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Oak trees decline; a sign of climate variability impacts in the west of Iran

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ABSTRACT

The Persian oak, *Quercus brantii*, trees in the Zagros region of Western Iran have been in decline since 2000. The decline is assumed to be highly connected with changes in meteorological parameters. Our objectives were to quantify the long-term trends in meteorological parameters and reference evapotranspiration (ET_0) in the Zagros region and estimate ecohydrological parameters highly affected by climate variability and related to rainfall interception (*I*) process (*i.e.*, canopy storage capacity (*S*), the ratio of mean evaporation rate from the wet canopy to the mean rainfall intensity (*E/R*), and the free throughfall coefficient (*p*)). Long-term (1961-2010) changes in air temperature (*T*), precipitation (*P*), and wind speed (*WS*) were obtained from six synoptic meteorological stations located in the region. Throughfall (*TF*) was measured using the sixteen rain gauges randomly located underneath the crown of the five individual trees. *P* was measured using rain gauges fixed in an open space nearby to the oak trees .*I* was computed as the difference between *P* and *TF*. From 2000 to 2010, meteorological parameters and ET_0 changed slightly; *T*, *WS*, and ET_0 increased (+0.6 ˚C, +0.4 $m.s^{-1}$, +0.25 $mm.day^{-1}$, respectively), while *P* decreased (-60 mm).When climate patterns between 1961-2010 were analyzed for 6 synoptic weather stations, *P* significantly decreased significantly at one station, whereas *T* significantly increased at two stations and significantly decreased at another. *I* was estimated to be 40% and 25% within in-leaf and leaf-less periods, respectively. During the in-leaf period, the mean values of *S*, *E/R*, and *p* were roughly estimated to be 1 mm, 0.22, and 0.23, respectively. Our results indicate that the Zagros region is getting warmer and oak trees will indisputably experience reduction in the available water because of increased evaporative loss.

Key words: Ecohydrological parameters, Evapotranspiration, Interception, Meteorological parameters, Oak trees decline.

INTRODUCTION

Decline/dieback of trees is a condition characterized by episodes of premature, progressive loss of trees or stand vigor without clear evidence of physical injury or attack by a primary disease or pest. Several biotic and abiotic factors have been considered important in tree health studies, such as climate conditions, drought, storms, heat (Drobyshev *et al.* 2008; Bolte *et al*. 2010), insect damage (Moraal & Hilszczanski 2000), disease outbreaks (Mistretta 2002), or human interventions induced influences such as climate change, air pollution and fires (Signell *et al*. 2005; Kabrick *et al*. 2008). Over the last few years, millions of oak (*Quercus* spp.) in the world have been affected by a complex disease known as oak decline, oak dieback or oak mortality, depending on the area and the particular case taken into consideration (González Alonso 2008).

The tree decline has heavily affected oak species in many countries e.g., Hungary, Austria, Slovakia, Turkey as well as Iran (Hämmerli & Stadler 1989; Freer-Smith & Read 1995; Führer 1998; Thomas & Büttner 1998; Davari & Askari 2005). Determining the reason for oak trees decline is challenging because there are numerous interacting factors that affect oak health (González Alonso 2008). Persian oak,*Q. brantii* var. *persica*, in the west of Iran have been in decline since 2000 (Beyranvand *et al*. 2016). Iranian forest managers believe that no single cause is responsible for the decline of oak trees (Attarod *et al*. 2016). Forest degradation, frequent droughts, overgrazing, suspended particles and dusts created from adjacent locations, coupled with changes in meteorological parameters in recent years, are assumed to reduce the ability of trees to deal with environmental stresses. One of the predominant hypotheses in decline of the oak trees in Iran is variations in meteorological parameters in recent years (Attarod *et al*. 2016). Research suggest that climatic variability and climate change may have a significant impact on hydrological parameters; namely runoff, evapotranspiration (*ET*), soil moisture, interception (*I*), and ground water (e.g., Remrova & Cislerova 2010; Wang *et al*. 2013; Murray 2014). The main objectives of our study were (i) to examine the long-term trends of the meteorological parameters and reference evapotranspiration (ET_0) in the Zagros region, and (ii) to estimate ecohydrological parameters of the individual Persian oak affected by climate change or climate variability.

To our knowledge, no studies used meteorological variables to detect and monitor the oak trees decline in Iran.

MATERIALS AND METHODS

Study area

The research was conducted in the Zagros region of Iran.

The region consists of the western and southern slopes of the Zagros Mountains range, which extends from the Turkish border to the Northwest to the Persian Gulf to the Southeast (Fig. 1).

In this region, the average annual precipitation (*P*) varies between 250 and 800 mm, while the mean annual air temperature (*T*) ranges from 9 ºC to 25 ºC (Fathizadeh *et al*. 2013).

Rainfall historically occurs during winter and spring. Summers are hot and dry (mean: 35 ºC) and winters are cool (mean: 7 ºC).

Meteorological data and evapotranspiration equation

Long-term meteorological data (1961-2010) from six synoptic meteorological stations (Fig. 2 and Table 1) were used to parameterize the De Martonne Aridity Index, I_{DM} (Baltas 2007).

We used the FAO Penman-Monteith (*PM*) combination equation to calculate daily ET_0. We also used *PM* method to ET_0 as the standard method proposed by the International Commission for Irrigation and Drainage (*ICID*) and Food and Agriculture Organization of the United Nation (*FAO*).

The *PM* equation for calculation of the daily ET_0 assumes the reference crop evapotranspiration. The hypothetical crop has an assumed height of 0.12 m, a surface resistance of 70 s m^{-1} and an albedo of 0.23. It closely resembles the evaporation from a green grass of uniform height, actively growing and adequately watered (Allen *et al.* 1998):

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1+0.34u_2)} \qquad \textbf{(1)}$$

whereET_0 (mm day^{-1}) is the reference *ET*; R_n (MJ m^{-2} day^{-1}) is the net radiation at the crop surface; *G* (MJ m^{-2} day^{-1}) is soil heat flux density; *T*(°C) is the mean daily air temperature at a height of 2 m; u_2 (m s^{-1}) is the wind speed at a height of 2 m; e_s (kPa) is saturation vapor pressure calculated as e_s= 0.6108 exp [(17.27 T) / (T+237.3)]; e_a (kPa) is actual vapor pressure computed as e_a = $(RH \times e_s) \times 100$, where *RH* is daily relative humidity (%); $e_s - e_a$ (kPa) is vapor pressure deficit (*VPD*); Δ (kPa $°C^{-1}$) is the slope of vapor pressure curve at the daily mean *T*; and γ (kPa $°C^{-1}$) is the psychometric constant calculated as 0.665× 10^{-3}×AP; in which AP (kPa) is the atmospheric pressure. G at the daily scale beneath the grass reference surface was relatively small and thus could be ignored in PM combination equation. Therefore, $G= 0$ ((MJ m^{-2} day^{-1}) (Goyal 2004; Maruyama *et al*. 2004).

To calculate daily ET_0, we employed daily mean T, RH, WS at 2 m height and sunshine hours.

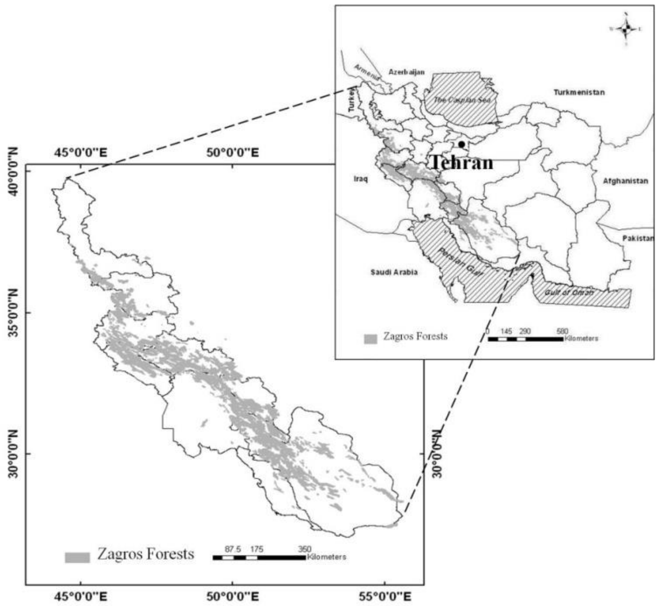

Fig.1. Location of the Zagros region, west of Iran

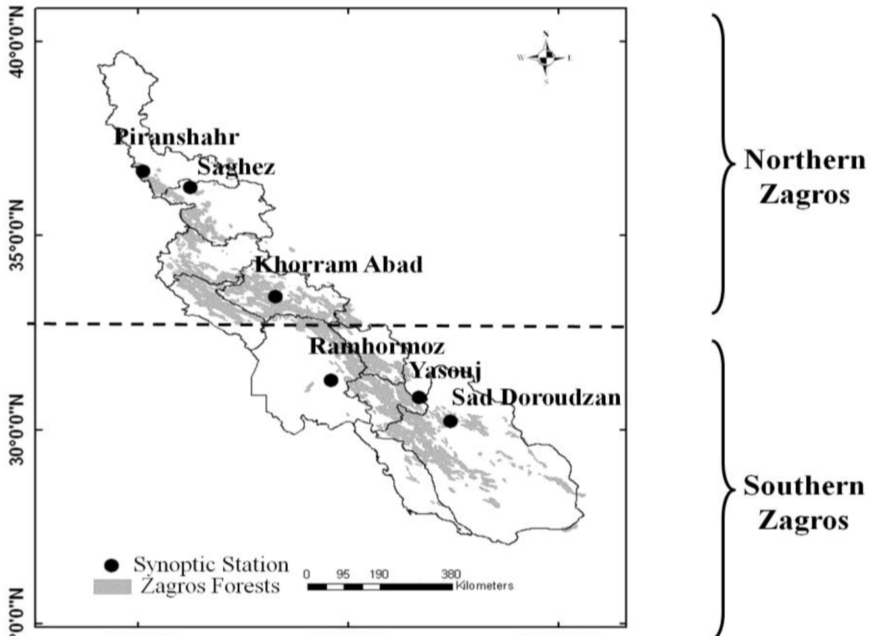

Fig. 2. Positions of the six synoptic meteorological stations in the Zagros region, west of Iran.

Trend test of the meteorological parameters and ET_0

The linear trends in meteorological parameters of Ta, P, WS, and ET_0 during the period 1961-2010 in the Zagros region were evaluated by the Mann-Kendall (MK) test, which has been found to be an excellent tool for trend detection and extensively used to detect monotonic trends in series of meteorological data (e.g., Ludwig *et al*. 2004; Zhang *et al*. 2004; Patra *et al*. 2012). When the MK statistic (Z_{MK}) is greater than 1.96 (based on normal probability Table), there is a significant increasing trend (α = 0.05), whereas negative Z_{MK} values lower than -1.96 show significant decreasing trends (α = 0.05).

Measurement of rainfall interception (*I*) and estimation of ecohydrological parameters

Measurements of *P* and throughfall (*TF*) were conducted at Shurab Forest Park, Khoram-Abad City (Fig. 2). The field experiment was carried out over two months started at October, 26, 2013 and ended in December, 19, 2013. Five isolated, typical, and mature *Q. brantii* trees were selected with similar morphology features (*i.e.*, tree height, h (7.0 m); diameter at breast height, *DBH* (30 cm); crown diameter, *Cd* (6 m²); crown-projected area, *CPA* (40 m²); and leaf area index, *LAI*, (2)). *LAI* was measured using a fish eye camera (Canon EOS 6D EF 8-15 mm f / 4L) during the in-leaf season. The standard method of measuring the *CPA* is to project the edges of the crown to a horizontal surface (Levia 2004). *CPA* was measured with a clinometer and a tape.

Table 1. Characteristics of the synoptic meteorological stations located in the Zagros region, west of Iran. Climate classification was achieved according to the De Martonne Aridity Index (I_{DM}) after Baltas *et al*.(2007).

Station	Lat. (North)	Long. (East)	Elevation a s l (m)	I_{DM}	Climate classification	Range of meteorological data
Piranshahr	36° 42′	45° 09′	1455	29	Humid	1986-2009
Saghez	36° 15′	46° 16′	1523	23	Mediterranean	1961-2009
Khorram Abad	33° 26′	48° 17′	1148	18	Semi-arid	1961-2010
Ramhormoz	31° 16′	49° 36′	150	8	Arid	1987-2010
Yasuj	30° 50′	51° 41′	1831	33	Humid	1987-2009
Sad Doroudzan	30° 13′	52° 26′	1620	17	Semi-arid	1988-2010

The crown radius was measured as the distance from the center of the tree bole to the edge of the crown. To obtain the best estimate of mean crown diameter, we used the average of 4 cardinal directions (N,E,S, and W) (Ahmadi *et al.* 2009). The canopies of these trees did not overlap with adjacent trees. *P* was collected using five rain-gauges (catch area, 64 cm² each), in a nearest neighboring open area. The average of the five rain-gauges was used to measure *P*. *TF* was measured on an event basis under the isolated crowns of five *Q. brantii* trees. For each tree, 16 *TF*-gauges (similar rain-gauges) were used, with four of these gauges placed along four transects (N, E, S, and W). We computed the total volume of *TF* captured underneath each tree for individual events using the total number of rain-gauges and the obtained average volume. *SF* was not measured, since it is usually a small fraction of each rain storm (e.g., Lloyd *et al.* 1988; Hutjes *et al*. 1990; Valente *et al.* 1997; Licata *et al.* 2011; Sun *et al.* 2013). Lastly, *I* was calculated as the difference between *P* and *TF*. A rain event was defined as a period of *P* bounded by 4 hours with no measurable rainfall as indicted by *P* rain-gauges (Fathizadeh *et al.* 2013). Four hours is long enough to allow the canopy to dry out completely in this semi-arid climate (I_{DM} = 18) (Carlyle - Moses *et al.* 2004). We measured the water collected in the gauges the day following each storm. *P* storms were grouped into three classes (Fathizadeh *et al*. 2013): *P*< 5 mm, 5 mm to *P*< 10 mm and equal or more than 10 mm, to allow for a better understanding of the relationship between *P* and *I*. We used indirect regression methods that relate *TF* and *P* to determine canopy ecohydrological parameters including canopy saturation point (P'_G), canopy water storage capacity (*S*, mm), free throughfall coefficient (*p*), the ratio of mean evaporation rate from the wet canopy to the mean rainfall intensity (*E/R*). The amount of *P* that is necessary to saturate the canopy before the drip of *TF* occurs is defined as P'_G, which is equal to *S* if *p* is zero, and can be estimated subjectively by finding the inflection point on a graph relating *TF* to *P* for multiple storms (Sadeghi *et al*. 2014, 2015a, b). In the present study, we used the mean method (Jackson 1975) for estimation of *S*. This method requires two regression lines relating *P* (*x*-axis) and *TF* (*y*-axis). The first regression line (R_1) fits to storms where *P* is ≥ P'_G (R_1), while a second regression line fits to storms where *P* is less than P'_G (R_2). The differences between *P* and *TF* at the intersection point of R_1 and R_2 offers the estimates of *S*. One minus slope of R_1 provides an estimate of E/R and the slope of R_2 arrange for an estimate of *p*.

RESULTS

Trends of meteorological parameters and ET_0

During 1961-2010, the mean annual *T* and *P* in the selected stations at the Zagros region were 16.7 ºC and 546 mm, respectively. The I_{DM} in the Zagros region ranged roughly from 8 (arid climate) in Ramhormoz to 33 (humid climate) in Yasuj. Mean I_{DM} across the meteorological stations was roughly 17 (semi-dry climate). Mean annual *WS*, and ET_0 were 2.0 m s^{-1}, and 4.2 mm day, respectively. Table 2 shows the ET_0 and *WS* trends in terms of Z_{MK} statistic within the long-term period (1961-2010). Three out of six stations exhibited statistically significant positive (2 sites increasing) and negative (1 site decreasing) trends (P < 0.05) for the annual *T*, whereas *P* and ET_0 indicated statistically negative trends only in one station (Z_{MK} = -0.4 for *P*; Z_{MK} = -0.2 for ET_0).

Table 2. MK statistic (Z_{MK}) obtained through the Mann-Kendall method for the meteorological parameters as well as reference evapotranspiration (ET_0) in the Zagros region of western Iran within the period 1961-2010.

Station	Air temperature (*T*)	Precipitation (*P*)	Wind speed (*WS*)	Reference evapotranspiration (ET_0)
Piranshahr	0.6**	-0.1	0.0	0.1
Saghez	-0.2	-0.1	0.1	-0.2*
Khorram Abad	-0.3**	-0.1	0.0	0.8
Ramhormoz	0.4**	-0.2	0.1	0.2
Yasuj	0.0	0.4	0.0	0.1
Sad Doroudzan	0.2	-0.4*	0.2	0.3
+ Trend number	4 (2)	1 (0)	6 (0)	5 (0)
-Trend number	2 (1)	5 (1)	0 (0)	1 (1)

Meteorological parameters and ET_0 changed in recent years (2000 - 2010) relative to the previous period (1961 - 1999) (Table 3). Average *T* at the five synoptic stations increased by an average of approximately 4%. *P* decreased an average of 10% at five of the six stations in the period 2000-2010 compared 1961 - 1999 whereas *WS* increased by an average of 22% at five stations and decreased by 5% in one station.

As a result of changing meteorological parameters, mean ET_0 increased by an average of 6.5% at the five stations and decreased by 18% in one station.

Table 3. Changes in meteorological parameters, reference evapotranspiration in the Zagros region, west of Iran, in the period 2000 - 2010 compared to previous years (before 1999).

		Piranshahr (1986-2009)	**Saghez (1961-2009)**	**Khorram Abad (1961-2010)**	**Ramhormoz (1987-2010)**	**Yasuj (1987-2009)**	**Sad Doroudzan (1988-2010)**
Air Temperature (°C)	Max (-1999)	13.8	14.1	19.8	29.4	16.1	18.4
	Max (2000-2010)	13.9	11.8	18.2	28.1	16.1	18.5
	Min (-1999)	9.1	8.0	14.4	24.2	13.4	15.9
	Min (2000-2010)	12.7	10.6	16.7	26.6	14.7	17.5
	Mean (-1999)	11.8	11.3	17.1	26.1	15.1	17.5
	Mean (2000-2010)	13.1	11.1	17.3	27	15.3	18
Precipitation (mm)	Max (-1999)	1040	791	771	515	1154	611
	Max (2000-2010)	885	560	607	437	1293	848
	Min (-1999)	404	238	237	188	517	300
	Min (2000-2010)	461	275	347	149	294	185
	Mean (-1999)	670.9	498.7	515.7	343.4	838.6	509.2
	Mean (2000-2010)	639.8	407.0	458.4	285.7	844.4	455.0
Wind speed ($m\ s^{-1}$)	Max (-1999)	4	3.8	2.7	2.5	2.0	2.3
	Max (2000-2010)	3.1	3.1	2.7	2.7	2.1	3.3
	Min (-1999)	1.8	1.1	2.1	1.7	0.8	1.5
	Min (2000-2010)	2.3	2.4	1.2	1.1	0.9	1.4
	Mean (-1999)	2.6	2.3	1.7	2.0	1.3	1.9
	Mean (2000-2010)	2.7	2.8	2.5	1.9	1.6	2.2
Reference evapotranspiration ($mm\ day^{-1}$)	Max (-1999)	4.5	4.6	4.8	7.3	3.8	4.7
	Max (2000-2010)	4.5	4.0	4.8	7.6	4.0	4.3
	Min (-1999)	3.1	3.0	3.3	5.1	3.3	3.7
	Min (2000-2010)	3.8	3.5	4.2	4.9	3.4	3.8
	Mean (-1999)	3.8	3.7	4.0	6.1	4.5	4.1
	Mean (2000-2010)	4.1	3.8	4.5	6.2	3.7	4.4

Interception and ecohydrological parameters of oak trees

During the study period, 15 rainfall events were recorded, and cumulative depth of these *P* storms was 137.6 mm with individual events averaging 9.2 mm and ranging from 1.1 to 25.3 mm. The average (± standard error) cumulative *I* for the five trees was 36.8 ± 0.2 mm (26.7% of *P*).

The mean annual event based ratio of *I* to *P* (relative *I* or *I*: *P*) value was 32.7% (SE: 3.8%). *I*: *P* ranged from 15.9% of *P* for the larger *P* events (25.3 mm) to 77.1% of *P* (1.1 mm) for smallest *P*. *I*: *P* was strongly correlated with *P*. A strong correlation was also observed between relative interception (*I*:*P*)%) and $P[(I{:}P)\% = -0.16\ Ln(P)+0.65$; $R^2= 0.64$] (Fig. 3). The mean *I*:*P* values in classes of the *P*< 5 mm, 5 mm to *P* < 10 mm and equal or more than 10 mm were 47.5%, 30.3%, and 23.8%, respectively (Table 4). I for the 15 events was 32.7% (Table 5). During the measurement period, P'_G, S, P, and E/R were 4.5 mm, 1.4 mm, 0.67, and 0.11, respectively.

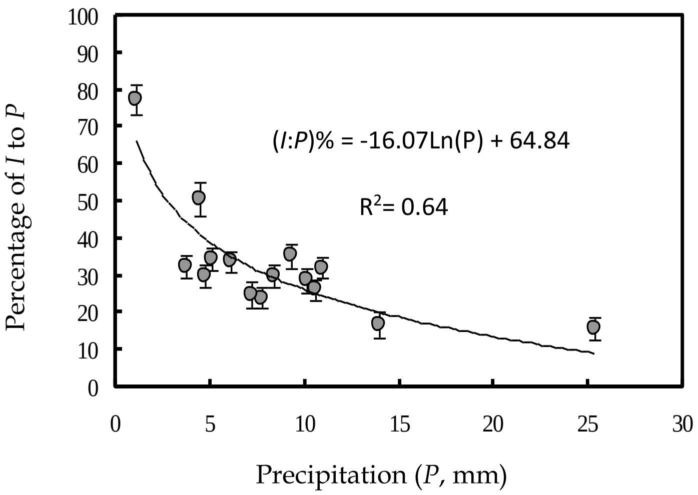

Fig. 3. Regression analyses between relative interception (I:P) and precipitation (P) for individual oak trees (*Q. brantii* var. *persica*). Error bars denote the standard error.

Table 4. Cumulative precipitation (P) depth, the percent of average relative interception (I:P)%, standard error (SE), and coefficient of variation (CV) divided into three P classes.

P classes	Storm frequency	Cumulative *P* (mm)	(*I:P*)%	SE (%)	CV
$P < 5$ mm	4	14.1	47.5	± 10.9	45.9
$5 \le P < 10$ mm	6	43.9	30.3	± 2.0	16.2
$P \le 10$ mm	5	71.0	23.8	± 3.2	30.5
Cumulative	15	128.95			
Average (± SE)		8.60	32.7 (± 3.8)		

Table 5. A summary of the ecohydrological parameters [(I:P)%, the percent of relative I; P'_G, canopy saturation; S, canopy water storage capacity; p, free throughfall coefficient; and E/R, the ratio of mean evaporation rate from the wet canopy to the mean rainfall intensity] of individual Persian oak (*Q. brantii* var. *persica*) trees.

n	(*I:P*)%	P'_G, mm	*S*, mm	*p*	*E/R*
15	32.7	4.5	1.4	0.67	0.11

DISCUSSION

Mean annual T increased by 0.6°C from 2000-2010, coinciding with oak trees decline in the region. Combined changes in meteorological parameters increased ET_0 to 6.5% by average in five stations. Increase in ET_0 may have significant impacts on oak trees and water resources in the Zagros region. Understanding the effect of climate change and climate variability on ET_0 rate in crucial for water resources planning. The I_{DM} also decreased down to 20.2, demonstrating that the Zagros region is getting drier and warmer. At five stations as average, within this period, P, WS, and ET_0 changed additionally by approximately -60 mm, +0.4 m s^{-1}, and +0.25 mm day^{-1}, respectively. From 1961 - 2010, trends in average annual T were statistically significant in three stations, however, the trend of P was only significant and negative in one station. The lack of a significant change in P is not surprising as several previous studies have demonstrated that most of the meteorological stations in Iranian arid and semi-arid regions had insignificant changes in annual P from 1966-2005 (Raziei *et al.* 2005; Modarres & Silva 2007; Tabari & Talaee 2011). In the short term, climate variability over the period 2000-2010 has resulted in warmer and drier conditions over much of the region. Historically, average annual *WS* in the Zagros region is 2.0 m s^{-1}. After 2000 *WS* increased by 22% and this would have reduced boundary layer resistance of the canopy, thereby increasing water demand.

The increased water demand may result in increased stomatal resistance as the trees attempt to conserve water. During the growing season, the naturally dry and hot wind results in a greater ET_0.

The values for (*I*:*P*)% obtained in the present study (32.7%) differed slightly from those measured for other broadleaved trees in semi-arid to arid regions during the growing season. David *et al*. (2006), for example, in a study on an evergreen oak (*Q. ilex*) in Portugal, estimated *I:P* to be 21.7%. The partitioning of *P* into *TF* and *I* in forest ecosystems has been showed to be a function of *P* characteristics (amount, duration, intensity, and temporal distribution of rainfall storms (Crockford & Richardson 2000; Xiao *et al*. 2000; Marin *et al*. 2000; Huber & Iroumé 2001; Sadeghi *et al*. 2014, 2015a, b), climatic parameters (*T*, and *WS*) (Crockford & Richardson 2000; Attarod *et al*. 2015), and vegetation characteristics (e.g., species composition, stand age, basal area, stand density, *LAI*, wood area index (*WAI*), and vegetation area index (*VAI*)) (Xiao *et al*. 2000; Carlyle-Moses 2004; Muzylo *et al*. 2009). Hence, it is likely that the differences in *P* partitioning reported by other researchers were due, in part, to differences in the aforementioned parameters. In the present study, *S* was estimated to be 1.4 mm. The estimates of *S* in the present study fall within the range reported for other broadleaved trees. Sadeghi *et al*. (2015b) reported *S* in a *Fraxinus rotundifolia* forest of Iran, to be 0.24 mm, while Pereira *et al*. (2009) determined *S* to be 1.16 mm for a *Q. ilex* in Spain and also Fathizadeh *et al*. (2013) determined *S* in a *Q. brantii* forest in west of Iran to be 1.57 mm during the leafed period. The nature of the intercepting surface controls the magnitude of *S* (type of species, leaf shape, dimension and orientation; see Friessen *et al*. 2015). The free throughfall coefficient, *p*, was 0.67 in in-leaf season. The E/R value was estimated to be 0.11 in in-leaf season, and is consistent with the E/R value reported for *Fraxinus rotundifolia* in Iran (E/R= 0.13; Sadeghi *et al*. 2015b). Hence, the canopy structure of *Q. brantii* var. *persica* significantly impacts the amount of *TF* reaching the forest floor. Therefore, *I*, canopy ecohydrological parameters and the magnitude of the *P* events all need to be considered in the further water balance research. The magnitude of *P* had a major impact on the partitioning of rainfall into *TF* and *I* for the present study, similar to other research (e.g., Fathizadeh *et al*. 2013; Sadeghi *et al*. 2014, 2015a, b; Attarod *et al*. 2015). As the magnitude of *P* increased, (*I*:*P*)% decreased. For instance, by increasing its value from $P< 5$ mm to $P \leq 10$ mm, (*I*:*P*)% decreased from 47.5% to 28.3% (Table 4). The magnitude of (*I*:*P*)% for small *P* storms is a result of a large portion of *P* being retained on the canopy, which evaporates during and after the rainfall. The composition of the species, ecohydrological and ecophysiological characteristics of the trees as well as the spatial distribution of the tree species may be threatened by changes in meteorological parameters. Consequently, ecohydrological parameters of oak trees will be affected by climatic change in the Zagros region. If there is a significant reduction in large storms, the considerable *I* during the remaining smaller *P* events will result in a reduction in the available water because of increased evaporative loss. Hence, ecohydrological parameters of oak trees can be highly affected by climate change or climate variability in the Zagros region and should be considered in further water cycles research.

CONCLUSION

This opening research on long-term trends of meteorological parameters and reference evapotranspiration in the Zagros region of western Iran suggests a possible link between oak trees decline and changes in meteorological parameters. We found that the values for (*I*:*P*)% measured in the present study (32.7%) was higher than those presented in other broadleaved forests in semi-arid to arid regions during the growing season. A decline in larger storm events and an increase in smaller storm events originated from climate change in this region will result in increased percent of precipitation lost to interception loss in the Zagros region. The model simulations suggest that this region may experience a decline in precipitation, further decreasing water resources.

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زوال درختان بلوط، نشانه‌ای از اثرات تغییرپذیری اقلیمی در غرب ایران

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چکیده

درختان بلوط ایرانی ناحیه رویشی زاگرس در غرب ایران از سال ۲۰۰۰ دچار پدیده خشکیدگی شده‌اند و احتمال ارتباط این پدیده با تغییر پارامترهای اقلیمی وجود دارد. هدف تحقیق حاضر بررسی روند درازمدت پارامترهای اقلیمی و تبخیرتعرق مرجع در ناحیه زاگرس و نیز برآورد پارامترهای اکوهیدرولوژیک تک درختان بلوط ایرانی (*Quercus brantii*) [باران-ربایی(I)، ظرفیت نگهداری آب تاج پوشش(S)، نسبت میانگین تبخیر از تاج پوشش مرطوب به میانگین شدت باران (E/R) و نیز ضریب تاج‌بارش مستقیم (p)] که متاثر از تغییرپذیری اقلیمی می‌باشند، بود. تغییرات درازمدت (۱۹۶۱-۲۰۱۰) دمای هوا، بارش و سرعت باد ثبت شده در شش ایستگاه همدیدی واقع در سراسر ناحیه رویشی زاگرس مورد بررسی قرار گرفتند. تاج-بارش توسط ۱۶ باران‌سنج دستی که بطور تصادفی در زیر تاج هر درخت بلوط ایرانی نصب شده بودند و نیز باران با استفاده از باران‌سنج‌های نصب شده در فضای باز نزدیک درختان اندازه‌گیری شد. باران‌ربایی از تفاضل باران و تاج‌بارش محاسبه گردید. از سال ۲۰۰۰ تا ۲۰۱۰، پارامترهای اقلیمی و تبخیرتعرق مرجع به مقدار کم افزایش (دما: ۰/۶+ درجه سانتی گراد، سرعت باد: ۰/۴+ متر بر ثانیه، ۰/۲۵+ میلی‌متر در روز) یا کاهش (بارش: ۶۰- میلی‌متر) نشان دادند. الگوهای اقلیمی بین سال‌های ۱۹۶۱ تا ۲۰۱۰ در شش ایستگاه همدیدی نشان داد که بارش در یک ایستگاه بطور معنی‌داری کاهش داشته است در حالی که در دو ایستگاه، دما افزایش معنی‌دار و در یک ایستگاه، کاهش معنی‌دار داشته است. باران‌ربایی در طی دوره‌های برگدار و خزان به ترتیب ۴۰ و ۲۵ درصد محاسبه شد. در طول دوره برگدار، میانگین ظرفیت نگهداری آب تاج پوشش، نسبت تبخیر از تاج پوشش به شدت باران و ضریب تاج بارش مستقیم به ترتیب ۱ میلی‌متر، ۰/۲۲ و ۰/۲۳ محاسبه شد. نتایج نشان داد که ناحیه رویشی زاگرس در حال گرم‌تر شدن است و درختان بواسطه تبخیر بیشتر، بی تردید با کاهش شدیدتر آب در دسترس مواجه خواهند شد.

*مولف مسئول