Erosion, Transport and Deposition Processes (Proceedings of the Jerusalem Workshop, March-April 1987). IAHS Publ. no. 189, 1990.

Seasonal variations of runoff rates from field plots in the Federal Republic of Germany and in Hungary during dry years

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Abstract Plot measurements from the Mosel region (FRG) and from northern Hungary have been used to compare seasonal variations of surface runoff and sediment production in two different types of moist-temperate climate. In addition to seasonal contrasts between the summer and winter periods, the following differences have been detected: under the maritime west coast climate of the western part of the Federal Republic of Germany, surface runoff and sediment production during the summer period exceed that in the winter; in contrast, under the humid continental climate of Hungary, having a mediterranean influence, autumn rainfall and snowmelt in early spring often exert a dominant role. This situation occurred during the measurement period. There are also years with a summer maximum in runoff. Besides precipitation distribution, temperature and soil moisture regimes contribute to the above findings obtained under extreme conditions. The measurement series from both areas point to the existence of semiarid years with 300–450 mm precipitation per year, which are prone to further modifications.

INTRODUCTION

In general the temperate climate of Central Europe is humid during all months of the year. Walter diagrams show that Germany never experiences aridity, and that Hungary only approaches semiarid conditions in September (Fig. 1). Where the curves of temperature and precipitation cross during the summer, as in the case of Haifa, Israel, semiarid or arid months are registered.

There are, however, years with long lasting dry summer periods even in Central Europe. Two examples of such dry years will be discussed, one associated with the maritime temperature climate of western Germany and the other with the continental temperature climate of Hungary. By using plot-measurements, runoff and soil loss during such dry years will be considered.

The Mertesdorf experimental station (Trier) in the Federal Republic of

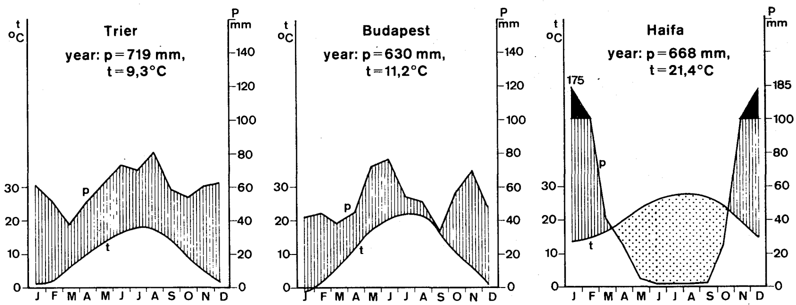

Fig. 1 Walter diagrams for the meteorological stations at Trier, Budapest and Haifa (t = temperature, p = precipitation).

Germany lies on the steep slopes of the Ruwer valley, a tributary of the Mosel. The slopes are covered with vineyards. The plots are 16 × 2.60 m (41.6 m^2) and have a slope angle of 25°. The rigosols developed on weathered slate have a profile depth of about 1 m, and a *K*-value of about 0.2. The mean annual precipitation is 720 mm.

The Pilismarót experimental station in Hungary lies near the well known "bend of the Danube" north of Budapest. The plots are 8 × 1 m (8 m^2) and have a slope angle of 8°. The *K*-value of the colluvial brown earth soils developed on loess is about 0.4. The mean annual precipitation of Budapest is 630 mm.

RESULTS

Although the values of soil loss from both sets of plots were adjusted to represent plots of 8° and 50 m, by use of the metric LS-diagram of Wischmeier, the soil losses cannot be directly compared. The main aim of this paper is, however, to compare the seasonal variation of runoff and soil loss during years with dry summer periods, such as occurred at Mertesdorf in 1975 and 1976 and at Pilismarót in 1984.

The characteristics of the rainfall distribution over the year are similar (Fig. 2): both stations have a minimum in late winter and early spring, a summer maximum and a second maximum in late autumn. A relatively dry period in Budapest during the late summer, however, reflects the mediterranean and continental influence.

With annual precipitation totals of 538 mm and 335 mm (the norm is 719 mm), the years of 1975 and 1976 were relatively dry in Trier. The Walter diagram shows dry conditions lasting from April to August 1976 (Fig. 3). The higher rainfall during July was caused by thunderstorms.

Similar conditions existed in Pilismarót in 1984 when the annual rainfall was 411 mm as compared to the norm of about 630 mm. The Walter diagram shows two dry months. In reality there were three, because the rainfall of August was nearly all associated with a single thunderstorm (Fig. 3). A neighbouring station a few kilometers away registered only 5 mm

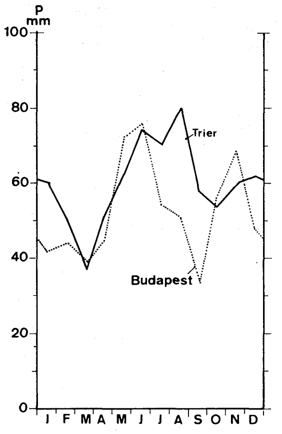

Fig. 2 The characteristic annual distribution of precipitation for Budapest (mean annual precipitation = 630 mm) and Trier (mean annual precipitation = 719 mm).

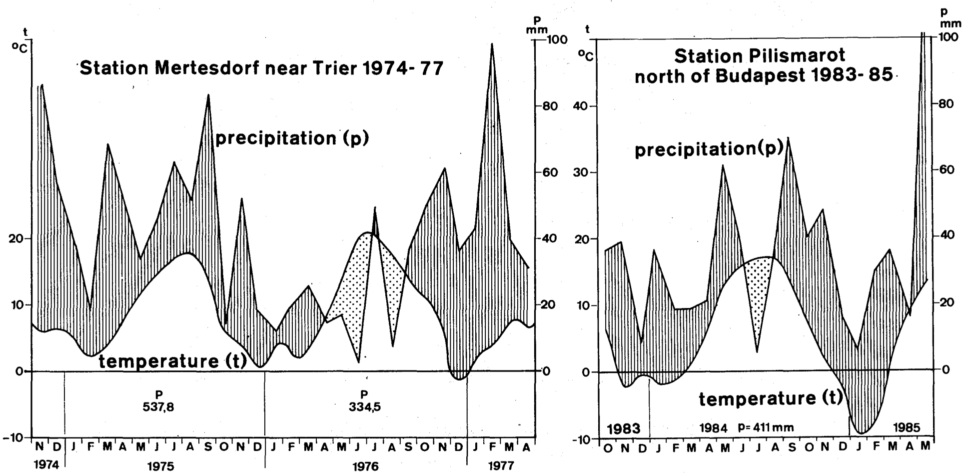

Fig. 3 Walter diagrams for dry years in Central Europe.

of rain as a total for the month.

Figure 4 shows the values of monthly runoff and soil loss for Mertesdorf. Runoff was high during the two winter seasons, for there were only short periods (1–2 weeks) with snowfall and snowmelt, which were interrupted by periods with rain. However, these winter seasons showed no soil loss. Towards spring the runoff values diminished in response to the lower precipitation and increased temperatures.

The two summer seasons were quite different. 1975 was a summer with several thunderstorms. They caused some high runoff events and soil losses. 1976 had a dry spring and summer, and there were no heavy thunderstorms. As a result it was a year with very low runoff and no soil loss.

Figure 5 shows the values of monthly rainfall, runoff and soil loss for

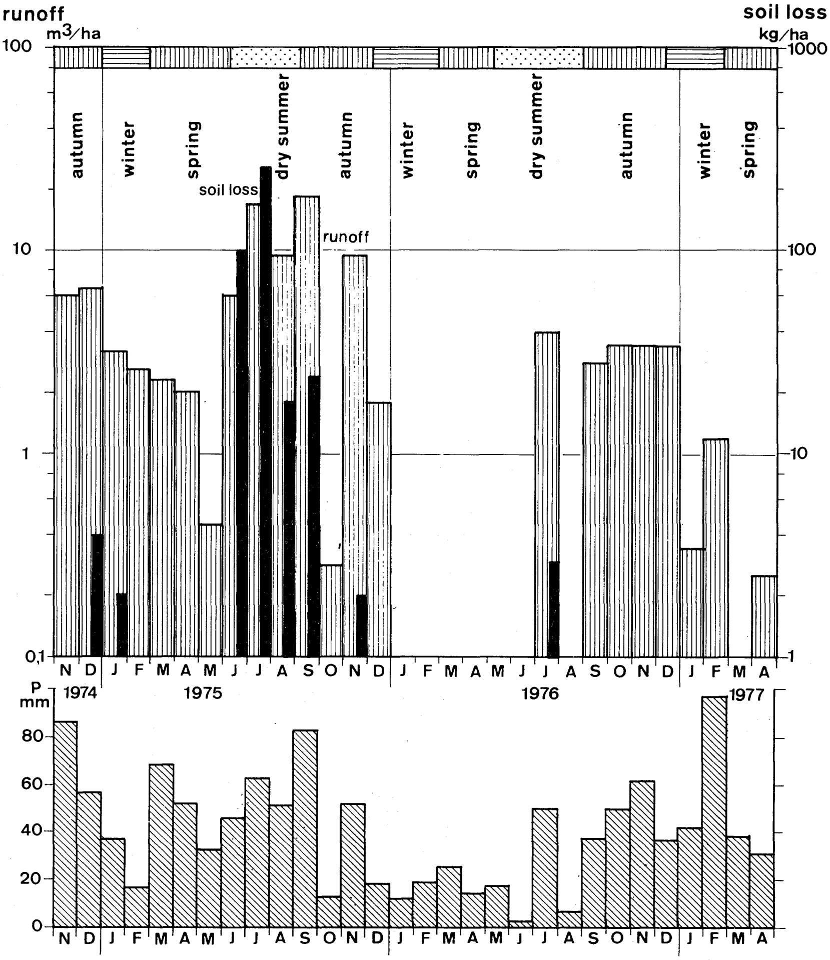

Fig. 4 Monthly values of precipitation, runoff and soil loss for the Mertesdorf experimental station near Trier, 1974–1977.

the Pilismarót experimental station during 1983–1985. Here the runoff periods were clearly separated by months with low runoff; the periods of snowmelt produced the maximum runoff values. They followed the winter periods with snow cover and without soil loss. If rainfall occurred during the melt period, as in March 1985, moderate soil losses occurred. The rainfall during the spring and the autumn caused runoff, but only the autumn showed moderate soil loss, a consequence of higher rainfall intensities. The dry summer of 1984 was generally a season with very low runoff, but in August a single thunderstorm caused high runoff and soil loss of nearly 2 t ha^{-1}.

DISCUSSION

This presentation of the data, based on monthly values, provides only a

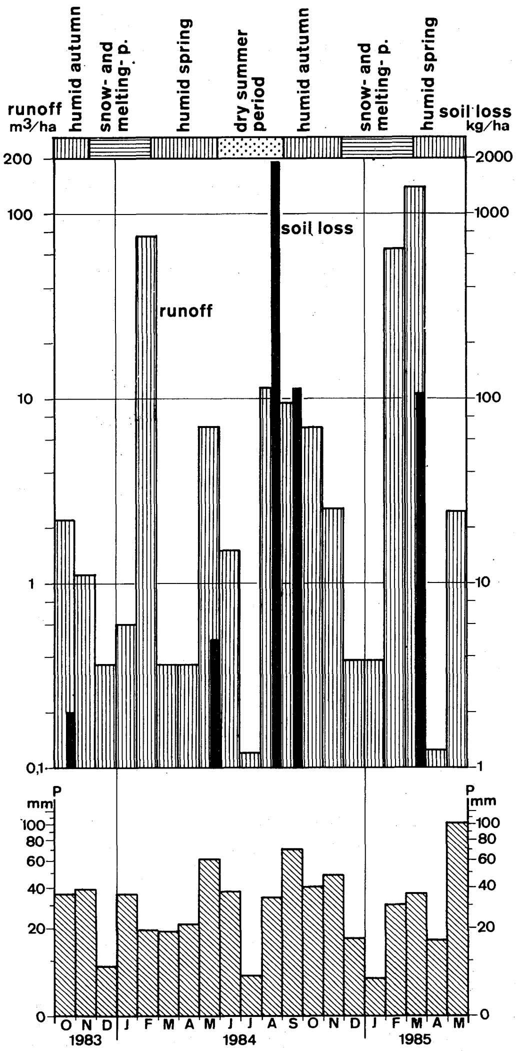

Fig. 5 Monthly values of precipitation, runoff and soil loss for the Pilismarót experimental station north of Budapest, 1983–1985.

limited view of the situation. The values were therefore aggregated for the natural seasons during the measurement period.

For the Mertesdorf station, the criteria for delimiting the natural seasons were:

winter: daily mean temperature below 5°C, short frost periods with snow and snowmelt, cyclonic rainfall less than in autumn and with low intensity;

spring: daily mean temperature 5–15°C, cyclonic rainfall of small amount and low intensity, sometimes short snow and sleet showers;

summer: daily mean temperature above 15°C, cyclonic and convective rainfall, the latter sometimes with high amounts and intensities, some dry periods;

autumn: daily mean temperatures 15–5°C, no frost days, mainly cyclonic but some convective rainfall of low to medium intensity. Towards the winter the amount of rainfall increases with an associated decrease in intensity.

For the station at Pilismarót the delimitation of natural seasons was much easier: the humid periods during the spring and the autumn were bounded by the dry summer periods and by the frost and snow periods of the winter, which ended with the period of snowmelt.

In Figs. 6 and 7 the values of runoff and soil loss for both stations are given for the natural seasons. In Mertesdorf the highest value of runoff

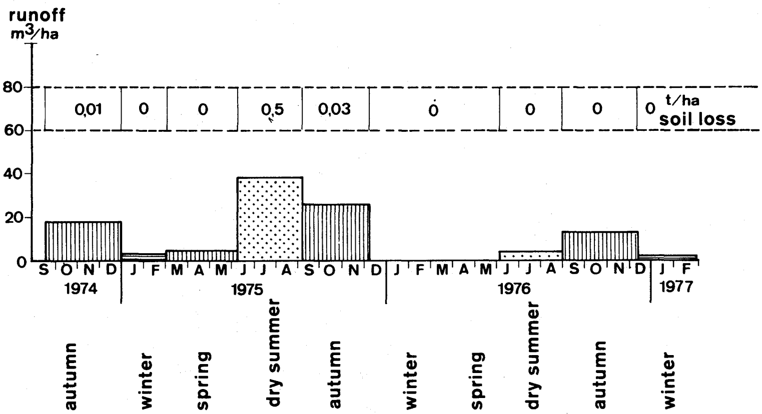

Fig. 6 Runoff and soil loss during the natural seasons 1974–1977 for the Mertesdorf station near Trier.

occurred during the summer, followed by the autumn. Only the summer season showed significant soil loss, and then only if thunderstorms occurred. At Pilismarót the main runoff season was the winter, especially during periods of snowmelt. The summer with some thunderstorms brought the maximum soil loss, although the runoff was much lower.

These features can be better expressed by diagrams showing proportional rates of runoff and soil loss during the natural seasons as a percentage of the annual total (Figs. 8 and 9). At Mertesdorf about 50% of the runoff and 90% of the soil loss occurred during the summer. At Pilismarót 60–80% of the runoff was measured during the winter season, but soil loss showed a concentration of 90% during the summer. In both regions the number of heavy thunderstorms during the dry "arid" summer period is responsible for the soil loss balance of the whole year. These significant differences in runoff can be related to the different winter climates. In the maritime temperate climate of Trier there is normally no continuous frost period during the winter. A large proportion of the rain infiltrates. As a result the runoff rate remains below 1% of the rainfall during winter and spring (Table 1). In the continental temperate climate of Hungary the soil profile was sealed by frost during

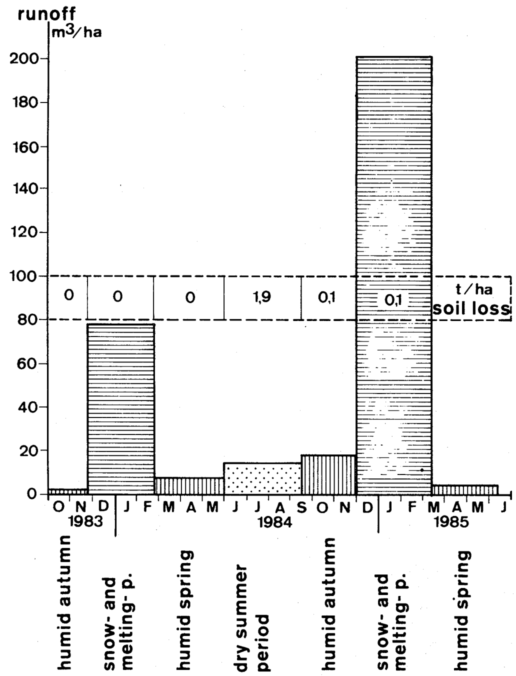

Fig. 7 Runoff and soil during the natural seasons 1983-1985 for the Pilismarót station north of Budapest.

both winter seasons. The precipitation accumulated as snow cover, and during the melt period high runoff values occurred. The runoff rate during the winter season was up to ~ 8% (winter 1983–1984) and ~ 27% (winter 1984–1985) of the precipitation (Table 1).

The dry summer periods, however, showed the same characteristics in both areas. Small rainfall events produced no runoff, but relatively high runoff rates and soil losses occurred if there were a few thunderstorms

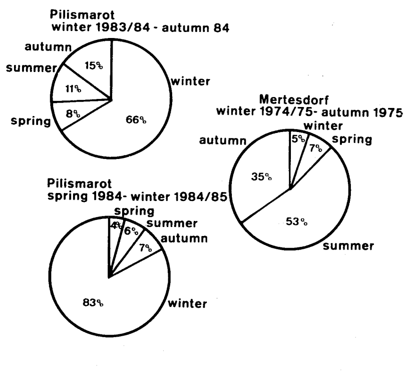

Fig. 8 Proportional runoff rates for the natural seasons.

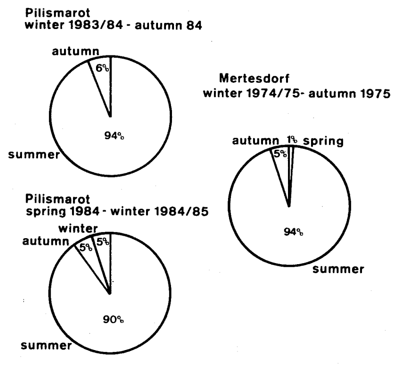

Fig. 9 Proportional rates of soil loss for the natural seasons.

Table 1 Values of precipitation, runoff, runoff rate and soil loss for the natural seasons (P = precipitation, R = runoff, R-rate = R in % of P, E = soil loss)

Station	Period	Season	P (mm)	R ($l\ ha^{-1}$)	R-rate (%)	E ($kg\ ha^{-1}$)
Mertesdorf	14.9.74 – 30.12.74	autumn	286.4	18798	0.6	12
	31.12.74 – 28.2.75	winter	65.4	3503	0.5	3
	1.3.75 – 5.6.75	spring	158.8	4800	0.3	4
	6.6.75 – 4.9.75	summer	170.6	37998	2.2	532
	5.9.75 – 3.12.75	autumn	149.1	25091	1.7	30
	4.12.75 – 23.3.76	winter	51.1	39	0	0
	24.3.76 – 5.6.76	spring	43.2	0	0	0
	6.6.76 – 1.9.76	summer	57.3	4011	0.7	4
	2.9.76 – 8.12.76	autumn	189.7	13693	0.7	3
	9.12.76 – 1.3.77	winter	143.9	1673	0.1	0
Pilismarót	29.9.83 – 25.11.83	autumn	37.6	2489	0.7	2
	26.11.83 – 25.2.84	winter	99.6	78152	7.9	0
	26.2.84 – 9.6.84	spring	128.2	9000	0.7	5
	10.6.84 – 14.9.84	summer	55.2	13500	2.5	1864
	15.9.84 – 2.12.84	autumn	159.2	18125	1.1	111
	3.12.84 – 17.3.85	winter	76.0	201625	26.5	104
	18.3.85 – 11.6.85	spring	145.4	2500	0.2	0

with high rainfall intensity. In this way, runoff and erosion react during these dry summer periods in a similar fashion to a semiarid environment.