HYDROMETEOROLOGICAL CONDITIONS OVER MUJIB BASIN, JORDAN

M.H.AL-Jabbari **A.K. Jamil** **I.A. AL-Nsour**
Department of Geology , College of Science , Baghdad University

ABSTRACT

The (P.E.) values reveal a similar seasonal variation .for six selected climatological stations over Mujib basin. The average annual values ranges between 2200 mm in the SE region to 1400 mm for the NW and SW regions of the basin. The relation between the long-term average values and the climatic parameters (Class A pan, Temperature; Wind, Sun Shine duration % RH %) for three climatological stations were determined using the linear regression equations. High correlation coefficient values suggest that the obtained equations are highly reliable. Mujib basin is divided into three climatic zones : Moisture index > -80 where the water balance for this zone shows water surplus during Dec. to Feb. and water deficit during March to November. Moisture indexes range between -80 to -90 where the water balance for the normal and wet water years show water surplus in this zone during the wetted months. Moisture index < -90 where the water deficit is experienced in high degree and no water surplus has been observed.

الخلاصة

أن قيم التبخر الكامن عند محطات مناخية مختارة في حوض الموجب (الأردن) قد عكست التباين الفصلي لهذه القيم. أن معدل هذه القيم السنوية تراوحت بين 2200 ملم عند الطرف الجنوبي الشرقي للحوض إلى 1400 ملم عند الأجزاء الشمالية الغربية والجنوبية الغربية من الحوض. تم تقييم العلاقة الرياضية بين المعدلات الطويلة المدى لهذه القيم مع المعاملات المناخية مثل قيم التبخر من حوض صنف-أ ، الحرارة، الرياح، نسبة ساعات السطوع الشمسي والرطوبة النسبية عند المحطات المناخية الرئيسة في الحوض حيث تميزت هذه العلاقات بدرجة ارتباط عالية بشكل عام تم تقسيم الحوض إلى ثلاثة مناطق مناخية متميزة وهي : مناطق تميزت بمعامل رطوبة عالية امتازت بوجود زيادة مائية وخلال الفترة من كانون الأول لغاية شهر شباط ومناطق تميزت بمعامل رطوبة متوسطة امتازت بوجود الزيادة المائية خلال أشهر الشتاء عموماً وأخيراً مناطق تميزت بمعامل رطوبة متدنية حيث لم تتواجد أيةة زيادة مائية خلال السنة

KEY WORD

Hydrometeorology, muijb basin, potential evaporation, climatic parameters, climatic zone.

INTRODUCTION

Mujib basin is located in the central part of Jordan, south of the Capital Amman. The coordinates of the study area with reference to the Palestine grid are (210 to 295) East and (020 to 147) North. Its area is approximately 6600 Km^2 of mainly plateau land to the east of the Dead Sea. The area is bound by Azraq basin in the north and Hasa basin in the south, while it extends to Azraq and Sirhan basins in the east and to the Dead Sea to the west (Fig. 1). The majority of the basins altitudes range between 700 to 900 meters above the mean sea level to the east of the hills, which mark the edge of the Jordan Rift Valley. The topographic relief becomes steeper with the direction eastward in the lower part of the study area. Because of the high difference in the elevation, especially in the lower parts of the basin, erosional features caused by rainfall and flashy floods, formed a scrap and steep canyon down to elevation about 400 meters below the mean sea level adjacent to the Dead Sea. However, during the rainy season, Jordan falls under the influence of frontal depression invading the Eastern Mediterranean region from the west at a rate of three to four frontal depression systems per month. As the air descends along the slopes of the western range of the Jordan Valley and the Dead Sea, its temperature increases causing substantial evaporation to the product of condensation Abandah,(1978). So the climate of the study area is predominantly considered to be under the influence of the east mediterranean sea, with cold wet winters and hot dry summers.

AIM AND SCOPE

This study is designed to assess the potential of water resources for Mujib basin based on long term records of data and to provide the specialists and the decision-makers with information in order to avoid any future problems throughout the planning of long term allocation and water development projects related to Mujib basin. This study will highlight on the evaluation of the climatological and hydrometeorological parameters of Mujib basin.

CLIMATOLOGICAL NETWORK

Water Authority of Jordan has six main climatological stations within Mujib basin (Table 1). Only three stations are still in operation. Hasa station has the longest period of records (June 1967 -Dec. 1996) **Fig. (1).**

The following data are measured at these stations :

Mean daily maximum and minimum air temperature (C°).

Wind speeds (km/hour) and total wind run (km/day) are measured at two meters height by anemometer.

Class A pan evaporation is measured (mm/day).

Two types of instruments were used in order to measure the solar radiation. first by (Gunn-Ballan) radiometer which measures the distillation (ml) and then converted to net back radiation (gm/cal/cm^2/day). Second by Campbell-Stokes (Solarimeter) which measures the sun shine hours by using the Glover Mcculooch relation then convert to radiation (0.29 cos Lat. + 0.52 n/N).

Piche' were used to measure the direct evaporation.

The missing data are filled using linear regression technique. Statistical values for the average monthly long-term means. Maximum, minimum values and standard deviation of the climatological data at six climatological stations are calculated.

RESULTS AND DISSCUSION

Vapour Pressure And Temperature

The relations between Vapour pressure (v.p.) and the average temperature (C°) and their equations at six climatological stations were created **Fig. (2)** and Table (2). High correlation coefficient (R^2) (0.89 to 0.97) between V.P and T. suggest that these equations are highly reliable.

Potential Evapotranspiration

IAM-ET0 computer program were used to calculate (P.E.) by mean of penman (1948) and Monteith, (1973) formula.(the Penman-Monteith model as FAO Expert recommends it). The monthly and annual long-term (P.E.) results were calculated **Table (3)** and **Fig. (3).** In January all the stations have minimum average monthly values ranging between 47 (mm/month) for Raba and Ez-Zeituna stations and 62(mm/month) for Hasa station. The maximum average monthly values observed where ranging between 183 (mm/month) at Mushaqqur station to 257 (mm/month) at Hasa station. The whole basin characterized by minimum values during Jan. and maximum in July. Regarding the annual long-term average (P.E.) values varies from 1283 (mm/year) at Mushaqqur climatological station to 1864 (mm/year) at Hasa climatological station.

The average long-term monthly (P.E.) values for the six climatic stations were calculated using Thornthwait's formula (1948) **Table (4)** and **Fig.(4).** In January have minimum average values ranges between 11 (mm/month) at Raba station and 19 (mm/month) at Mushaqqur station. The maximum average values were observed at all stations duringn July and range between 116 (mm/month) at Ez-Zeituna station to 132 (mm/month) at Hasa station except at Mushaqqur station where the maximum of 112 (mm) was observed during Aug. to Sep. while the basin has minimum values during Jan. The value of average annual long term (P.E.) values were ranging between 724 (mm/year) at Mushaqqur station to 892 (mm/year) at Hasa station. Comparison between the (P.E.) values calculated by both methods show that the values of Thornthwaite's method were far below the values calculated by Penman's method. It seems that Thornthwaite method is subjected to limitations under the conditions prevailing in the basin. Thus, Penman formula were recommended because it is and provide more satisfactory results. Monthly and annual (P.E.) average were computed for the selected normal wet and dry water years at the selected stations **Table (5).** and **Fig.(5).** The results shows a similar seasonal variation for the selected water years. The monthly values plotted versus the monthly climate factors (mean air temperature, wind run, class A pan, sunshine hours, relative humidity and Piche's) for main climatological stations **Figs. (6,7)** and **Fig (8)**. Such relations enable to estimate the (P.E.) values directly from any available climatic factor. These relations may be applied to other stations of similar climate in the basin. The regression equations and correlation coefficient values of these relations were given **Table (6).**

CLIMATIC CLASSIFICATIONS

The mean monthly value of each climatic factor is plotted versus time **Fig. (9).** The diagrams show a periodical cycles which can be divided into :

- Period that begins in August and ends in January where the values of mean T, V.P, P.D, Sunshine hours and Class A pan shows decrease with time and their lowest values during January.
- Period that begins in February and ends in July which characterized by increase in the values of the same climatic factors, except for RH% and Wind run values.
- Accordingly, three periods can be distingushed in Mujib basin :
- Wetted period prevail during the months November to February. Piche's difference and sunshine hours would be at lower limit, whereas the relative humidity and wind speed at their higher limit. During this period the region is mainly under the influence of the Mediterranean low pressure, cold front from the east moving to the west.
- Transition period prevail during late winter and spring (from middle of March and lasts to middle of May). It represents the transition period between the wetted and dry periods, where the values of the mean air temperature, Piches difference, sunshine hours, vapour pressure and class A pan increase, whereas the relative humidity, and wind speed decrease.
- Rest of the water year is practically dry with almost clear sky.

To determine the climate of Mujib basin, the classes suggested by Brown and Cocheme (1973) were used **Table (7).** The Rainfall values (R) and (1 P.E. 0.5 P.E, 0.25 P.E. and 0.1 P.E.) plotted versus time (month) **Fig. (10).** These relations show that within the main three stations the (R) curves intersect four curves of (P.E.) for more than two months and at (Ez-Zeituna) station intersect the four curves of (P.E.) for one month. suggesting that the climate at these stations in these months can be classified as humid (H). for Hasa station the curve of the rainfall intersect only 0.1 (P.E.) curve for 3 months (Dec. to Feb.) suggesting that the climate can be classified as intermediate (I). **Table (8).**

Aridity (I_a) and humidity (I_n) indeses where calculated using Thornthwaite, (1948) method while to calculate the moisture index (I_m), the equation given by (Carter and Mother, 1955) were used. The moisture index ($I_m = 1_n - 1_a$) for 31 rain-gauges over the period 1962-1998 (37 water years) were calculated Table (9). The data shows negative values ranging between -76 to -98. (i.e high aridity index values and low humidity index values). However, the majority of the area of the basin shows negative results. On these basis of the values of moisture index, Mujib basin can be divided into three climatic zones:

- Moisture index > -80, where the prevailing climate is considered moderate to semi arid. It represents areas of the high lands located north west and south west of the basin and extend to the 150 mm isohyetal line presenting about 15% of the total Mujib basin area. The water balance equations shows that this zone has a water surplus for three months (Dec. to Feb.) and low water deficit over the period Nov. to March.
- Moisture indexes between -80 and -90, indicating a semi arid climate representing the area 150 mm 250 mm isoyetal line forming about 15% of the total Mujib basin area. The water balance equation for the normal and wet water years show surplus in this region during the wetted months. These regions also experienced water deficit over longer duration than upper region.
- Moisture index < -90, prevailing climate is dry representing more than 70% of the total Mujib basin area. It covers Siwaqa, Qutrana and Sultani sub basins. This zone is located east and south east of 150 mm isohyetal line The water deficit is experienced in high degree and no water surplus has seen for long-term average water year.

SUMMERY AND CONCLUSIONS

The (P.E.) values reveal a similar seasonal variation fat the six selected climatological stations over Mujib basin. The average annual (P.E.) value ranging between 2200 mm in the SE region and 1400 mm in the NW and SW regions of the basin. The relation between the average long-term (P.E.) values and the climatic factors (Class A pan, Temperature, wind run, Sun Shine RH% and Pechie') for the main three climatological stations (Mushaqqar, Raba and Hasa) were determined using the linear regression equations. High correlation coefficient values suggest that these equations are highly reliable. The majority of the area shows negative moisture index at the 31 rain-gauge stations over the period of the observation (1962-1998) ranging between -76 to -98. Accordingly, Mujib basin is divided into three climatic zones : The moisture index > -80 representing high lands area located at the NW and SW of the basin extending to of 150 mm isohyetal line. The water balance for this zone shows water surplus during the period Dec. to Feb. and water deficit during Nov. and March. The miosture indexes range between -80 to -90 representing the area located between 150 mm to 250 mm isohyetal lines. The water balance for the normal and wet years show water surplus in this zone during the wetted months. The miosture index < -90 representing more than 70% of the total basin located E and SE of 150 mm isohetal line. The water deficit is experienced in higher degrees and no water surplus has been observed for the long-term average.

REFFRENCES

Abandah, A., I., (1978), Long range forecasting seasonal rainfall in Jordan, A report, 9p, Meteorological department, Aman, Jordan.

Carter and Mother, J., R., (1955), Climatic classification for environment biology, Publications in climatology, Vol XIX No.4.

Monteith J., (L.1973), Principles of environmental physics, Handbook, Edward Arnold,241 p, London, UK.

Penman, H., L., (1948), Natural evaporation from open water, bare soil and grass, Proc. Roy. Soc., A. 193, p 120-l46, London, UK.

Thornthwaite, C., W., (1954): A re-examination of the concept and measurement of potential evapotranspiration, Lab. of climatology, Geo. Rev., Vol. No.7, p55-94, Centerton, New Jersey, USA.

Brown, I. H. and Cocheme J., (1973), A study of the geometerology of high lands of eastern Africa, W.H.O, Tech. No. 129, 197 p, Jeneva, Switzerland.

Table (1): Climatological stations within Mujib Basin

ID. No.	Station Name	Palestine Grid		Coordinates		Elev.	Duration of record		Remarks
		East	North	Long.	Lat.	m.a.m.s.l	From	To	
CC04	Mushaqqar	226.2	132.9	31° 46′	35° 52′	787	Dec-64	Sep-96	In operation
CD20	Siwaqa	253.7	66.8	31° 22′	36° 06′	775	Jan-68	Mar-73	Closed
CD23	Qaser	221	80.9	31° 19′	35° 45′	900	Jul-68	Jan-85	Closed
CD26	Ez-Zeituna	235.7	129.7	31° 45′	35° 54′	765	Nov-84	Oct-69	Closed
CD10	Raba	220.5	75.5	31° 16′	35° 45′	870	Jan-86	Dec-96	In operation
CF07	Hasa	243.6	30.6	30° 52′	35° 59′	800	Jun-67	Dec-96	In operation

Table (2): Long-term polynomial regression equations for the relation between temperature (T) versus Vapour pressure (V.P) at the climatic stations

Station	Regression Equations	R^2
Mushaqqur	$V.P = 0.03T^2 - 0.423T + 9.23$	0.96
Raba	$V.P = 0.03T^2 - 0.38T + 8.82$	0.97
Qaser	$V.P = 0.01T^2 + 0.16T + 5.95$	0.94
Ez-Zeituna	$V.P = 0.025T^2 - 0.285T + 8.16$	0.93
Hasa	$V.P = 0.01T^2 - 0.06T + 6.3$	0.89
Siwaqa	$V.P = 0.02T^2 - 0.12T + 6.7$	0.93

Table (3) Long-term monthly averages of the P.E (mm) for the six climatic stations calculated by Penman's Formulae.

Month	Hasa mm	Siwaqa mm	Qutrana Mm	Raba Mm	Ez-Zeit. mm	Mushq. mm
OCT	143	133	127	102	118	112
NOV	90	84	81	78	72	75
DEC	65	59	53	50	47	68
JAN	62	59	50	47	47	50
FEB	76	76	73	50	56	50
MAR	118	115	93	87	84	68
APR	168	150	132	123	123	90
MAY	220	211	167	164	171	130
JUN	243	222	192	162	198	159
JUL	257	245	211	186	208	183
AUG	239	220	195	171	195	174
SEP	189	171	156	144	153	123
Annual	1870	1745	1530	1364	1472	1282

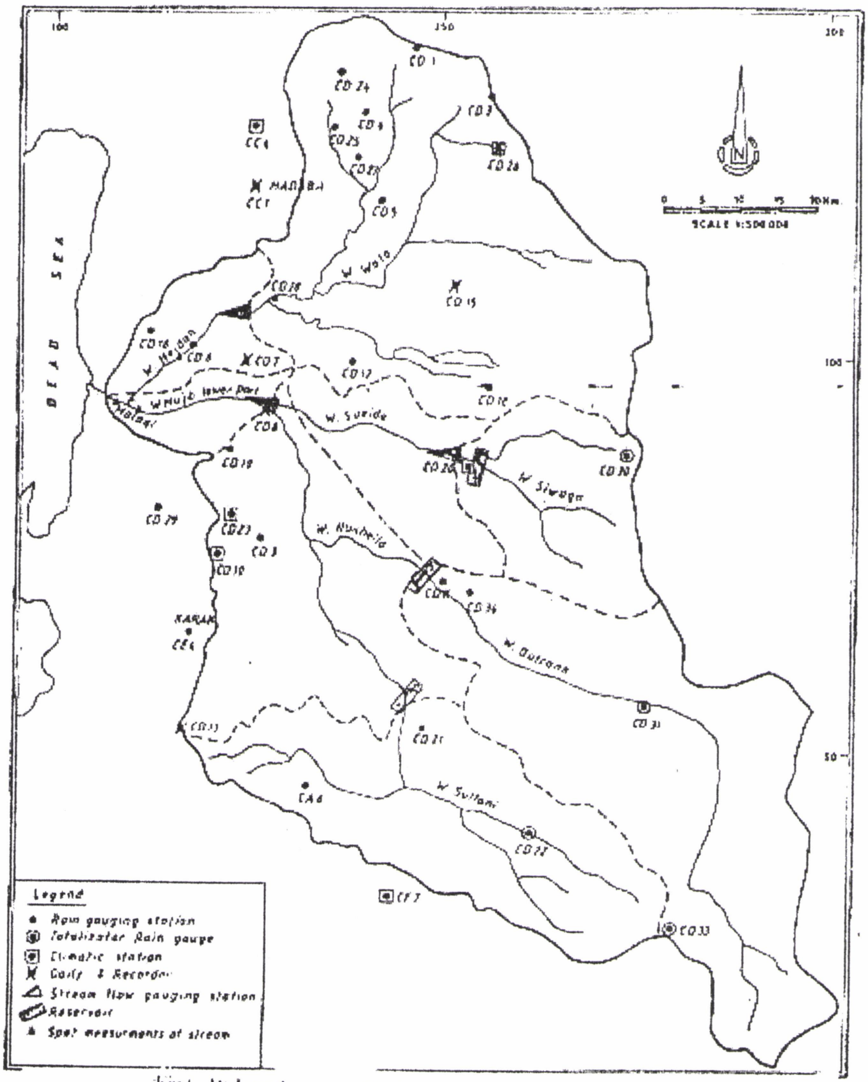


Fig (1): Location map of hydrological and climatological stations at Mujib basin.

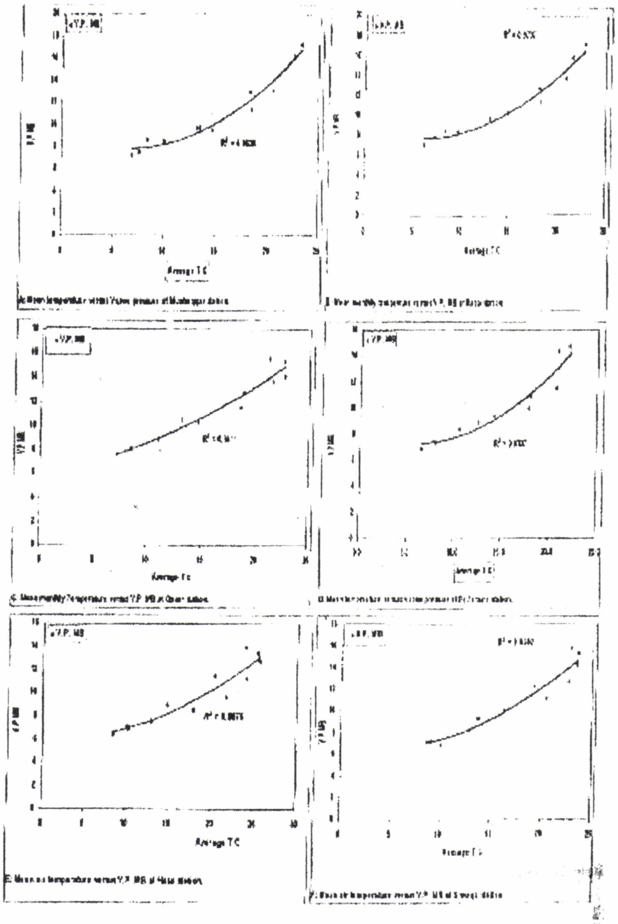
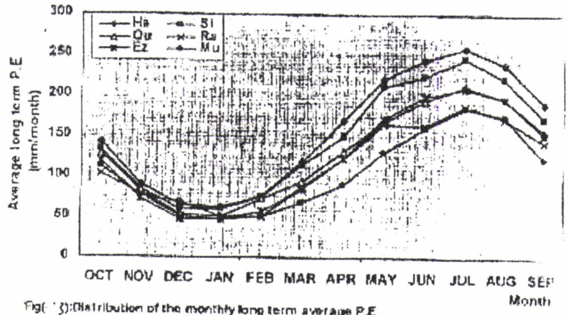
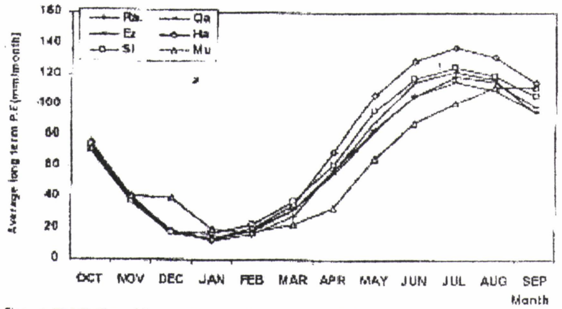


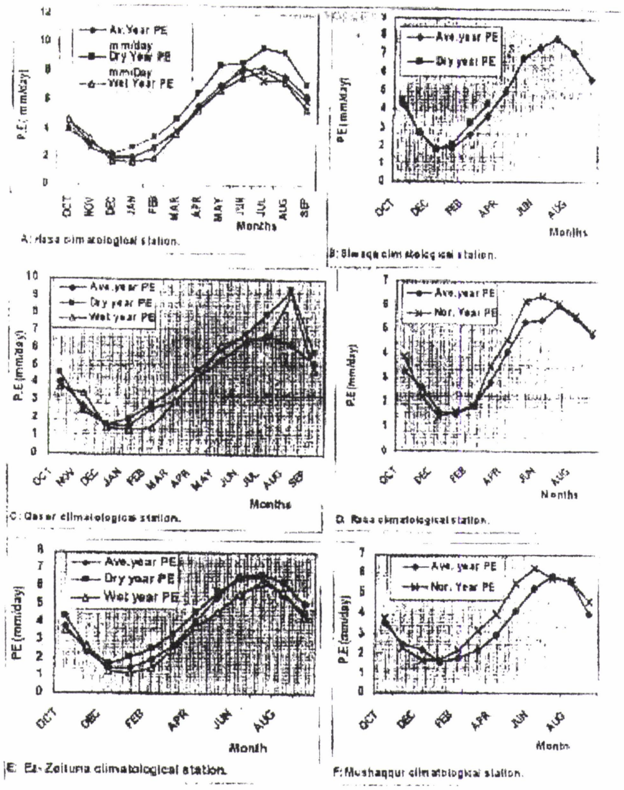
Fig (1): Relation between Mean air temperature and Vapour pressure at the six climatological stations.



Fig(3):Distribution of the monthly long term average P.E calculated by Penman's Method at the six cimatic stations.



Fig( ): Distribution of the monthly long-term average P.E calculated by Thornthwait's method at the six climatic stations.



ig (5): Monthly P.E results at the six climatological stations within Mujib basin for the normal, wet, and dry water years

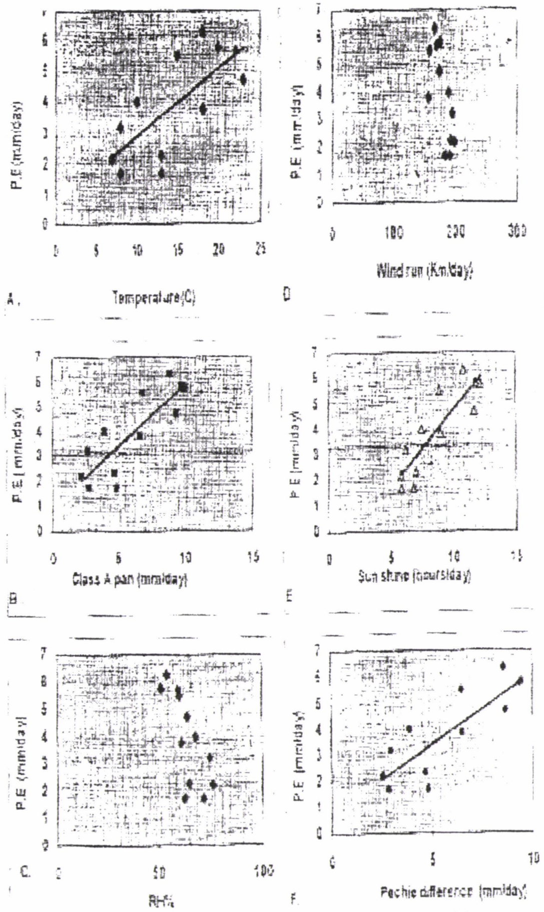


Fig (6): Relationships between potential evapotranspiration PE and climatological elements at the Mushaqqur climatological station(Dec1984-Sep1996).

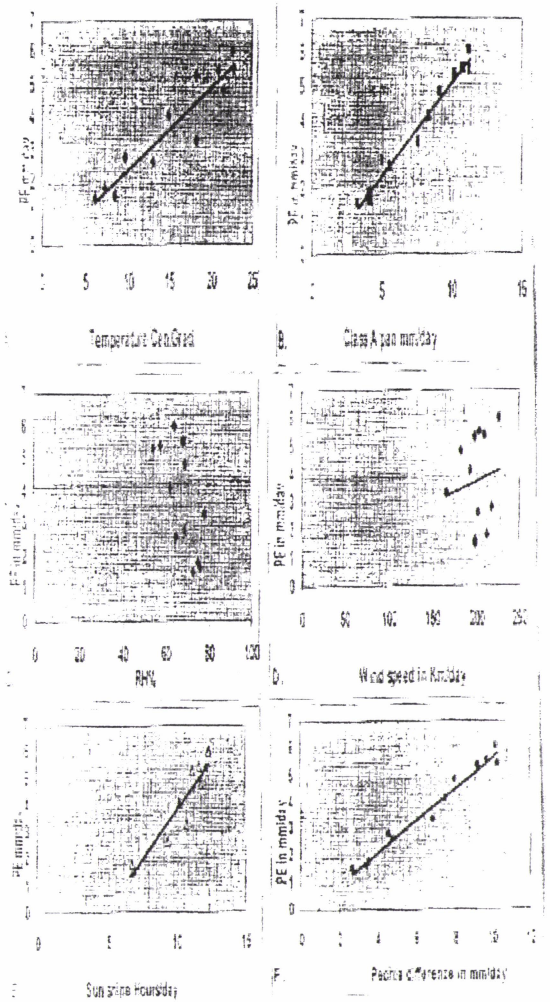


Fig ( ): Relationships between potential evapotranspiration PE and climatological elements at Raba climatological station over the period(Jan1986-Dec1996).

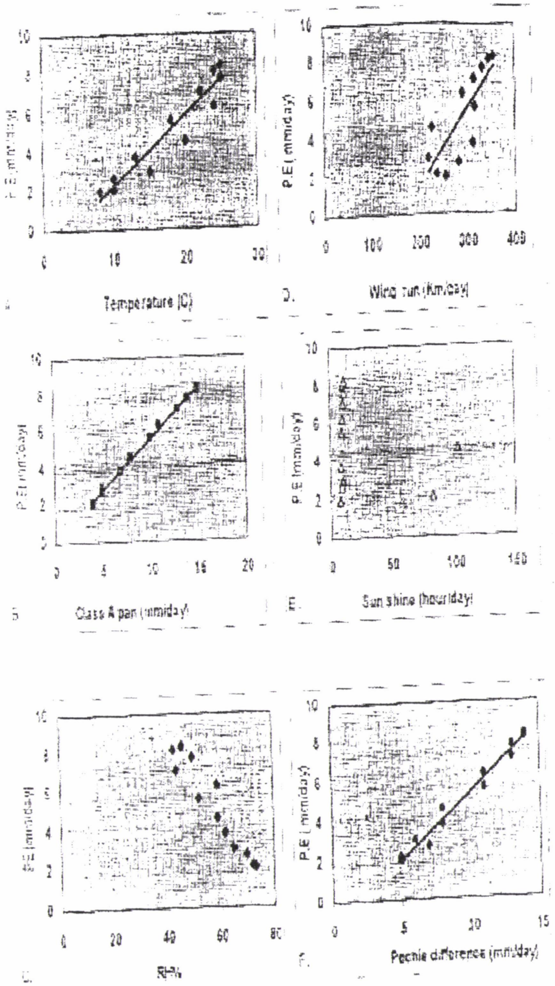


Fig (5): Relationships between potential evapotranspiration and the climatological elements at Hasa station.

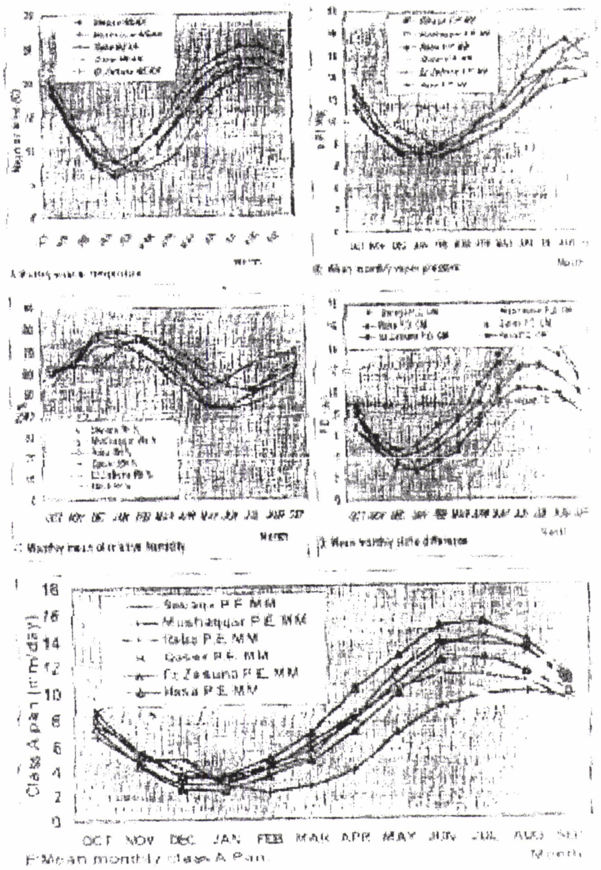


Fig. [illegible] Long term variations of the climate elements of Mujib [illegible] as they appear in the six climatological stations.

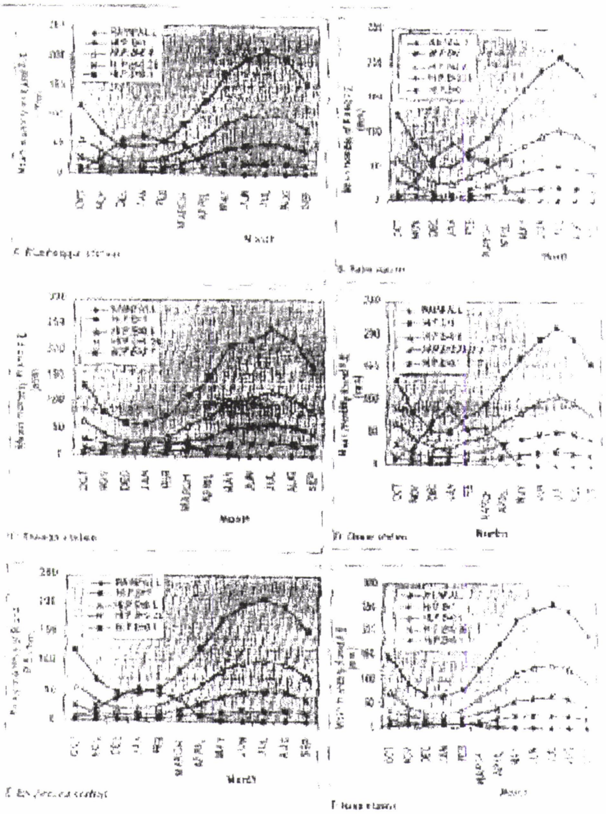


Fig. [illegible] Relationships between mean monthly rainfall and the [illegible] over the six climatic stations at