RUPTURE PROPAGATION DIRECTION IN MAJOR EARTHQUAKES ALONG THE HIMALAYAN CONVERGENCE ZONE

RAMESH CHANDER
Department of Earth Sciences, University of Roorkee, Roorkee 247 667, India.

THE four recent major earthquakes of the Himalayan Convergence Zone, viz., the Kangra earthquake of 1905, the Bihar-Nepal earthquake of 1934, and the two Assam earthquakes of 1897 and 1950 were assigned magnitudes greater than 8 by Richter[1]. Although estimates[2-5] of areas vary, it is agreed that an extended rupture with its long dimension parallel to the local strike of the Himalaya was involved in each case. Such a rupture does not occur instantaneously but spreads from the hypocentre at finite speed[6]. Sustained rupture propagation in a given direction leads to enhanced seismic wave amplitudes in that direction[7]. If a uniform pattern in regard to rupture propagation direction exists for major earthquakes of the Himalayan Convergence Zone, it can have the following notable implications, among others. First, the view that plate tectonic processes are operating in a systematic way over the 2500 km length of the Himalayan Convergence Zone is supported. Second, premonitory observations for earthquake prediction can be focused at the end of a seismic gap at which the rupture is expected to initiate. Third, more concerted steps can be taken for mitigation of seismic risk at the end of the seismic gap toward which the rupture is expected to propagate. Currently we are constrained to search for a pattern of the above type through interpretation of the (mainly non-instrumental) data from the four major earthquakes. Yet the search should be undertaken because its result would be useful for evolving rational strategies to meet the threat of the next major earthquake of the Himalayan Convergence Zone.

No evidence is available regarding the direction of rupture propagation in the case of the 1897 Assam earthquake for two reasons. A reliable instrumental estimate of the earthquake epicentre could not be obtained from the data recorded at the small number of seismograph stations then operating. Also there is divergence of opinion[2,5] on the size and location of the rupture as deduced from the intensity data[8].

Chander[9] argued that rupture propagation in the case of the 1905 Kangra earthquake was from SE to NW parallel to the general strike of the Himalaya locally because the region of maximum devastation around Kangra and Dharamsala overlapped the northwestern part of the rupture zone that extended from Shahpur near Kangra to Dehra Dun along its longer dimension and northeastward from the Main Boundary Thrust along the shorter[2,3,9-11].

Roy[12] argued convincingly that since the instrumentally determined estimate of the 1934 Bihar-Nepal earthquake epicentre lay near the southeastern end of the ESE-WNW oriented main zone of maximum damage in the Madhubani-Sitamarhi region[13], the direction of rupture propagation was from ESE to WNW parallel to the local strike of the Himalaya. A more recent estimate[14] of rupture propagation direction for this earthquake may be disregarded even though analysis of Rayleigh waves from two seismograms was attempted because (i) the instruments available at the time of the earthquake were not suitable for recording surface waves, (ii) one of the two seismograms used was obtained from a horizontal instrument on which Love waves would also have been recorded, and (iii) clear evidence was not presented that the stipulations of the method of analysis had been strictly followed.

The 1950 Assam earthquake occurred in the extreme eastern part of the Himalayan Convergence Zone. Rupture propagation from NE to SW parallel to the local strike of the Himalaya may be inferred because the instrumental epicentre of the main shock lay near the northeastern end of the main lobe of a somewhat irregularly shaped rupture zone defined by the aftershock epicentres[2,4,7].

Thus the available evidence is that the rupture propagation was predominantly along the long dimension of the rupture from its eastern to western end parallel to the local strike of the Himalaya in each of the three most recent major earthquakes of the Himalayan Convergence Zone. It is suggested on this basis that the trend may continue in the future major earthquakes of the Zone also.

Admittedly the extrapolation is based on a very small sample. But it is all the evidence we have at the moment. The hypothesis derives support from the fact that the earthquakes involved occurred in widely separated localities in the western, central and eastern parts of the Himalayan Convergence Zone. Since some hypothesis is better than no hypothesis at all, the proposal made here may be entertained at least until the next major earthquake of the Zone.

The author is grateful to Prof. K. N. Khattri for a perusal of the manuscript and for helpful suggestions.

21 December 1987; Revised 22 February 1988

1. Richter, C. F., *Elementary seismology*, W. H. Freeman and Co., San Francisco, 1958, p. 709.
2. Seeber, L. and Armbruster, J. G., *Earthquake prediction — an international review*, American Geophysical Union, Washington, 1981, p. 259.
3. Chander, R., *J. Geol. Soc. India*, 1988, (in press).
4. Chen, W. and Molnar, P., *J. Geophys. Res.*, 1977, **82**, 2945.
5. Molnar, P., *J. Geol. Soc. India*, 1987, **30**, 13.
6. Kasahara, K., *Earthquake mechanisms*, Cambridge University Press, Cambridge, 1981, p. 126.
7. Benioff, H., *Earthquakes in Kern County and California during 1952*, California Division of Mines, San Francisco, 1955, p. 171.
8. Oldham, R. D., *Mem. Geol. Surv. India*, 1899, **29**, 379.
9. Chander, R., *Tectonophysics*, 1988, (in press).
10. Molnar, P., *J. Geol. Soc. India*, 1987, **29**, 229.
11. Middlemiss, C. S., *Mem. Geol. Surv. India*, 1910, **37**, 409.
12. Roy, S. C., *Mem. Geol. Surv. India*, 1939, **73**, 49.
13. Dunn, J. A., *Mem. Geol. Surv. India*, 1939, **73**, 76.
14. Singh, D. D. and Gupta, H. K., *Bull. Seismol. Soc. Am.*, 1980, **70**, 757.

LEAF VARIANT IN WINGED BEAN

A. D. CHOUDHARY
Department of Botany, Nagpur University, Nagpur 440 010, India.

THE winged bean, *Psophocarpus tetragonolobus*, is a promising unexploited food crop of tropic. Attempts are being made all over the world to identify and isolate the germplasm for breeding purposes. It has been reported that the winged bean in different parts of Asia exhibited wide differences in many physical features: leaf-shape and size, flower colour, pod length, shape and colour, seed shape size, seed colour, etc[1]. With the growing interest in the winged bean several new types have been recorded in Asian countries. The present note describes the plant type for leaf character segregated in a line IIHR/Sel 21.

During the studies on *P. tetragonolobus* (IIHR/Sel 21) a new plant type was noticed. While evaluating the germplasm of IIHR/Sel 21, a few plants with variation in leaf shape and size, and pod length were observed. These plants were isolated and evaluated for different characters during the subsequent season.

The parent line IIHR/Sel 21 was obtained from the National Bureau of Plant Genetic Resources, IARI, New Delhi. The line is characterized by the trifoliate leaf. The shape of the leaflet is nearly cordate and is broad (figure 1).

These new variants were evaluated for certain morphological and yield characters. The data are presented in table 1. A significant variation was noticed in leaf shape (figure 2). Measurements revealed no difference in the lengths of the leaf and the leaflet. However, the breadth of leaflet exhibited significant difference. As regards pods, 21.19 cm pod length was observed in parent line, while the length of pods was 16.76 cm in variant plants. However, there was no significant difference in number of seed/pod and weight/100 seeds in the present variety and variant plant types. The leaf shape and pod size seem to be associated with each other and further studies are needed to confirm this.

The author is grateful to the Director of the National Bureau of Plant Genetic Resources, IARI, New Delhi for the supply of seeds.

Table 1 *Data on morphological and yield characters*

	Parent IIHR/Sel 21	Variant
Leaf length including petiole (cm)	16.54	15.37
Petiole length (cm)	6.96	6.49
Lamina		
Length	9.62	8.88
Breadth	5.07	2.58*
Pod length (cm)	21.29	16.76**
No. of seeds/pod	9.25	8.20
Weight per 100 seeds (g)	38.44	36.89

F value: * 63.90, highly significant at 1% level; ** 6.17, significant at 5% level.