. S., Proceedings of All India Seminar on Sugarcane Variety, Cane Quality and its Effects on Sugar Industry. STAI, Lonavla-Khandala, 29–30 June 2003, pp. 1–7.
19. Anonymous, Status of sugarcane woolly aphid in northern Karnataka and its management, submitted to UAS, Dharwad, 2003.
20. Lingappa, S., Kulkarni, K. A., Patil, R. K., Tippannavar, P. S. and Shekharappa, K., Status of woolly aphid, *Ceratovacuna lanigera* Zehntner on sugarcane in Karnataka. Paper presented at brain storming session on sugarcane woolly aphid, MPKV, Rahuri, 10 June 2003.
21. Mote, U. N. and Puri, S. N., Present status of sugarcane woolly aphid, *Ceratovacuna lanigera* Zehntner, a new pest problem on sugarcane in Maharashtra. Paper presented at brain storming session on sugarcane woolly aphid, MPKV, Rahuri, 10 June 2003.
22. Patil, A. S., Proceedings of State Level Seminar on Pest Management for sustainable Agriculture, MAU, Parbhani, 6–7 February 2003, pp. 33–37.
23. Sunil Joshi and Viraktamath, C. A., The sugarcane woolly aphid, *Ceratovacuna lanigera* Zehntner (Hemiptera: Aphididae): its biology, pest status and control. *Curr. Sci.*, 2004, **87**, 307–316.
24. Painter, R. H., *Insect Resistance in Crop Plants*, Macmillan, New York. 1951, p. 250.
25. Pan, Y. S., Yang, S. L. and Shieh, H. L., Occurrence of sugarcane woolly aphid, *Ceratovacuna lanigera* Zehntner, in relation to sugarcane varieties. *Taiwan Sugar*, 1984, **31**, 6–13.
26. Rueda, L. M. and Calilung, V. J., Biological studies on the sugarcane woolly aphid, *Ceratovacuna lanigera* Zehntner (Hemiptera: Aphidoidea: Pemphigidae) on five varieties of sugarcane. *Philipp. Entomol.*, 1974, **3**, 129–147.
27. Mirzawan, P. D. N. and Irawan, Lamadji, S., Problems of pests and diseases for sugarcane and the resistance breeding program in Indonesia. In *Sugarcane Germplasm Conservation and Exchange: Report of an International Workshop Brisbane, Queensland, Australia* (eds Croft, B. J., Piggin, C. M., Wallis, E. S. and Hogarth, D. M.), 28–30 June 1995, pp. 36–41.
28. Takano, S., The sugarcane woolly aphids, *Ceratovacuna lanigera* Zehntner, in *Formosa*, Government Sugar Experimental Station Report, 1941, p. 76.
29. Pan, Y. S. and Yang, S. L., Control of *Ceratovacuna lanigera* Zehntner with ultra-low volume aerial application of insecticides. *Sugarcane*, 1983, **3**, 13–15.
30. Venkatraman, T. S., Sugarcane breeding in India, hybridization to testing. *Agric. J. India,* 1925, **29**, 173–176.
31. Thuljaram Rao, J., Sugarcane origin, taxonomy, breeding and varieties. In *Sugarcane Varietal Improvement* (eds Mohan Naidu, K., Sreenivasan, T. V. and Premachandran, M. N.), Sugarcane Breeding Institute, Coimbatore, 1989, pp. 83–113.

ACKNOWLEDGEMENTS. We thank staff of R&D unit and management board of Nandi Sugars, Hosur (Bijapur Dist.) and Ugar Sugars, Ugarkhurd, (Belgaum Dist.) for providing facilities to conduct clonal trials.

Received 15 March 2004; revised accepted 20 September 2004

Role of planning strategies in success/ failure of joint forest management plantation

Leena Abraham* and G. Sandhya Kiran

Department of Botany, M.S. University of Baroda,
Vadodara 390 002, India

Joint Forest Management (JFM) relies on low cost option for regeneration of degraded forest patches. We review here criterion-based assessment of these community developed carbon sinks in four villages of Narmada district, Gujarat. Forest villages were ranked based on primary and secondary plant analysis, carbon sequestration rate, forest per household, landless families and gochar land available per Animal Cattle Units (ACU). Weightage was given to each criterion and changing the weightage value resulted in the changes in rank of the villages. This study highlighted the significance of planning strategy in success or failure of any JFM activity in restoration of forest areas of these villages.

FOREST policies like Wild Life Act 1972, Forest Conservation Act 1980 and the Forest Policy 1988, have contributed significantly in conserving forests and have triggered several afforestation programmes[1–4]. Joint Forest Manage-

*For correspondence. (e-mail: abrahamleena@rediffmail.com)

ment (JFM) is one such programme developed during the implementation of these policies. It seeks to develop partnership between local community institution and state forest department for sustainable management of degraded public forest lands on the basis of sharing forest management responsibility and benefits of forest produce[5]. Thus this programme which empowers tribal and rural community relies on low cost options for regeneration of degraded forest patches.

In India, Gujarat is one of the pioneering states to initiate JFM. Narmada, a newly formed district of this state, is a tribal heart inhabited by Tadvi, Vasava, Turi, Mruki, Varli, etc. but the impoverished tribes have been lately outnumbered by influx of settlers from different areas due to implementation of Narmada River Valley Project. This has resulted in both population as well as developmental pressure on the forest of these areas resulting into decline in forest cover. The twin crisis of environment and development in this critical habitat prompted the government to implement a number of afforestation programmes like those of JFM in this district.

Forest, in addition to being the focal point of economic and cultural life of the country, is also recognized as an important option to mitigate the increasing levels of Green House Gases (GHGs) in the atmosphere. Forests play a critical role in global carbon cycle and also offer significant potential to capture and hold carbon. Decrease in deforestation helps to preserve current carbon reservoir and afforestation helps holding carbon for longer time. Though plantation programmes like JFM have been developed for restoring the degraded forests and offset the GHGs, they are neither systematically determined nor reported frequently for their contribution towards restoration of these forest lands. We attempt here to assess in terms of both ecological diversity and economic stability, restoring ability and carbon sequestration in four villages of Narmada district.

Narmada district of Gujarat state lies between 73′17″E to 73′58″E and 22′23″N to 21′23″N (Figure 1). This district has good forest cover and about 40% of the total land area of 2,755.5 km^2 is forested[6]. According to the identification of forest types by Champion and Seth[7], two distinct forest types are found in this area – Southern tropical moist deciduous forests, subtype slightly moist teak forests and Southern tropical dry deciduous forests, subtype dry teak forests. The district receives an average rainfall of 976 mm. Bulk of rainfall is received in a short period of about 10–12 weeks, starting from last week of June to mid-September. The villages selected for the present study with respect to their forest boundary and the forest type therein are listed in Table 1.

For primary and secondary plant analysis quadrate and belt transect were laid down in three replicates at each site of the village. Plant types in each of these were studied thoroughly. Frequency, density, abundance, IVI and various indices like Simpson[8], Shannon–Wiener[9] and Sorenson[10] were calculated. The growing stock was calculated using the following regression equation given by Ravindranath[11]:

$$\text{Standing Woody Biomass (t/ha)} = -1.689 + 8.32 \times \text{B.A},$$

where SE of coefficient = 1.689, $R^2 = 0.5$, B.A. = Basal area in m^2/ha.

Forest area per household, proportion of landless households were generated from questionnaires distributed in all the villages. Animal Cattle Units (ACU) were calculated from the ACU criteria based on ref. 12.

Vegetation analysis exhibited Limkhetar with maximum number of tree species and Kodba with the maximum number of undercover vegetation. Similarity in tree species between Limkhetar and Nani Chikhli and also between Kodba and Nani Chikhli were quite high except for the plantation in Naghatpur as exhibited by Sorenson similarity index (Tables 2 and 3).

Despite the similarity in plantation, each forest village had its own dominant plant type. Naghatpur and Kodba showed *Tectona grandis* L. f. to be having highest phytosociological status with IVI values 194.99 and 143.36 respectively. Limkhetar on the other hand showed *Butea monosperma* (Lam.) Taub with higher IVI value followed by *Gmelina arborea* Roxb. and *Tectona grandis* L. f. *Acacia catechu* Willd. with 106.6 IVI was prominent in Nani Chikhli. This understanding of dominance and ecological success of a species determined by the IVI values is well accepted by the earlier workers like Curtis[13] and Misra[14]. The forest plantation is covered with a canopy which is formed by different species like *Tectona grandis* L. f., *Butea monosperma* (Lam.) Taub, *Acacia catechu* Willd., *Madhuca indica* (Roxb.) Macbr., *Azadirachta indica* Juss., *Terminalia catapa* L., *Anona squamosa* L., *Citrus* sp., etc.

Herbs are many on the forest floor with few climbers but very few grasses and epiphytes. Average depth of the ground cover ranged from 12 to 15 cm. The floor was not much covered with decomposed and semi-decomposed humus. Though plantations usually show lower species diversity[15], Limkhetar and Nani Chikhli exhibited good number of tree

Table 1. Villages selected for the study

District	Division	Range	Round	Village	Type of forest
Narmada		Kevadia	Haripura	Limkhetar	Fairly dense jungle mainly teak
	Rajpipla		Naghatpur	Naghatpur	Fairly dense jungle mainly teak
	East	Rajpipla	Khutamba	Nani Chikhli	Open mixed jungle mainly teak
	Division	Sagbara	Sagbara	Kodba	Dense mixed jungle mainly teak and bamboo

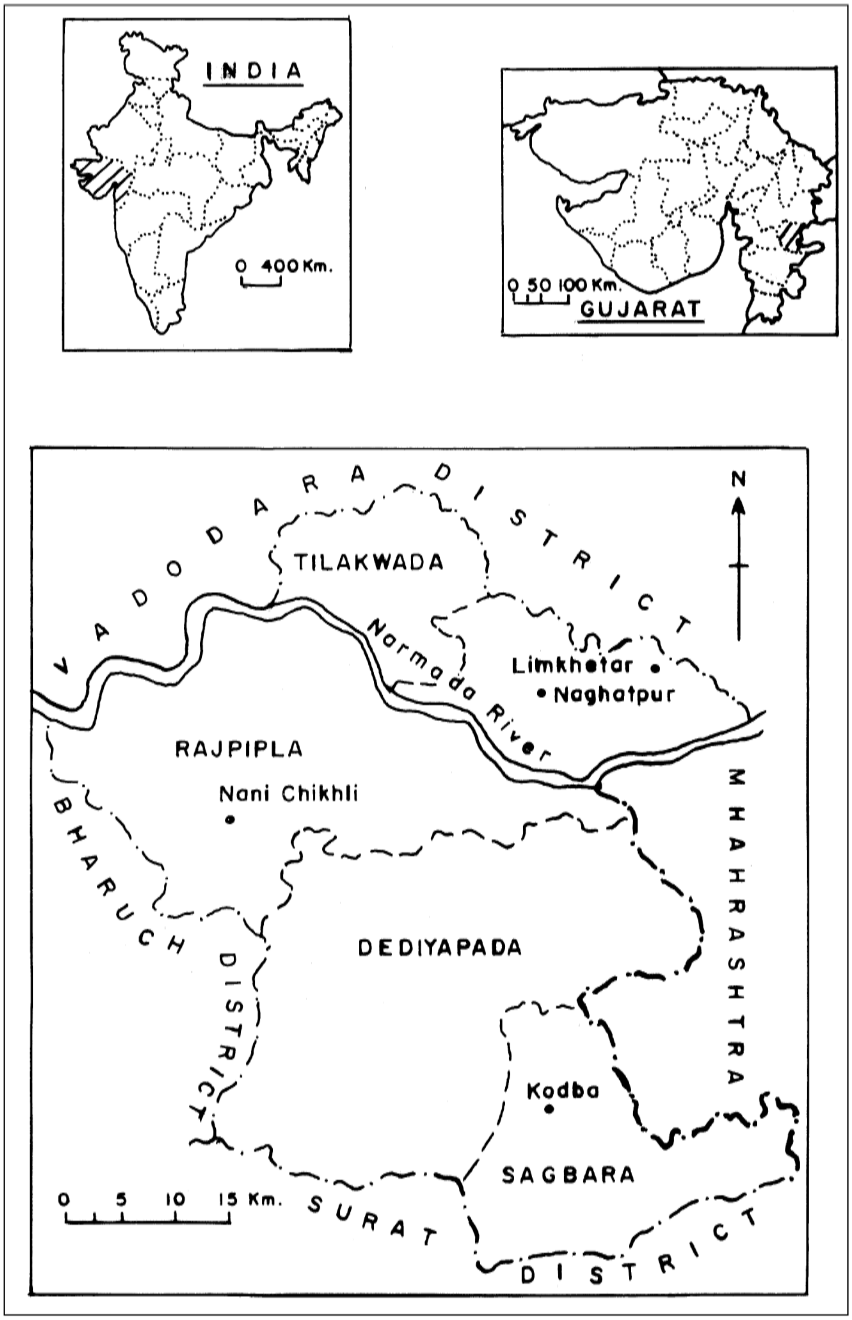

Figure 1. Narmada District – Site of study.

Table 2. Sorenson's Similarity Index for tree species of JFM areas

	Naghatpur	Limkhetar	Kodba
Nani Chikhli	0.26	0.44	0.50
Naghatpur		0.27	0.35
Limkhetar			0.26

Table 3. Sorenson's Similarity Index for undercover vegetation of JFM areas

	Naghatpur	Limkhetar	Kodba
Nani Chikhli	0.20	0.18	0.24
Naghatpur		0.18	0.35
Limkhetar			0.22

Table 4. Plantation analysis from different villages

	Naghatpur	Limkhetar	Kodba	Nani Chikhli
Years of plantation	14	6	3	12
No. of species				
Tree	5	17	6	10
Understorey	5	6	12	5
Basal area (m^2/ha)	14.59	4.34	3.25	10.59
Standing woody biomass (t/ha)	119.69	34.42	25.39	86.45

Table 5. Profile of villages selected for vegetation assessment

Feature	Naghatpur	Limkhetar	Kodba	Nani Chikhli
No. of households	430	165	90	70
Population	NA	1094	300	425
No. of landless households	200	43	58	11
Geographic area (ha)	957.29	1920.61	114.10	484.55
Forest area (ha)	408.88	475.96	0.29	382.49
Gochhar area (ha)	86.06	1168.04	3.02	24.74
Livestock	3000	890	400	265
Area under JFM (ha)	130	25	50	50

*NA, Not available.

Table 6. Assigning point values to different parameters

	Points assigned				
Parameters	2	4	6	8	10
Carbon sequestered (t/ha/yr)	2.60–2.88	2.88–3.16	3.16–3.44	3.44–3.72	3.72–4.0
Gochar land/ACU (ha)	<0.7	0.70–1.30	1.30–1.90	1.90–2.50	2.50–3.10
Forest/household (ha)	0.15–0.27	0.27–0.39	0.39–0.51	0.51–0.63	0.63–0.75
Landless (%)	<20	20–40	40–60	60–80	80–100
Shannon–Wiener Diversity Index	0.25–0.40	0.40–0.55	0.55–0.70	0.70–0.85	0.85–1.0
Simpson's Dominance Index	0.60–0.75	0.45–0.60	0.30–0.45	0.15–0.30	<0.15

Table 7. Weighted sum rank for the study villages

	Carbon sequestration	Gochar land/	Forest/ house-	Landless	Diversity index		Dominance index		Weighted
Village	(t/ha/yr)*	ACU (ha)	hold (ha)	(%)	Tree spp.	Under cover	Tree spp.	Under cover	Sum Rank
Naghatpur	3.93	0.03	0.30	46.51	0.25	0.57	0.71	0.31	38
Limkhetar	2.64	2.53	0.15	26.06	0.90	0.62	0.11	0.30	52
Kodba	3.89	0.01	0.55	64.44	0.42	0.82	0.54	0.24	52
Nani Chikhli	3.32	0.17	0.71	15.71	0.74	0.59	0.22	0.28	50

*1 ton of woody biomass = 0.46 tonnes of carbon (ref. 16).

species and Kodba showed maximum number of undercover vegetation (Table 4). The number of both tree species as well as understorey vegetation in Naghatpur is restricted to 5. The reason for this reduced tree species number could be attributed to monoculture practices in Naghatpur. The overall plantation analysis carried out considering the number of years of protection has been presented in Table 4.

Table 5 gives a profile of different attributes for each village reflecting the developmental status in terms of ecology as well as economy.

By giving weightages to each variable linked with these plantations, the significance of planning strategy and the role of the variables considered or linked with that plantation is highlighted (Table 6). However, changing the weightage value for each criterion resulted in changes in the rank of the village.

Carbon sequestration is highest in Naghatpur closely followed by Kodba (Table 7). Limkhetar and Kodba both share the first position in the ranking list, since both the villages had adopted polyculture strategy in the JFM plantations, resulting in increased tree species diversity in Limkhetar and increased under-storey diversity in Kodba. Highest number of tree species in Limkhetar may also be attributed to greater awareness among the people regarding the protection of these plantations. In addition, this strategy has sufficed the NTFP needs of the dependent population of Limkhetar up till the timber-yielding trees are ready for harvest. Census data has reflected a loss of 50% of natural forest in Limkhetar between 1981 and 1991, but this strategy has been able to check further degradation in last decade. Kodba on the other hand, exhibits absence of gochar land compelling the rural to be totally dependant upon this understorey vegetation. They, therefore, protect this plantation at least for four months after the rainy season, which led to greater diversity for the undercover. If Kodba managed to secure the top position due to the high levels of carbon sequestration, greater percentage of forest-dependent households and higher diversity for under cover vegetation, then, Limkhetar shares the first position with Kodba, due to sustainable gochar lands and selection of trees species keeping in mind the needs of forest-dependent community. Considering the number of years of protection in case of Kodba and Limkhetar it could be observed that both stand almost equal in terms of ecological (carbon sequestration, dominance and diversity indices) and economical (gochar land, forest/household and % landless) parameters, with Limkhetar slightly higher in position ecologically due to higher species diversity and due to presence of gochar land in this area and Kodba slightly higher economically. Few more factors in relation to implementation of these plantation strategies like protection given to plantation in early years resulting in increased species diversity as in case of Nani Chikhli, presence of gochar land resulting into less stress on forest also have significant impetus on success of any plantation programme.

Ecorestoration requires that the redevelopment process should go in accordance with or achieve parallel progress in environment, social and economic sectors both in short and long term and across a range of spatial scales. Such a goal could be achieved only by implementing proper planning strategies as mentioned above while carrying out the plantation activities. In this context, linking up ecological process with social process becomes significant to ensure community participation in ecorestoration leading to sustainable livelihood development of this area.

Criterion-based ranking of different villages in terms of their contribution towards restoration of the area has highlighted the significance of polyculture strategy which should go parallel with the protection of these plantation in early years and which would definitely lead to the success of any plantation programme.

1. Ravindranath, N. H. and Hall, D. O., *Biomass Energy and Environment: A Developing Country Perspective from India*, Oxford University Press, Oxford, 1995.
2. Murali, K. S. and Hegde, R., Patterns of tropical deforestation. *J. Trop. For. Sci.*, 1997, **9**, 465–476.
3. Saxena, N. C., *The Saga of Participatory Forest Management in India*, CIFOR Special Publication, Indonesia, 1997.
4. Bhat, D. M., Murli, K. S. and Ravindranath, N. H., Formation of secondary forests in Southern India. *J. Trop. For. Sci.*, 2001, **13**, 601–620.
5. Sarin, M., *Joint Forest Management: The Haryana Experience*, Centre for Environment Education, 1996.
6. Varsani, N. R., *Bharuch District Census Handbook*, Census of India, 1991.
7. Champion, H. G. and Seth, S. K., *A Revised Survey of Forest Types of India*, Manager of Publications, Delhi, 1968.
8. Simpson, E. H., Measurement of diversity. *Nature*, 1949, **163**, 688.
9. Shannon, C. E. and Wiener, W., *The Mathematical Theory of Communication*, University of Illinois Press, Urbana, 1949, p. 117.
10. Sorenson, T., *A Method of Establishing Groups of Equal Amplitude in Plant Society Based on Similarity of Species Content*, K. Danske Vidensk. Selsk, 1948, vol. 5, pp. 1–34.
11. Ravindranath, N. H., Community Forestry: An Ecological, Economic and Institutional Assessment in Western Shiwaliks of J&K, Draft report of Sampark – Centre for Development Interaction, Udhampur, 1995.
12. Jain, H. K. and Dholakia, R. H., Pasture Development Project in Sayla taluka, Project Report, Sardar Patel Institute of Economic and Social Research, Ahmedabad, 1980.
13. Curtis, J. T., *The Vegetation of Wisconsin*, Univ., Wisconsin Press, Madison, 1959.
14. Misra, R., *Ecology Work Book*, Oxford, New Delhi, 1968.
15. Murthy, I. K., Murali, K. S., Hegde, G. T., Bhat, P. R. and Ravindranath, N. H., A comparative analysis of regeneration in natural forests and joint forest management plantations in Uttara Kannada district, Western Ghats. *Curr. Sci.*, 2002, **83**, 1358–1364.
16. Negi, J. D. S., Manhas, R. K. and Chauhan, P. S., *Carbon Allocation in Different Components of Some Tree Species of India: A New Approach of Carbon Estimation*, pers. comm., 2002.

Received 25 May 2004; revised accepted 28 September 2004

Guar gum and isubgol as cost-effective alternative gelling agents for *in vitro* multiplication of an orchid, *Dendrobium chrysotoxum*

Ruchi Jain and Shashi B. Babbar*

Department of Botany, University of Delhi, Delhi 110 007, India

Guar gum (isolated from the endosperms of *Cyamopsis tetragonoloba*) and isubgol (husk derived from *Plantago ovata* seeds) have been successfully used as exclusive gelling agents for *in vitro* multiplication of an orchid, *Dendrobium chrysotoxum* from leaf and protocorm explants. The explants were cultured on Mitra's medium supplemented with 2% sucrose, 1 g l^{-1} peptone and gelled with either 0.9% agar, 3% guar gum or 3% isubgol. The medium used for leaf explants contained 1 mg l^{-1} BA. Both the alternative gelling agents supported differentiation of protocorm-like bodies and their growth into shoots two and half to threefold higher than agar.

ORCHIDS constitute an outstanding royalty in the world of ornamentals because of their intricately fabricated flowers of exquisite beauty. Orchids account for 2.7% of the global cut-flower production in terms of their value[1]. Because of heterozygous nature of orchids and their extremely slow vegetative propagation, tissue-culture techniques are routinely applied for their clonal multiplication. In fact, the application of these techniques for the production of quality plants in large quantities and propagation of exquisite and rare hybrids have catapulted orchids among the top ten cut flowers in the international market[2]. As for other plants, culture media used for orchids are also gelled with agar, an expensive component. Agar has remained the most frequently used gelling agent for microbial and plant tissue

*For correspondence. (e-mail: babbars@rediffmail.com)