

were 17 spells of heat waves over Punjab compared to 15 over Orissa but the loss of lives in Punjab was 114 compared to 529 in Orissa.

To conclude it may be mentioned that the impact of heat waves over Bihar, Punjab and parts of Maharashtra (Marathwada, Vidarbha and Madhya Maharashtra) is more as it may create water scarcity and adversely affect agriculture if heat waves occur during years succeeding El-Nino events; also, these places have high probability of concurrent El-Nino and drought during the south-west monsoon season. The impact

also depends upon the socio-economic condition of the inhabitants.

1. Sinha Ray, K. C., Mukhopadhyay, R. K. and De, U. S., *Natural Disasters, Some Issues and Concerns*, Visva Bharati, Shantiniketan, 1999, pp. 10–23.
2. De, U. S. and Mukhopadhyay, R. K., *Curr. Sci.*, 1998, **75**, 1308–1311.
3. Sinha Ray, K. C. and Shewale, M. P., submitted for publication in *Mausam*, 1999.
4. Bedekar, V. C., Dekate, M. V. and Banerjee, A. K., Rep. No. IV-6, FMU, 1974.

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S. K. CHAUDHURY  
J. M. GORE  
K. C. SINHA RAY\*

India Meteorological Department,  
Shivajinagar,  
Pune 411 005, India

\*For correspondence.  
e-mail: ksinha\_ray@hotmail.com

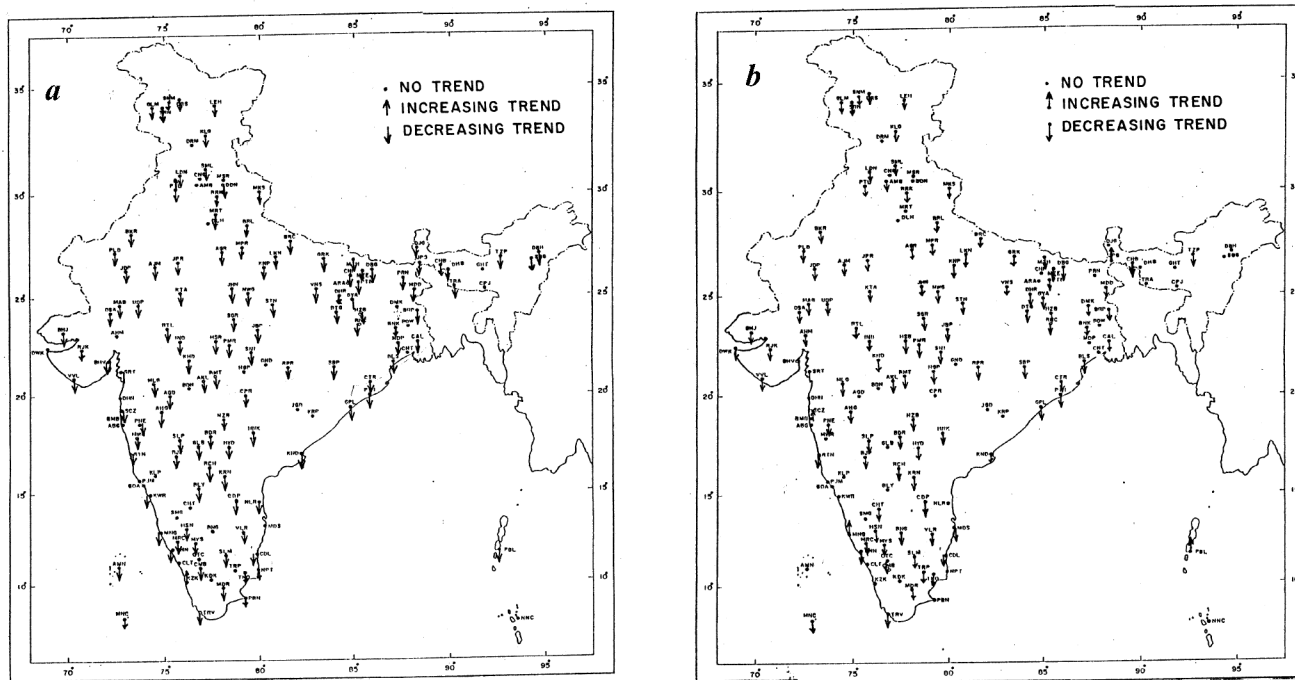
## Is there any change in extreme events like heavy rainfall?

The problem of climate change has been a major thrust area of recent scientific research. In the scenario of increased CO<sub>2</sub> and thereby increase in global temperature, a question often raised by the climate research community is whether there is any increase in the extreme events like droughts and heavy rainfall spells? Some studies in India have dealt

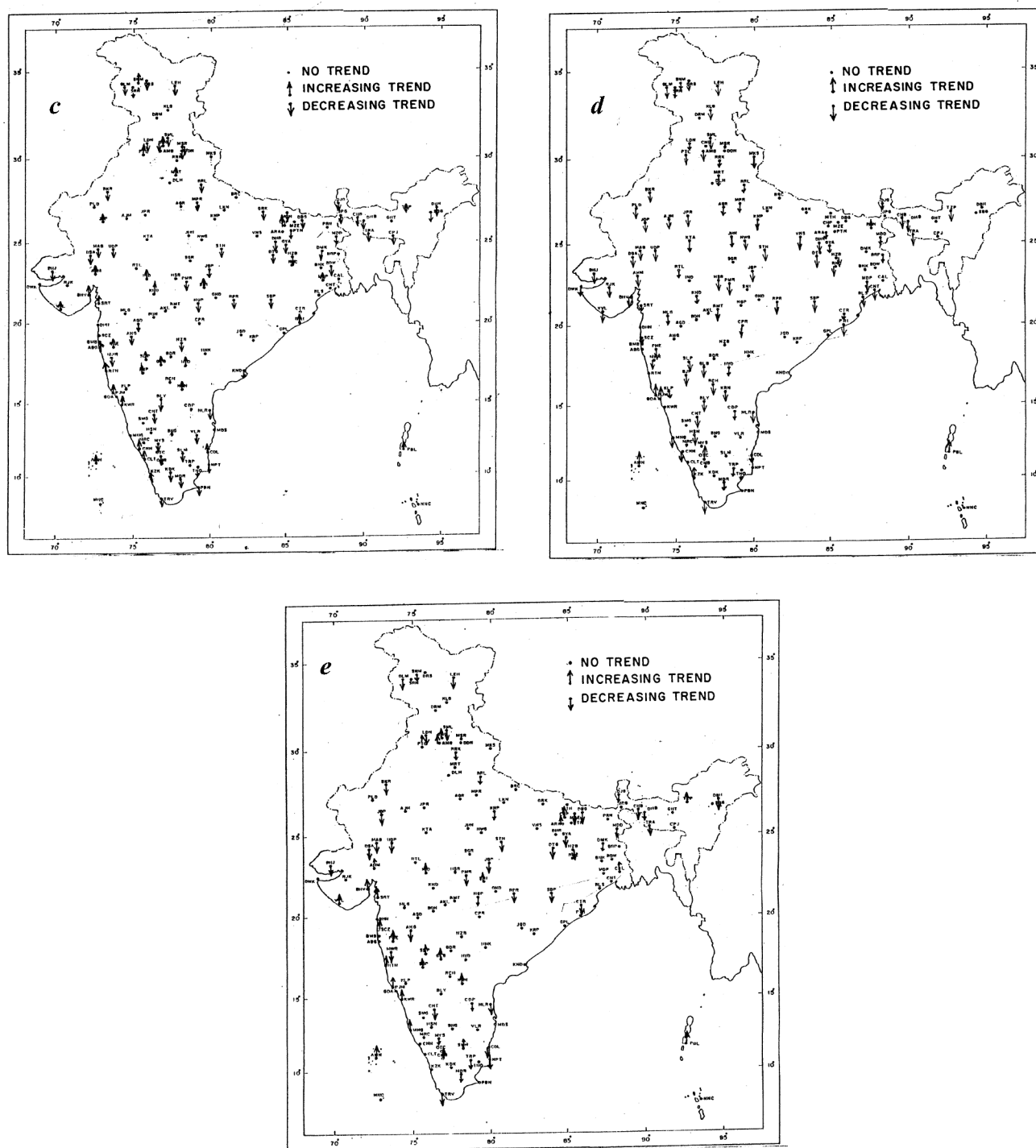
with changes in rainfall over the sub-continent as a whole and in some smaller spatial scales. But so far, there are no studies dealing with trends in heavy rainfall spells over various stations in India.

Srivastava *et al.*<sup>1</sup> have shown that there is no trend in the all-India rainfall during the monsoon season as well as

the annual rainfall. However, they found a decreasing trend in rainfall over some hilly areas of north-east India. Srivastava *et al.*<sup>2</sup> studied trends in rainfall during the south-west (SW) monsoon season and that of annual rainfall over 35 sub-divisions of India and over all districts of India based on a long series of rainfall data. Their study



**Figure 1 a, b.** Trends in the frequency of rainfall  $\geq 7$  cm in 24 h (1901–1990). *a*, January to February; *b*, March to May.



**Figure 1 c–e.** Trends in the frequency of rainfall  $\geq 7$  cm in 24 h (1901–1990). *c*, June to September; *d*, October to December; *e*, annual.

showed that though there is no trend in the all-India rainfall, a few subdivisions in India show increasing trends in rainfall, whereas a few show decreasing trends.

In the present study, the authors have tried to find out whether there is any trend in the occurrence of heavy rainfall events. Daily rainfall data for the period 1901 to 1990 for 151 observatory sta-

tions in India having rainfall data for at least 60 years have been considered for the study. When the daily rainfall over a station is 7 cm and above, then that day is considered as a heavy rainfall day.

The frequency of heavy rainfall days over each station during each month was considered. Based on climatic features of the months, India Meteorological Department has defined four seasons, viz. winter (comprising January and February), pre-monsoon (March–May), monsoon (June–September) and post-monsoon (comprising October–December). Eleven year running total frequency of heavy rainfall days for each station and for each season was subjected to Mann-Kendall rank statistic test at 95% level of confidence.

During the winter season most of the stations over India show a decreasing trend in the frequency of heavy rainfall (Figure 1 *a*).

During the pre-monsoon season a large number of stations over various parts of India show a decreasing trend in heavy rainfall (Figure 1 *b*). However, only two stations, viz. Mangalore and Port Blair show increasing trend in heavy rainfall.

During the summer monsoon season (June–September), a number of stations over Gujarat and Kutch and most of the stations on the west coast of India except Thiruvananthapuram and most of the stations over north interior Karnataka, Rayalaseema, Telangana, islands like Aminidivi and Port Blair show an increasing trend in heavy rainfall. Similarly, a few stations in Haryana and Punjab like Chandigarh and Ambala show an increasing trend. Some stations in west Madhya Pradesh, i.e. Indore, Khandwa and Seoni show an increasing trend in heavy rainfall. Pune also shows an increasing trend in heavy rainfall. Similarly, some discrete stations like Meerut in the plains of west Uttar Pradesh, Puri in Orissa, Midnapore in Gangetic West Bengal and Tezpur in Assam show increasing trend in the frequency of heavy rainfall. The remaining stations over India show either a decreasing trend or no significant trend in heavy rainfall during the season (Figure 1 *c*). It may also be mentioned that in the study by Srivastava *et al.*<sup>2</sup>, it was found that the total SW monsoon rainfall over Haryana, north interior Karnataka and Telangana indicates an increasing trend which supports the increasing trend in heavy rainfall found over some areas of these regions. It was also found that most of the districts

along the west coast of India except that of Kerala show an increasing trend in the total SW monsoon rainfall which supports the present finding of increasing trend in heavy rainfall during the SW monsoon season. For the remaining regions over India, though there is no significant trend in total sub-divisional or in district rainfall, there is a significant decreasing trend so far as 24 h heavy rainfall over observatory stations in that region is concerned. This indicates that the rainfall has become more evenly distributed in time over these regions.

During the post-monsoon season also a large number of stations over India show a decreasing trend in the frequency of heavy rainfall. However, a few stations in Marathwada, Telangana, Rayalaseema and Tamil Nadu do not show any significant trend. Similarly, a few stations over Bihar plains do not show any significant trend. Purnea, Goa, Panjim, Kozhikode, Ootacamund, Port Blair and Aminidivi show increasing trend in frequency of heavy rainfall during the season (Figure 1 *d*).

Annual frequency of heavy rainfall shows an increasing trend over the stations in Gujarat and Kutch and stations of the west coast, viz. Mangalore, and over other stations north of it. Trends over all other stations were found to be similar to that of the SW monsoon season except that over the southeastern parts where trends are similar to that in NE monsoon season (October–December).

In general, it has been seen that there is a decreasing trend in heavy rainfall in all the seasons over most parts of the country. Srivastava, Sinha Ray and De<sup>3</sup> have found that there is a significant decreasing trend in the occurrence of cyclonic storms over the Indian seas for the period 1891–1997. The decreasing trend in heavy rainfall over most parts of the country may be attributed at least partly due to the decreasing trend in the occurrence of the cyclones. The increasing trend in frequency of heavy rainfall over some of the drought-prone areas of the peninsula and some portions over Saurashtra and Kutch supports the find-

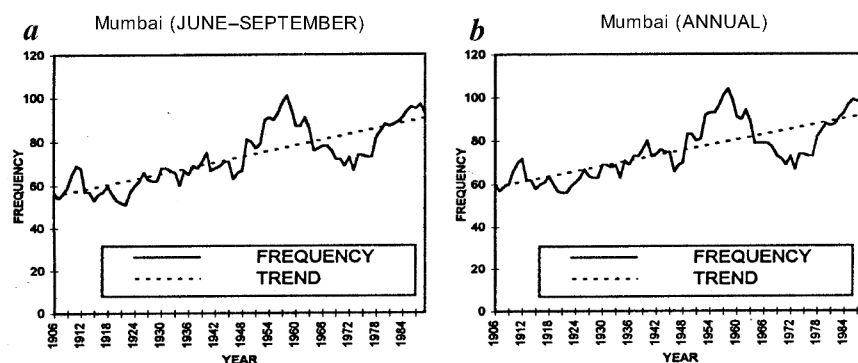


Figure 2. Frequency of heavy rainfall over Mumbai during *a*, SW monsoon season and *b*, annual.

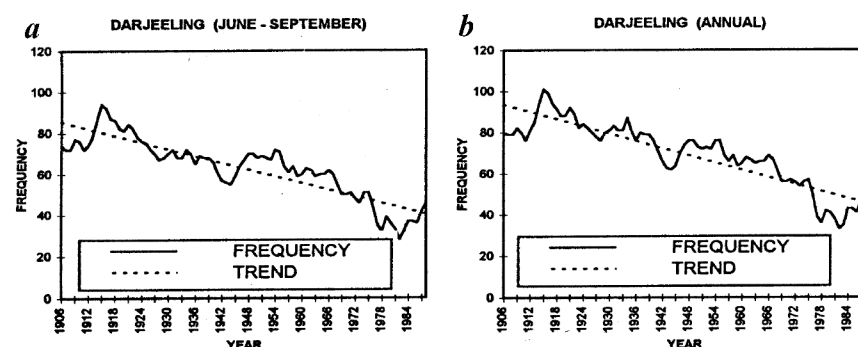


Figure 3. Frequency of heavy rainfall over Darjeeling during *a*, SW monsoon season and *b*, annual.

ings by Sen and Sinha Ray<sup>4</sup> regarding decreasing trend in the occurrence of the drought in these regions.

Figure 2 *a, b* shows increasing trend in the frequency of heavy rainfall over Mumbai during the SW monsoon season and annual, respectively. Figure 3 *a* and *b* shows a decreasing trend in the frequency of heavy rainfall over the hill station Darjeeling during the SW monsoon season and annual, respectively.

The frequency of heavy rainfall during pre-monsoon and post-monsoon season shows significant decreasing trend which may be at least partly attributed to the decreasing trend in cyclonic activity.

The frequency of heavy rainfall during winter shows a decreasing trend which may be attributed to the increase in turbidity, modifying the cloud micro-

physical process which requires in-depth study.

The frequency of heavy rainfall during the SW monsoon season shows an increasing trend over the west coast of India which may be due to increasing activity of the west coast trough. Increasing trend in the frequency of heavy rainfall over drought-prone areas of the country may partly be attributed to the decreasing trend in the occurrence of drought over India.

1. Srivastava, H. N., Dewan, B. N., Dikshit, S. K., Prakash Rao, G. S., Singh, S. S. and Rao, K. R., *Mausam*, 1992, **43**, 7–20.
2. Srivastava, H. N., Sinha Ray, K. C., Dikshit, S. K. and Mukhopadhyay, R. K., Paper presented in Tropmet 94, 1994.
3. Srivastava, A. K., Sinha Ray, K. C. and De, U. S. (to be published in *Mausam*), 1997.

4. Sen, A. K. and Sinha Ray, K. C., Paper presented in International Tropmet, 1997.

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K. C. SINHA RAY\*  
A. K. SRIVASTAVA

India Meteorological Department,  
Shivajinagar,  
Pune 411 005, India

\*For correspondence.  
e-mail: rsinha\_ray@hotmail.com

## Groundnut mutants resistant to tobacco cutworm (*Spodoptera litura* F.)

Tobacco cutworm (*Spodoptera litura* F.), a defoliating insect has become a major pest on groundnut crop in recent years<sup>1</sup>. In Karnataka, the transitional tract has been identified as the hotspot for *S. litura* during the rainy season, where yield loss to the extent of 66.6 per cent has been reported<sup>2</sup>. At present groundnut is predominantly grown under rainfed conditions, where insecticidal control is more expensive. Further, the insecticidal control of *S. litura* may not be always effective because of its polyphagous nature, rapid multiplication and resistance developed to some commonly used insecticides<sup>3</sup>. Integrated pest management which aims at keeping the pest population below the economic threshold through ecologically sound, economically feasible and environmentally sustainable means could be a potential option. The cultivation of resistant varieties is an important component of integrated management of this pest in India.

All the cultivated varieties are susceptible to *S. litura* and prone to substantial yield loss. Research efforts have been successful in identifying genotypes

resistant to *S. litura* but they suffer from undesirable attributes<sup>4,5</sup>, making them unsuitable for direct cultivation. A number of wild *Arachis* spp. have shown very high resistance to *S. litura*<sup>6</sup> but their exploitation is restricted because of difficulties in hybridization and introgression. Hence, there is a strong need to develop a new germplasm combining high level of resistance to *S. litura* with other desirable attributes.

In a mutation breeding programme with Dharwad Early Runner (DER), a Valencia line (VL 1) was isolated in our laboratory. This on further treatment with Ethyl Methane Sulphonate (EMS) yielded twenty-two secondary mutants resistant to rust and/or late leafspot<sup>7</sup>. Some of these mutants were found to be resistant to *S. litura* in the field. The present investigation was undertaken to systematically evaluate these mutants in the field and also to study the effect of selected mutants on the growth and development of *S. litura* when reared artificially in the laboratory.

The experimental material for field evaluation comprised 22 stabilized mu-

nants and their parents (DER and VL 1) along with resistant germplasm (GBFDS 272), and susceptible (JL 24) checks. Each genotype was sown in 2.5 m row with an inter row spacing of 30 cm and intra row spacing of 10 cm. The experiment was conducted in a randomized block design with two replications during the rainy season. Infestation of *S. litura* was artificially created by pinning an egg mass on each line at 45 days. As damage was mostly confined to the top leaves, the top five leaflets on the main stem of five randomly selected plants were scored at 65 days. The number of leaflets damaged and per cent leaf area damaged were visually assessed. The range and other parameters, viz. phenotypic and genotypic coefficients of variation, heritability and genetic advance revealed substantial amount of heritable variation for *S. litura* damage (Table 1). As indicated by high heritability and genetic advance, the area damaged was better than the number of leaves damaged as a criterion of resistance. Based on this, seven mutants (28-1, 28-2, 45, 98-1, 110, 110-1 and 172) were significantly