Risks of Aflatoxin Contamination of Groundnut in Vietnam: a Preliminary Study

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Aflatoxin contamination of groundnut occurs on an extensive scale in the tropics. It is an important food quality reducer. The main cause of aflatoxin contamination is the susceptibility of the groundnut germplasm currently in use by farmers. There is also an abundance of the aflatoxin-producing fungus, *Aspergillus flavus,* particularly in sandy and sandy loam soils which are suitable for groundnut production.

Biotic Factors and Aflatoxin Contamination

Aflatoxin contamination of groundnut becomes a serious problem in the presence of drought stress, pod-damaging insect pests, and soilborne diseases. In areas where groundnut is grown year after year in the same field, aflatoxin contamination is observed to be high.

In the presence of one or all of the biotic factors enumerated above for the occurrence of aflatoxin in groundnut in the field, the spread, intensity, and the extent of the damage caused to the quality of groundnut kernels is climate-driven. A detailed study of the weather parameters favoring aflatoxin contamination was initiated: (1) to highlight key climatic parameters that control contamination at various phenological stages of growth, and (2) to analyze the different agroecologies of Vietnam, in which the groundnut crop is grown, for aflatoxin risks.

Weather x Aflatoxin Contamination

The weather parameters that affect aflatoxin contamination are:

- Drought during seed-formation and maturation stages of crop growth, particularly in the top 10 cm of soil,
- Release of a long stretch of dry-soil conditions, when the crop is at maturation stage, by rain,

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- Occurrence of wet weather during field drying of the crop after harvest, and
- Climate of the storage space, which has an important bearing on the prevalence of aflatoxin contamination in seed, especially if the crop has escaped A *flavus* infection/aflatoxin contamination in the field. High humidity of the storage area, coupled with high temperatures or seepage of water into the store rooms, increases the chances of aflatoxin contamination.

The hot spots for aflatoxin contamination in groundnut production systems are generally drought-prone sandy soils, in which the groundnut crop is grown year after year, and the humid conditions under which the crop produce is stored.

Groundnut Production in Different Agroecologies in Vietnam

Vietnam has been divided into seven agroecological zones (Table 1). In the northern parts of the country (AEZs I-IV), three main seasons are recognized. A cool dry season when average daily temperatures are <20°C. It extends from Oct to Mar in the Northeast highlands ecoregion. This is followed by an intermediate season with a temperature regime ranging between 20 and 28° C. The warm season with a temperature regime exceeding 28°C is observed in AEZs II and IV; it extends during the summer season from May/Jun to Aug.

Of the three AEZs in southern Vietnam, a cool temperature regime (<20°C) is found only in the Southwest highlands ecoregion, otherwise these ecoregions are characterized by an intermediate thermal regime (20-28° C) for most of the year except for the rainy months.

The soil-moisture regime, particularly during drought stress, is favorable for at least 230 to 290 days across three of the AEZs. The length of the unfavorable soil-moisture regime, when moisture deficits occur, is about 75 days in AEZs I and II (the Northeast highlands and Northern midlands ecozones). In all the other ecozones, it ranges between 105 and 135 days.

Rainfall and Soil Moisture in Some Selected Locations

Groundnut is grown in all the seven AEZs of Vietnam (Fig. 1). In northern Vietnam, groundnut is grown mainly in the spring season (Feb-Jun), while in southern Vietnam it is mainly grown in the winter-spring season (Nov-Feb). One location with long-term climatic data was selected in each of the agroecological zones to quantify the probabilities of weekly rainfall for rainfall/potential evaporation (PE) ≥ 0.33, mean weekly rainfall, and soil-moisture variations in weekly steps. The Markov Chain model was used to calculate initial (W) and conditional (W/W) probabilities of rainfall. The 'standard meteorological weeks' scheme (established by the World Meteorological Organization) was employed. Soil moisture was simulated from weekly rainfall and PE records. The soil-moisture balance was estimated by the WATBAL:

Table 1. Agroclimatic characteristics of seven ecoregions of Vietnam[1].

		Thermal regime						Moisture regime[3]			
		Cool season (< 20°C)		Intermediate season (20° – 28°C)		Warm season (> 28°C)		Favorable		Unfavorable	
Agro-ecozone[2]		Period	Days	Period	Days	Period	Days	Period	Days	Period	Days
I	Northeast highlands	Oct–Mar	135±15	Apr–Sep	230±15	–	–	Mar–Nov	290±30	Dec–Feb	95±15
II	Northern midlands	Dec–Mar	105±15	Apr–May Sep–Nov	170±30	Jun–Aug	90±15	Mar–Nov	290±30	Dec–Feb	75±15
III	Northwest midlands	Dec–Mar	105±15	Apr–Nov	260±15	—	–	Apr–Sep	230±30	Oct–Mar	135±15
IV	North central midlands	Dec–Mar	60±30	Mar–Apr Sep–Nov	185±15	May–Aug	120±15	May–Nov	230±30	Dec–Mar	105±15
V	South central midlands	–	–	Oct–Apr	215±15	May–Sep	150±15	Apr–Nov	245±30	Dec–Mar	120±30
VI	South western highlands	Dec–Jan	30±30	Jul–Nov	235±15	–	–	Apr–Nov	260±30	Dec–Mar	105±15
VII	Southern lowlands	–	–	Jun–Mar	320±15	Apr–May	45±15	May–Nov	230±30	Dec–Apr	135±15

1. This table is a revision of the ecoregionalization of Vietnam reported by Dao The Tuam (1982).
2. In all the agroecozones, high-, mid-, and low-lands coexist. Generalized climatic tendency has been described as an average condition.
3. Moisture regime is based on a ratio of precipitation (P) and evaporation (E). If P/E is ≤ 0.5 the moisture regime is termed unfavorable for potential crop production, otherwise favorable.

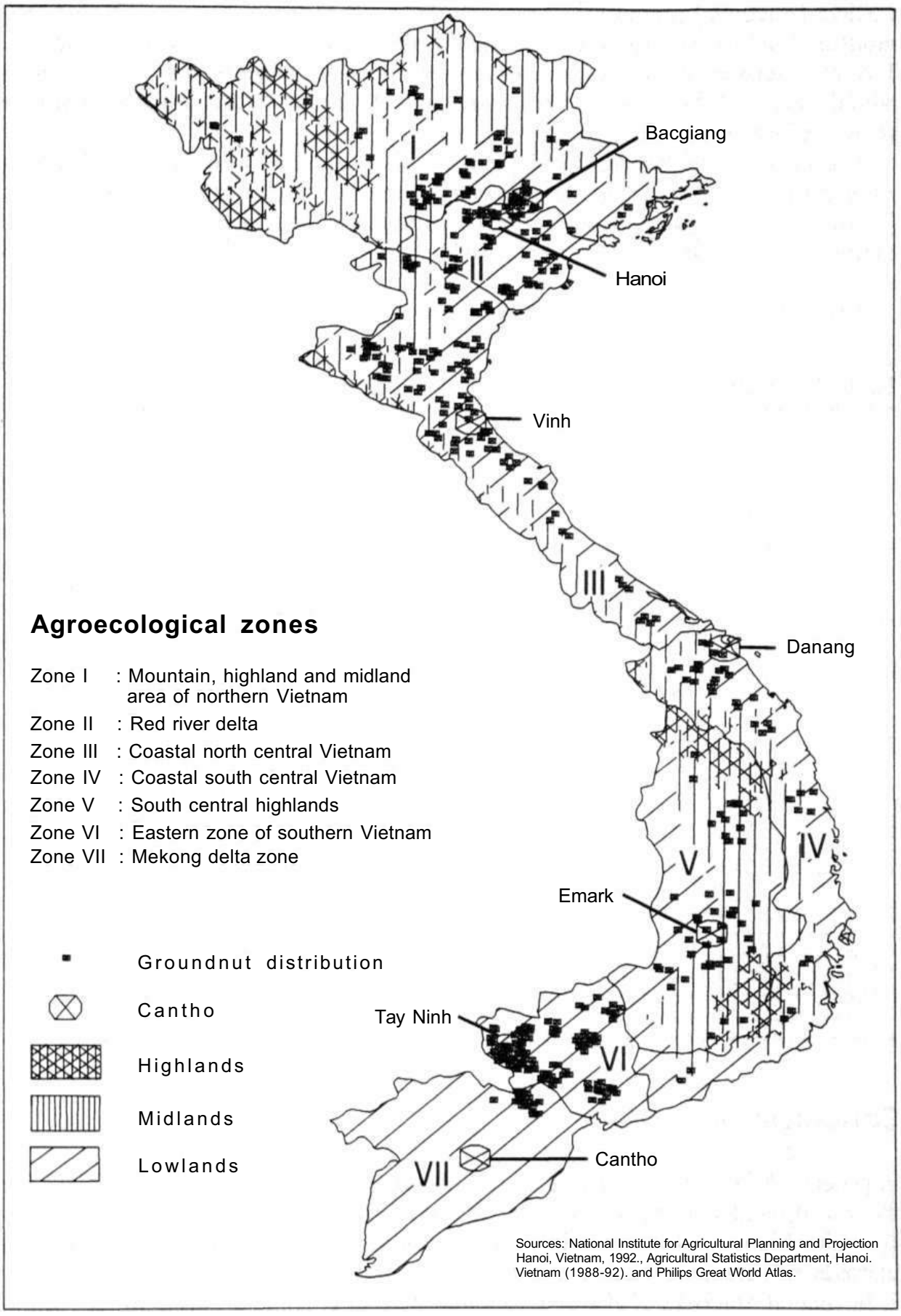

Figure 1. Groundnut distribution in the agroecological zones (AEZs) of Vietnam.

CSIRO (Australia) method; 120 mm was assumed as the maximum available soil-moisture holding capacity of the groundnut root profile across all the agro-ecozones. Two soil-moisture variation scenarios are given for each location: one for the lowest rainfall year, and the other for the highest rainfall year in the data available. Data are shown in Figures 2 to 8.

The relative risks of aflatoxin contamination in the different AEZs of Vietnam were assessed by comparing the amount of available soil moisture at three stages: (1) from establishment through to the reproductive phase of the crop, (2) from harvest to field drying of the crop, and (3) storage of the crop produce at the farm level.

The first approximation results obtained are given in Table 2.

Table 2. Potential incidence of aflatoxin in groundnut in Vietnam.

		Rating[1] of risks of aflatoxin contamination at 3 stages		
	Agro-ecoregion	Maturity[2]	Field drying	Storage[3]
I	Mountain highland and midland areas of northern Vietnam	2	4	8
II	Red river delta of northern Vietnam	2	4	8
III	Coastal north central area of Vietnam	2	2	7
IV	Coastal south central area of Vietnam	2	1	6
V	South central highlands	2	2	9
VI	Eastern zone of southern Vietnam	2	1	6
VII	Mekong delta zone	2	3	3

1. Rated on a scale of 1-9, where 1 = lowest, 9 = highest. This is based on frequency of drought stress and relative humidity of the air in storage rooms.
2. Maturity = Maturation stage of growth and development.
3. Storage means on-farm storage.

Conclusions

In general, AEZ VII represented by the Mekong delta zone presents conditions for the lowest incidence of aflatoxin in groundnut. Zones II and IV also present relatively low risks. Medium aflatoxin-risk areas are located in AEZs III and V, while the high aflatoxin-risk areas are AEZs I and II.

In general, the risks of aflatoxin contamination of groundnut during storage at the farm level are high throughout Vietnam.

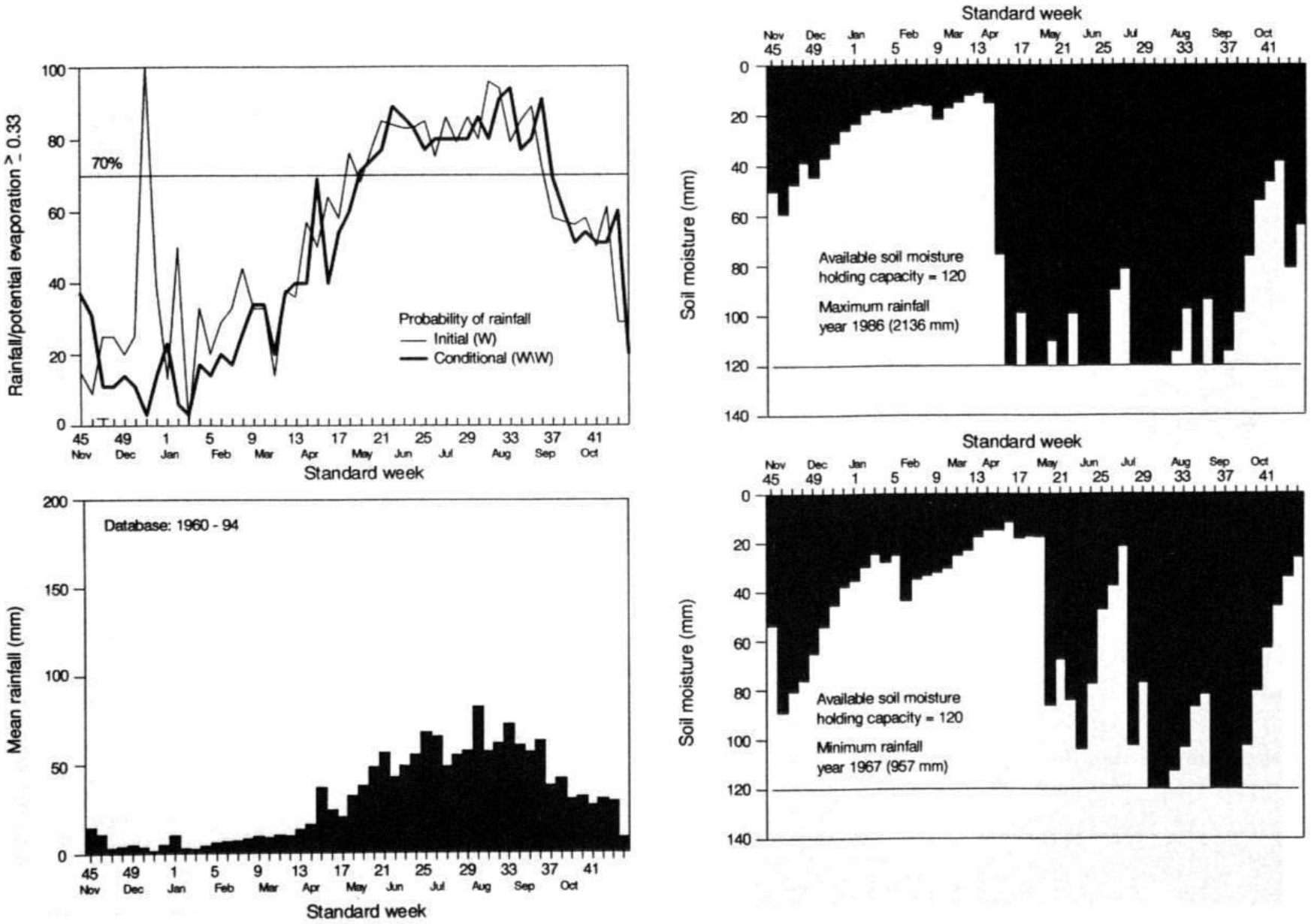

Figure 2. Rainfall and soil moisture in Bacgiang (21°16'N, 106°11'E; AEZ I).

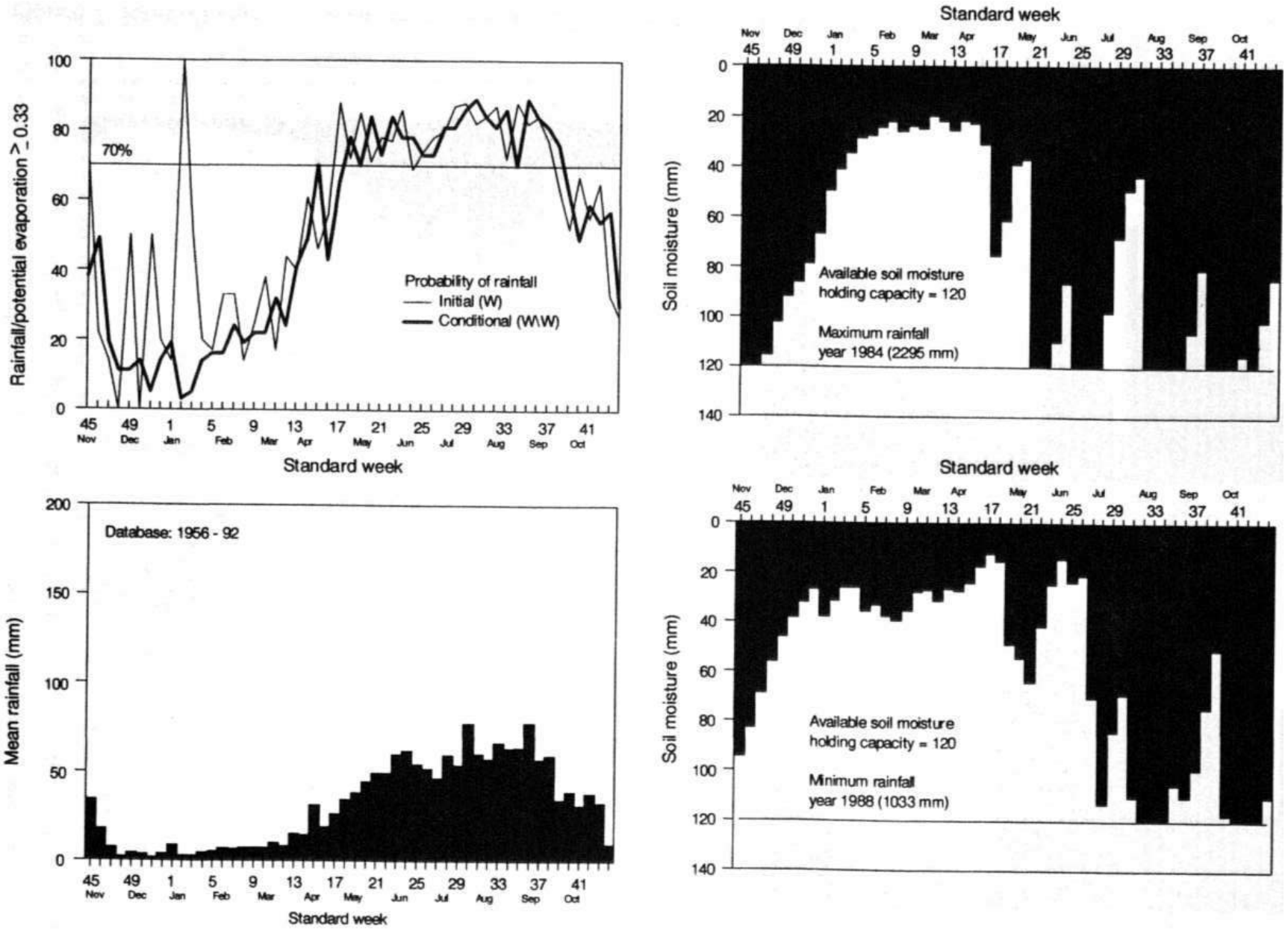

Figure 3. Rainfall and soil moisture in Hanoi (21°05'N, 105°55'E; AEZ II).

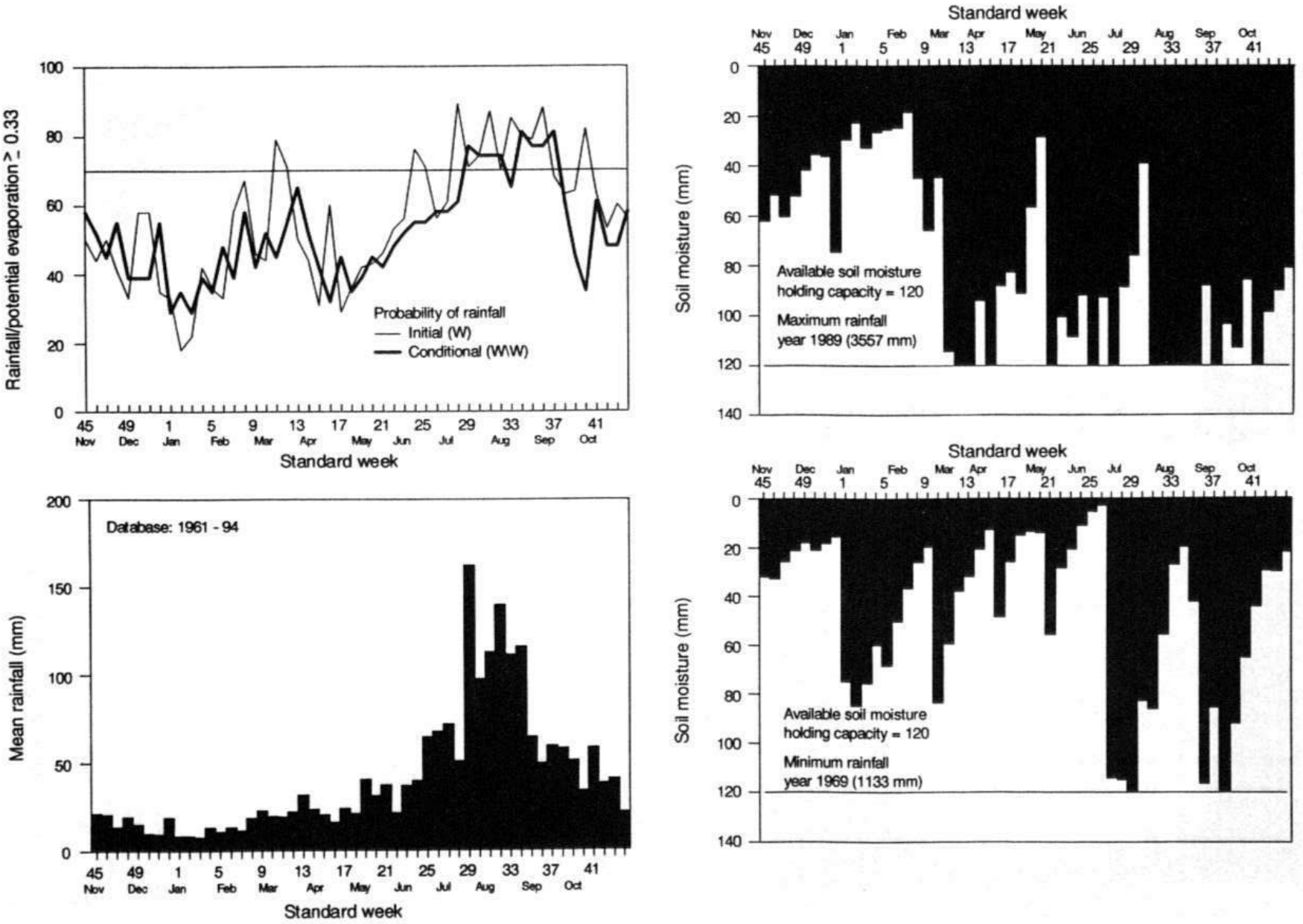

Figure 4. Rainfall and soil moisture in Vinh (18°45'N, 105°38'E; AEZ III).

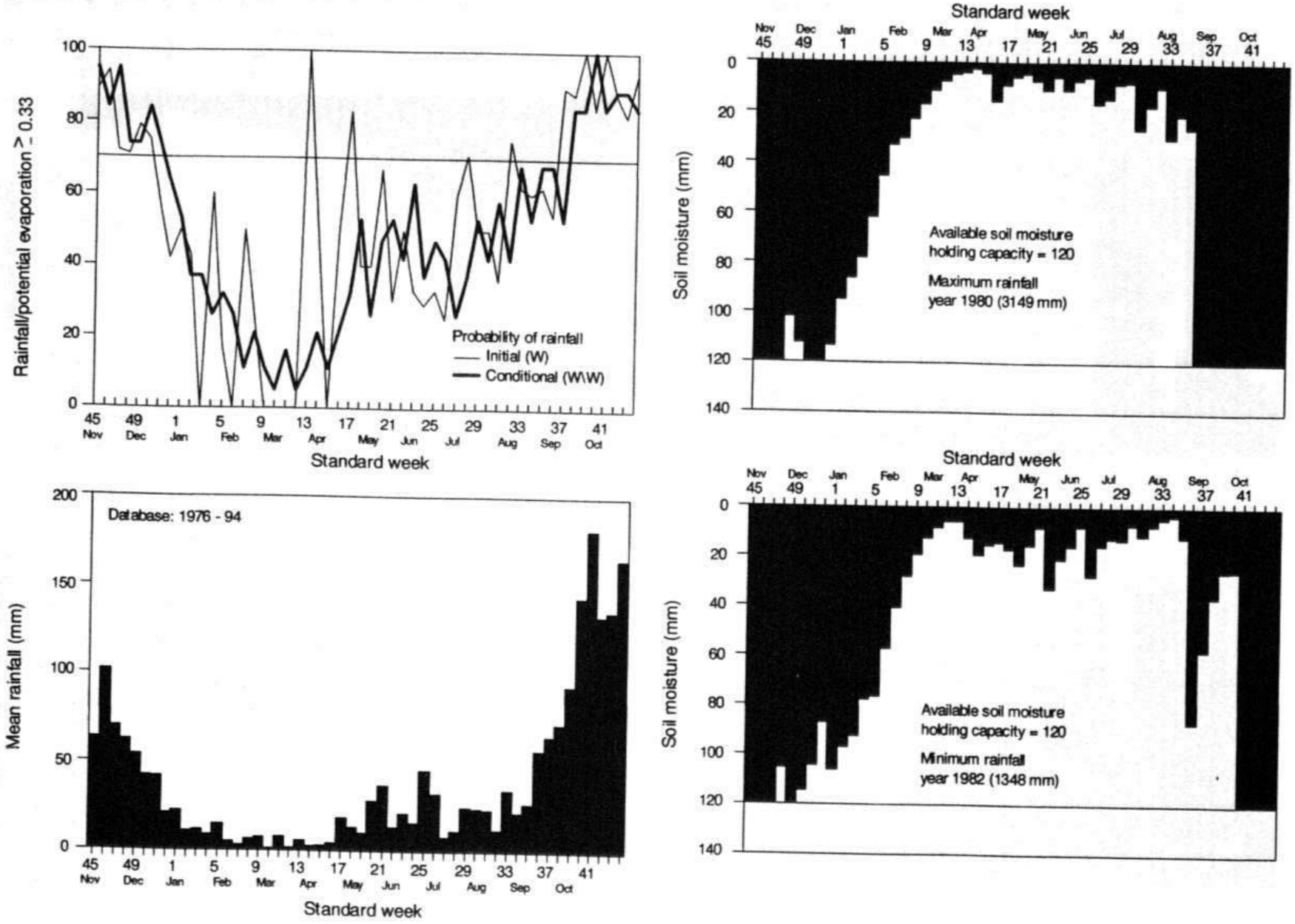

Figure 5. Rainfall and soil moisture in Danang (16°5'N, 108°10'E; AEZ IV).

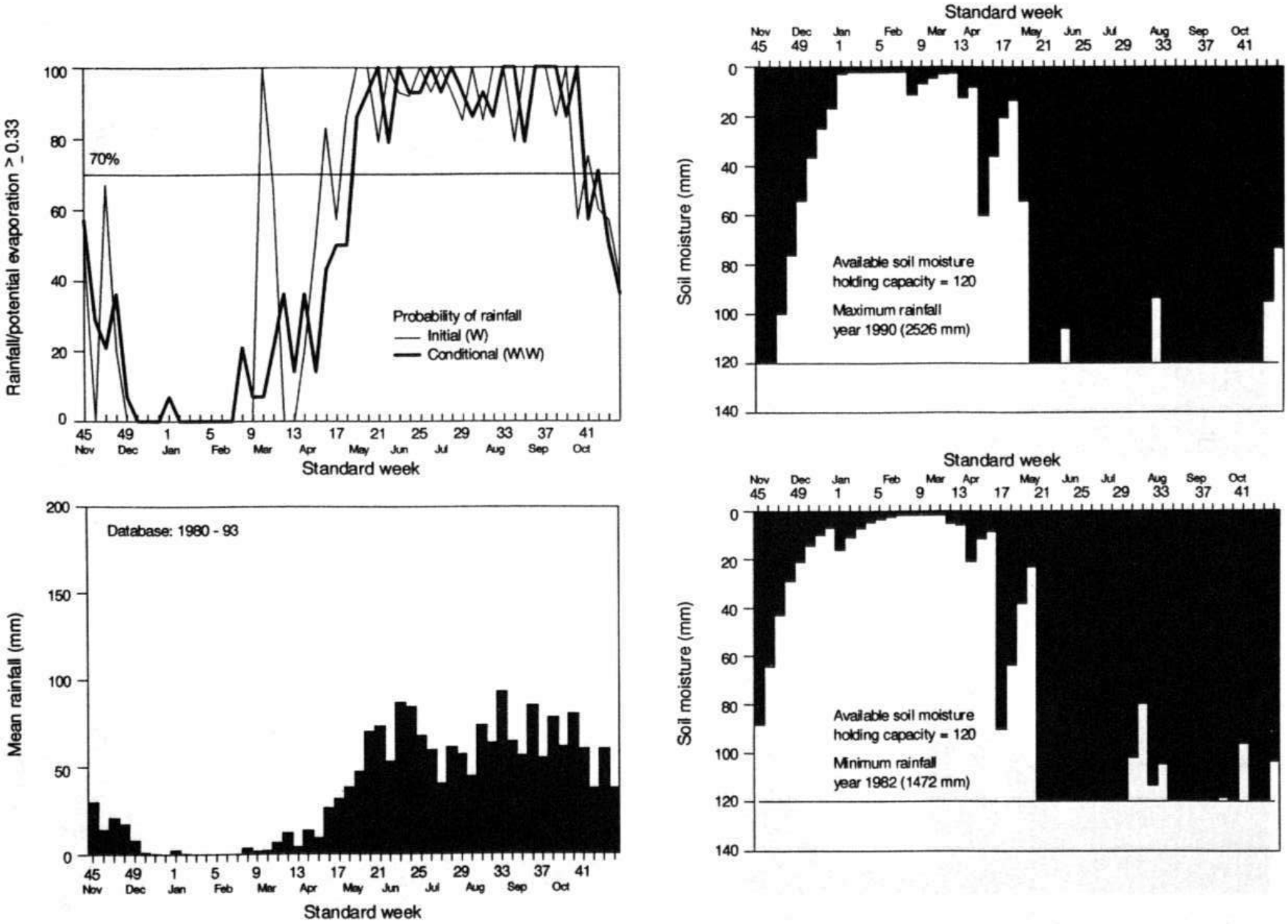

Figure 6. Rainfall and soil moisture in Emark (12°26'N, 108°13'E; AEZ V).

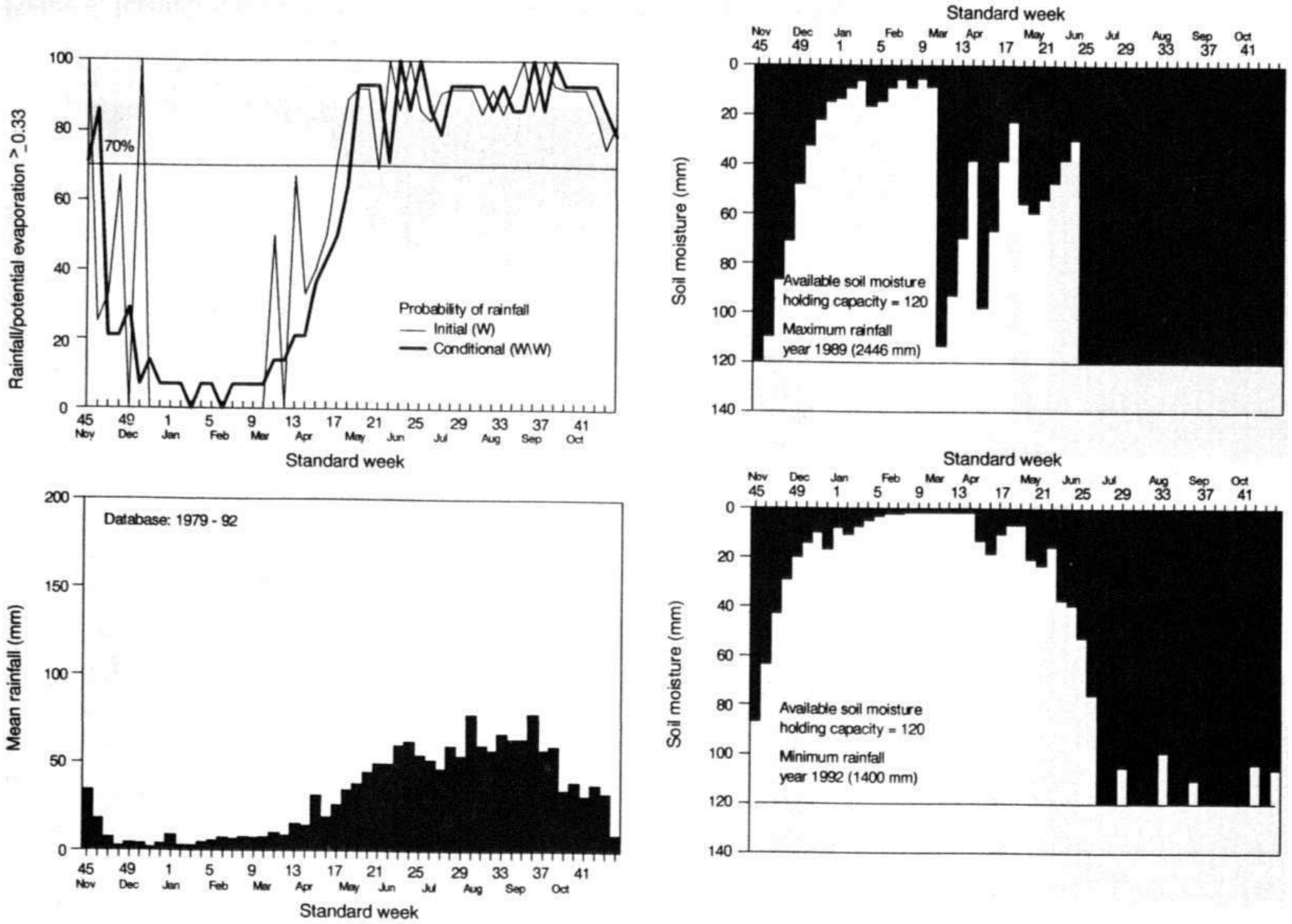

Figure 7. Rainfall and soil moisture in Tay Ninh (11°18'N, 106°04'E; AEZ VI).

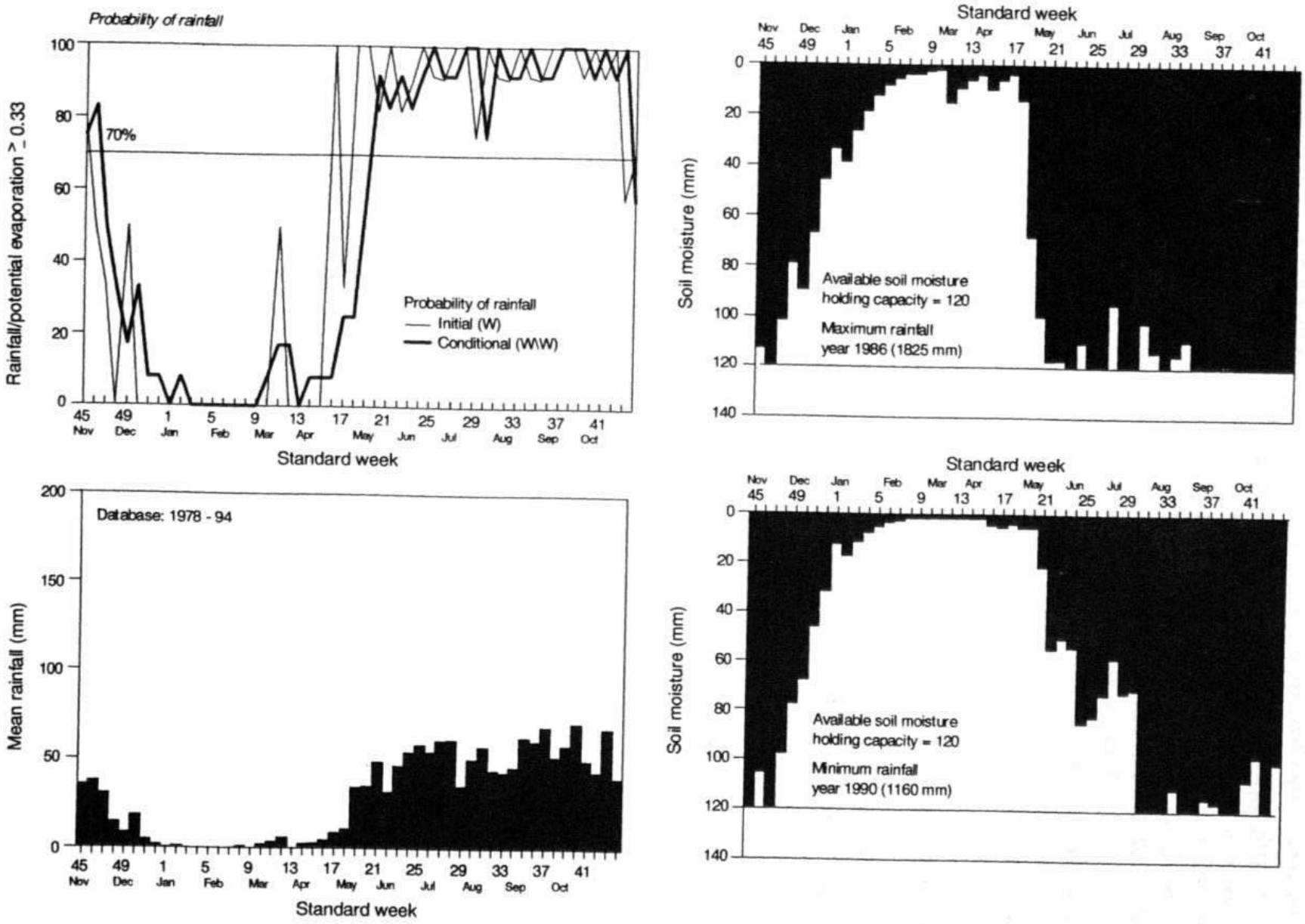

Figure 8. Rainfall and soil moisture in Cantho (10°2'N, 105°46'E; AEZ VII).

Future Research

This is a preliminary study. It is predominantly driven by climatic factors and, therefore, presents only a first approximation of aflatoxin contamination risks in groundnut during its production cycle and storage under on-farm conditions. It is suggested that well-designed experiments should be conducted across the seven AEZs in Vietnam. Some well-characterized benchmark sites should be chosen. All data pertaining to soil, climate, crops, and diseases should be collected. Farmers' produce and market arrivals of groundnut should be checked for A *flavus* and aflatoxin levels at regular intervals, using reliable analytical techniques.Complete analysis of the climatic data and abundance of aflatoxin-producing fungus should be carried out. This is a priority research area for Vietnam, as higher levels of groundnut production have been targeted for the coming years.

References

Dao The Tham. 1982. [Agroecological zones of Vietnam.] (In Vietnamese.) Hanoi, Vietnam: Vietnam Agricultural Science Institute. 16 pp.