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RESEARCH PAPER

Effect of forest exposure on growth and nutrient balance at Hijran forest.

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A B S T R A C T:

The study was conducted during 2022 at Hijran forest at right side of the main road of Salahaddin - Shaqalawa in Erbil governorate Iraqi Kurdistan region with GPS reading (latitudes = 36°22' to 36º24' N; longitudes = 44°16' to 44°19' E.). This study was carried out to determine the effect of two forest exposures (north east and south west) using randomized block design using three replicates on growth and nutrient balance of oak trees (*Quercus aegilops* L.). Growth parameter including tree height (m), stem diameter (cm), and leaf area (cm^2) as well as nutrient balance were measured according to the standard methods. The results indicated that the forest exposure affected significantly on the studied characters. The highest values of tree height, stem diameter at breast height level, and leaf area were (4.48 m, 11.03 cm, and 39.60 cm^2) which were recorded from north east while their lowest values (3.22 m, 4.64 cm, and 25.78 cm^2) were observed from south west.

On the other hand, the exposures also affected on nutrient balance, the nutrient balance at north east exposure was better than the south west. The difference between the ratios of the studied nutrients and their critical values were higher at north east exposure in comparing with south west.

The goals of this study is testing the influence Hijran forest exposure on nutrient balance and tree growth to notice some factors to be followed that affects widely on the reforestation program like site selection that must take into account elements including soil quality, topography, water availability, climate in addition to the selection of native tree species that can live in the degraded area and are well fit into the regional ecosystem; there is also to be the plantation of the variety of tree species to increase biodiversity.

KEY WORDS: Growth characteristics, North east and south west exposures, nutrient balance, Oak trees.
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1. INTRODUCTION:

Oak trees (*Quercus aegilops* L.) belong to Fagaceae family which is a medium sized deciduous tree. It is considered as one of the most important, widespread, and native tree species in the Kurdistan Region of Iraq**.** The trunk diameter, height, and crown width of the tree may reach to (1, 20, and 7) m, respectively (Younis and Hassan, 2019). It grows at 500 to >1000 meters above sea level. It grows widely on most soil types, but the best soil for its growth is loamy sand, it can be grown in dry climate with a rainfall of 400 mm year^{-1}(Goor and Barney, 1976).

Predominant oak species in Iraqi Kurdistan Forests are (*Q. aegilops*, *Q. infectoria*, *Q. libani and Q. macranthera*) (Chapman, 1949). Shahbaz (2010) indicated that oak trees represent %90 of Kurdistan regions forest which includes %70 of Valonia oak trees (*Quercus aegilops* L.). Rasheed (1990) explained that the Hijran forest has an unique ecosystem and it is one of the important natural forests among other forests in the region especially in Erbil governorate. The forest exposure influenced on soil physical , chemical , biological properties, plant growth characteristics and nutrient balance (Al-Khafaji and Nazar, 2001).

Tree growth and mortality are considered to be two of the most important vital rates of tree demography and they are the result of combined effects of biotic and abiotic factors that interact with tree ontogeny (Visser *et al.*, 2016). The

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decrease in plant or trees growth affecting by heat, drought, pathogens and pests, on the other hand, intensity of their stresses playing a great role in plant growth (Chen *et al.*, 2018).

Slope aspect had significant effect on some vegetation properties of tree height and stem diameter of (*Quercus aegilops* L.) trees , their higher values (3.83 m, and 8.70 cm) were recorded at north site at Safin Mountains in Hijran forest, while lowest values of them (2.82m, and 5.27 cm) were obtained at south site respectively (Zandi *et al.*, 2018).

Zandi *et al.*, (2018) explained the effect of forest exposure at Safin Mountains (north and south) on most of chemical properties of the soil. In general the highest values for pH, EC, organic matter, nitrogen, phosphorus, and potassium (7.8, 0.27 $dS.m^{-1}$, % 7.38, % 0.14, 5.6 ppm, 4.9ppm) were recorded at north exposure, while their lowest values (7.6, 0.22 $dS.m^{-1}$, % 1.9, % 0.09, 3.4 ppm, 2.8 ppm) were obtained at south exposure respectively.

Nutrient concentration in plant biomass is the result of the balance between nutrient uptake, plant growth and nutrient retranslocation, and the loss of these processes are likely to be influence by both plant genetic make-up and soil fertility, as well as other environmental conditions (Hagen-Thorn *et al.,* 2004) . Esmail *et al.,* (2011) indicated that the concentration of some nutrients like nitrogen, phosphorus, and potassium were ranged from (4.00 to 4.20%, 0.38 to 0.30%, and 3.00 to 2.95%), respectively in oak trees at east and west exposure at Hijran forest. The best nutrient balance was recorded at east exposure in comparing with west exposure. Esmail *et al.*, (2011) studied the concentration of main cations ($Ca^{2+,}$ Mg^{2+}, Na^{+}, and K^{+}) of Hijran forest soil at two exposures. The results explained that the range of the mentioned cations were (3.30 to 2.98, 0.80 to 0.70, 0.57 to 0.40, and 0.40 to 0.38 $mmolc.L^{-1}$), respectively and the results showed that the east exposure is better than west exposure.

Slope aspect affected significantly on quantity of SOC, TN, and enzyme activity by altering the rate of litter decomposition and the activity of soil microbes. Soil nutrient conditions, especially carbon (C) and nitrogen (N)contents, are affected by slope aspect, which are among the most important factors shaping soil microbial activity (Nahidan *et al.*, 2015).

Yang *et al.,* (2020) compared between the influence of north and south forest exposure on soil properties. The results showed that the highest values for pH, organic matter%, available nitrogen, available phosphorus, available potassium were (7.93 , 9.14 %, 260.87, 1.98 , and 188.38 mg kg^{-1}) respectively which recorded at north exposure, on the other hand their lowest values (7.39, 4.88%, 124.15, 0.81, and 95.09 mg kg^{-1}) were observed at south exposure.

Since the forest exposure has great influence on nutrient balance and plant growth in additional to there was no studies about influence of forest exposure on above characteristics for this reason the goals of this study was to test the influence Hijran forest exposure on nutrient balance and tree growth.

2. MATERIALS AND METHODS

2.1.Study Site

The study was carried out during June 2022 at Hijran forest which located at right side of the main road of Salahaddin (PirMam) to Shaqalawa in Erbil governorate Iraqi Kurdistan region with a distance about 40 km from north-east of Erbil city which is surrounded by Safin and Mezgawta Mountains. The GPS reading of the study location were (latitudes = 36°22' to 36º24' N; longitudes = 44°16' to 44°19' E.) (Galalaey *et al.,* 2021) (Figure1). The climate condition of the forest is cold and semi-arid with frequent snowfall in winter and dry hot in summer. In addition, the vegetation cover of the forest is dominated by open oak forests and herbaceous plants (Hameed *et al.,* 2016). The elevation of the study area ranged between 887-922 meters above sea level. Oak trees (*Quercus aegilops.* L.) is the more dominant tree in Hijran location.

2.2. Experimental Layout

On June 2022 the study area was divided into two main exposures (Figure 1); firstly, North-East exposure (NE) which was divided into three equal blocks (20m X 20m) with different elevations toward the NE exposure, secondly, South-West exposure (SW) which was also divided into three equal blocks (20m X 20m) with different elevations toward SW exposure. Moreover, all the coordinate GPS points were recorded for each block for both NE and SW (Table 1).

2.3. Studied Parameters

2.3.1. Growth Characteristics

The height and diameter (DBH) of all selected trees were measured. Moreover Caliper and Haga tools were used for diameter and height tree measurements respectively according to West, (2004); in this survey for all selected trees randomly for each block in the study area for both exposures. Also, the number of trees recorded at both sites.

Leaf Area (LA) was determined for three leaf samples per tree for the five selected trees in each block, and then, Image J Java 8 software according to (Stawarczyk and Stawarczyk, 2015) were used for calculating leaf area. (Figure 2, 3, A and B).

2.3.2. Nutrient balance measurement

For measuring nutrient balance in leaves of *Quercus aegilops*, leaf samples were collected in June 2022, eighteen composite leaf samples were collected randomly for both sites, three composite samples per block were taken, each composite sample included five trees, the six leaves at each of lower, middle, and upper part of each tree were taken from there five trees then mixed to obtain composite sample, which equivalent to 90 plant leaves per composite sample, the total number of composite leave samples was 90 composite samples (Table 2). After that, the samples were oven dried at 65 C° for 72 hrs. , then ground by the mill and were digested for determining nitrogen, phosphorus and potassium using the standard methods mentioned by (Jaiswal, 2003).Then depending on the obtained mean of nutrient content the DRIS chart (Diagnosis Recommendation Integrated System) was used for determining the nutrient balance of oak tree at both studied exposures as described by (Esmail *et al.,* 2011)**.**

2.3.3. Soil Samples

Three soil samples were taken randomly from 0-30 cm depth soil at both sites. The soil samples were air dried and sieved by 2mm sieves, then saved in plastic containers then stored. Later, the some chemical and physical soil properties analysis was examined for both study sites according to (Ryan *et al.,* 2001).

2.4 Statistical Analysis:

The Statistical analysis were conducted using SPSS program version (26), the comparison between mean of parameters using paired and non-paired t-test.

2. RESULTS :

Table (4) explained the significant influences of forest exposure on some growth characteristics of *Quercus aegilops* trees. The highest values of tree height, stem diameter, and leaf area (4.48 m, 11.03 cm, and 39.60 cm^2 respectively) were recorded from north east, while their lowest values (3.22m, 4.64 cm, and 25.78 cm^2 respectively) were observed from south west.

Table (5) and figure (3) showed nutrient ratio and their balance at north east exposure, it appeared from this figure that the nutrient content of oak trees was varied between balances to imbalance statuses depending DRIS chart methodology.

The critical levels which were selected depended on the direction of arrows of ratios. The arrow sign towards the upper direction indicates to the higher balance of nutrient while the arrow sign was down it indicates the low balance of nutrient. The difference between nutrient ratios (N/P, N/K and K/P) and their critical values refers to balance or imbalance between nutrients. The balance values for N/P, N/K and K/P were between (8.7-11.6), (1.3-1.7) and (5.9-7.8) respectively. The increase and decrease in the mentioned ranges means shifting the nutrient ratios to imbalance conditions, and the similar explanation is true at both exposure. The negative value for K/P ratio was (-1.6), while the positive value for N/P and N/K were (0.45 and 0.13) respectively at north east exposure. On the other hand, the negative value for K/P ratio was (-1.04), while the positive value for N/P and N/K were (0.11 and 0.01) respectively at south west exposure (table 5 and 6).

Figure (3 and 4) refers to balance between K/P while the imbalance in north east is less than imbalance of nutrients comparing with south west depending on the calculated ratios between N/P, N/K and K/P which were **(**7.25, 0.97 and 7.5) and their differences (0.45, 0.13, and -1.6) with critical values (8.7 - 11.6, 1.3-1.7, and 5.9-7.8) at north east while their ratio values were (7.59, 1.09 and 6.94) and their differences (0.11, 0.01, and -1.04) with critical values (8.7 - 11.6, 1.3-1.7, and 5.9-7.8) at south west respectively. They indicated that nutrient status at north east were better than those at south west exposure. More difference between ratios and critical values means increase in balance and vice versa (Darwesh, 2007).

3. DISCUSSIONS:

The highest values of tree height, stem diameter, and leaf area were recorded from north east while their lowest values were observed from south west as shown in (Table 4). This may be due to differing in microclimatic condition, similar results were obtained by Zandi *et al.,* (2018) who indicated to significant effect of slope and aspect exposure on some vegetation characteristics (tree height, stem diameter) and leaf area (Kattge *et al.*, 2020) which was significantly influenced by microclimate; the amount of solar irradiation influences soil temperature, soil water retention and availability, nutrient dynamics *(Egli et al.*, 2009) composition and activity of soil microbial communities (Ascher *et al.,* 2012). In addition, there was the degradation of forest at south west exposure may be due to overgrazing and illegal felling by the citizens.

The balance values for N/P, N/K and K/P were between (8.7-11.6), (1.3-1.7) and (5.9-7.8) respectively. The increase and decrease in the mentioned ranges means shifting the nutrient ratios to imbalance conditions. The direction of arrows explaining the nutrient status, the horizontal arrows explain the balance conditions, while the arrows with 45^{o} mean the nutrient status were between balances to imbalance status. On the other hand, the vertical arrows towards the north mean imbalance due to the higher ratios and the vertical arrows towards the south refers to low ratios and imbalance of the studied nutrients (Darwish, 2007) As shown in (table 5 and table 6), (figure 3, and 4). They indicated to better nutrient status at north east in comparing with south west. For this reason the growth is differing between two exposures. More difference between ratios and critical values means increase in balance and vice versa. Similar results were reported by Esmail *et al.*, (2011).

4. CONCLUSION

Results of the present study concluded that the exposure of forest had great effect on nutrient balance of oak trees (*Qurcus aegilops* L.) They indicated that nutrient status and most of their growth characteristics at north east were better than those at south west exposure.

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Conflicts of Interest

The authors declare no conflict of interest.

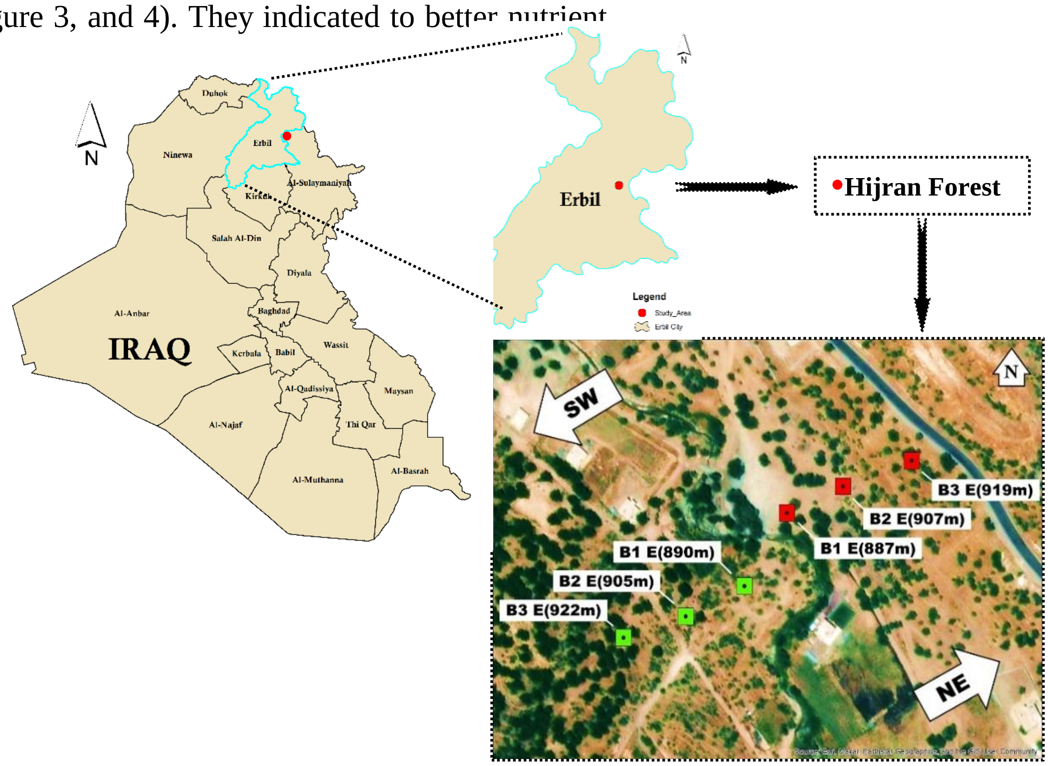

Figure 1:shows the map of the study location

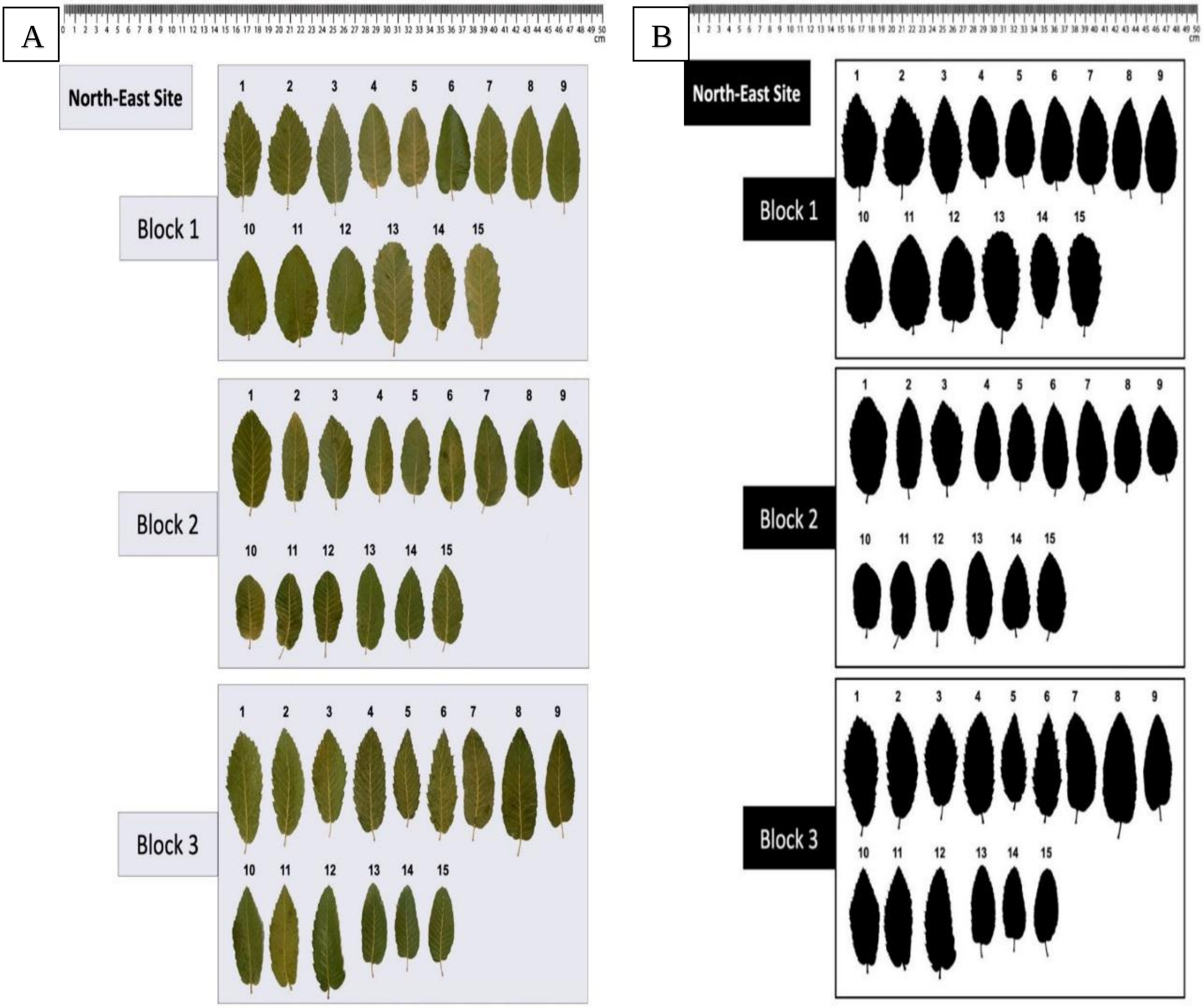

Figure 2: (A) *Quercus aegilops* L. scanned leaves of different sizes used to determine the leaf area at north east exposure, using Image J Software (B) Scanned leaves with contrasting background used to determine the leaf area, using Image J software.

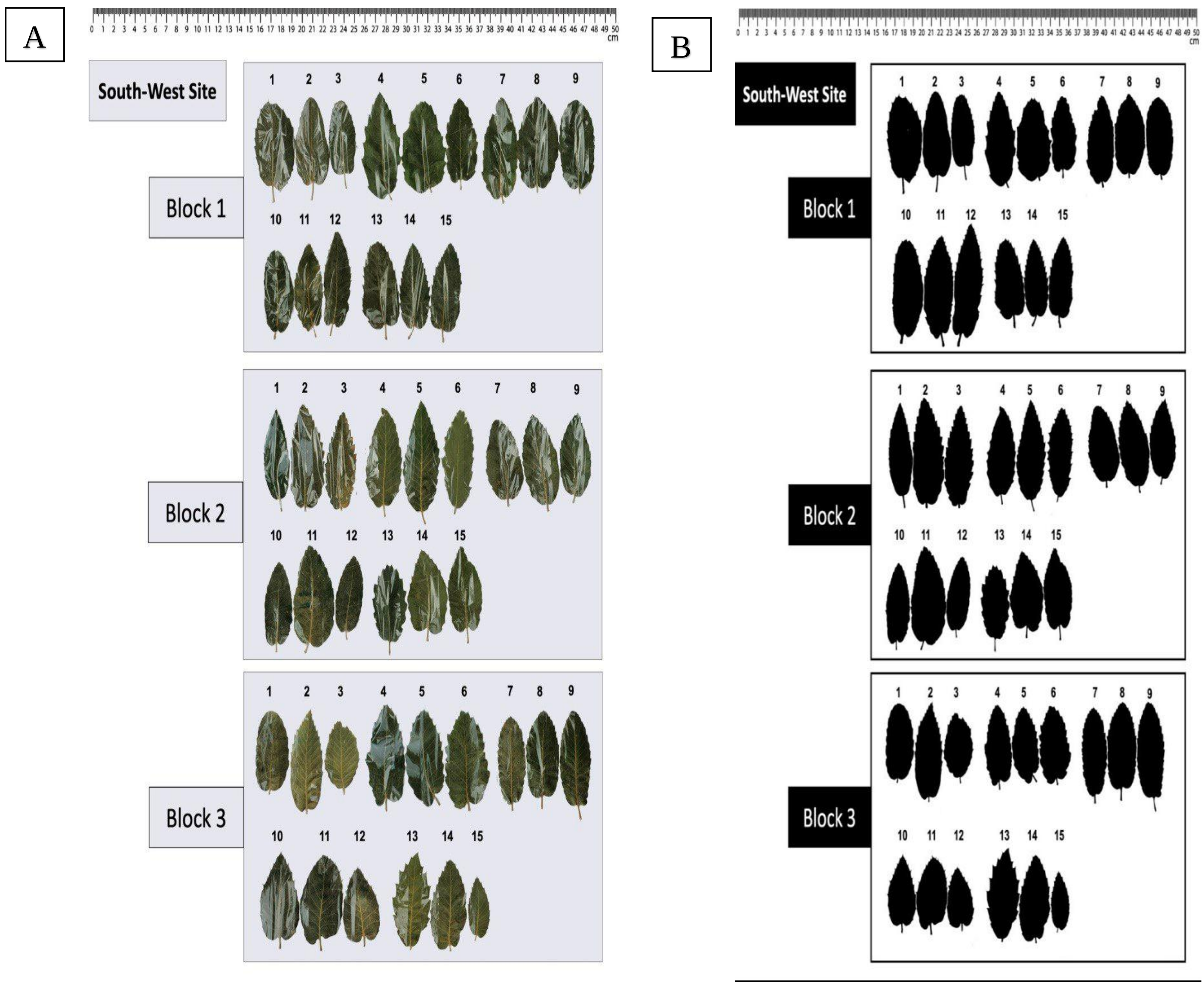

Figure 3: (A) *Quercus aegilops* L. scanned leaves of different sizes used to determine the leaf area at south west exposure, using Image J

Software (B) Scanned leaves with contrasting background used to determine the leaf area, using Image J software.

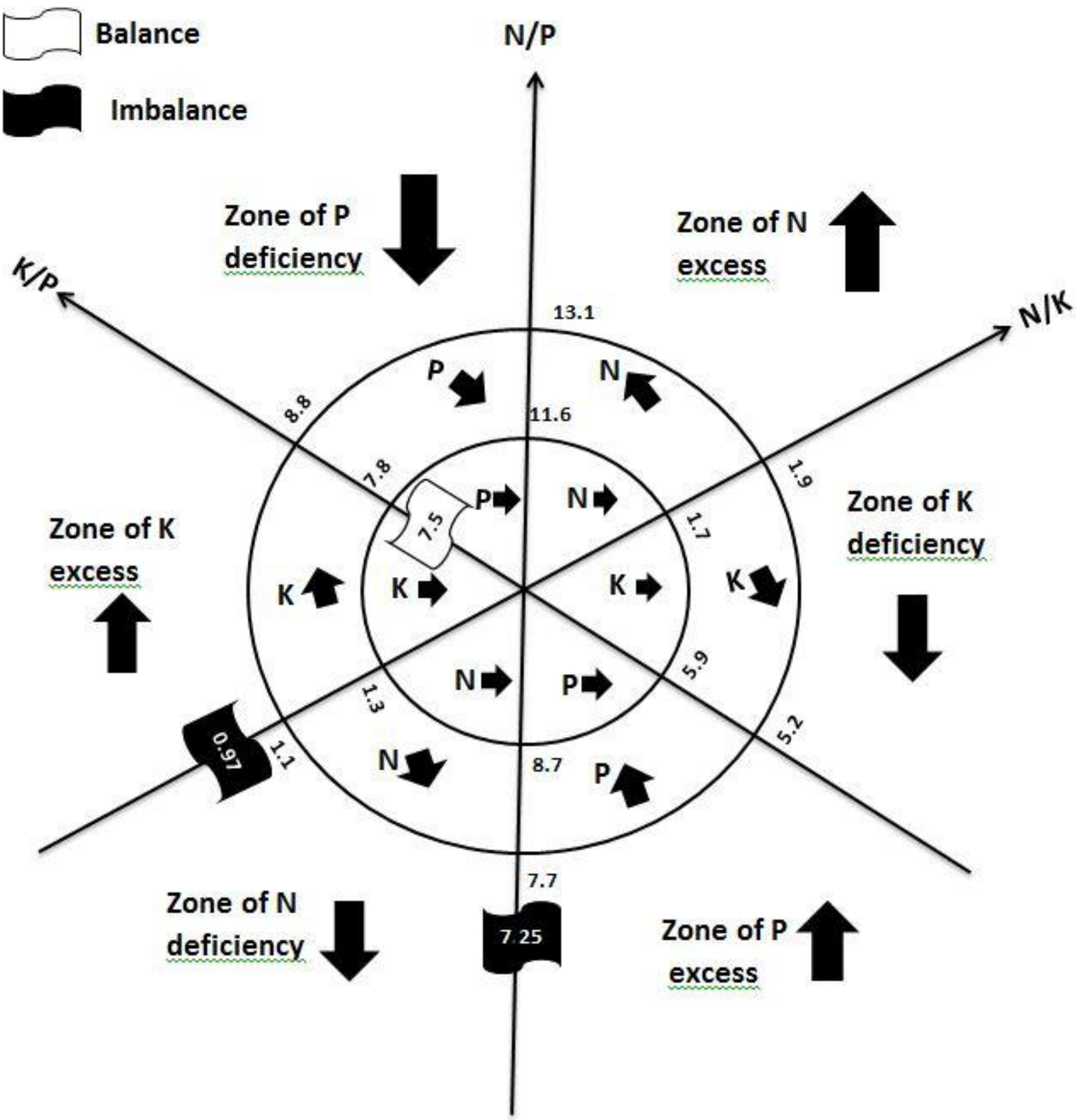

Figure 3: Shows tree nutrient balance at north east exposure

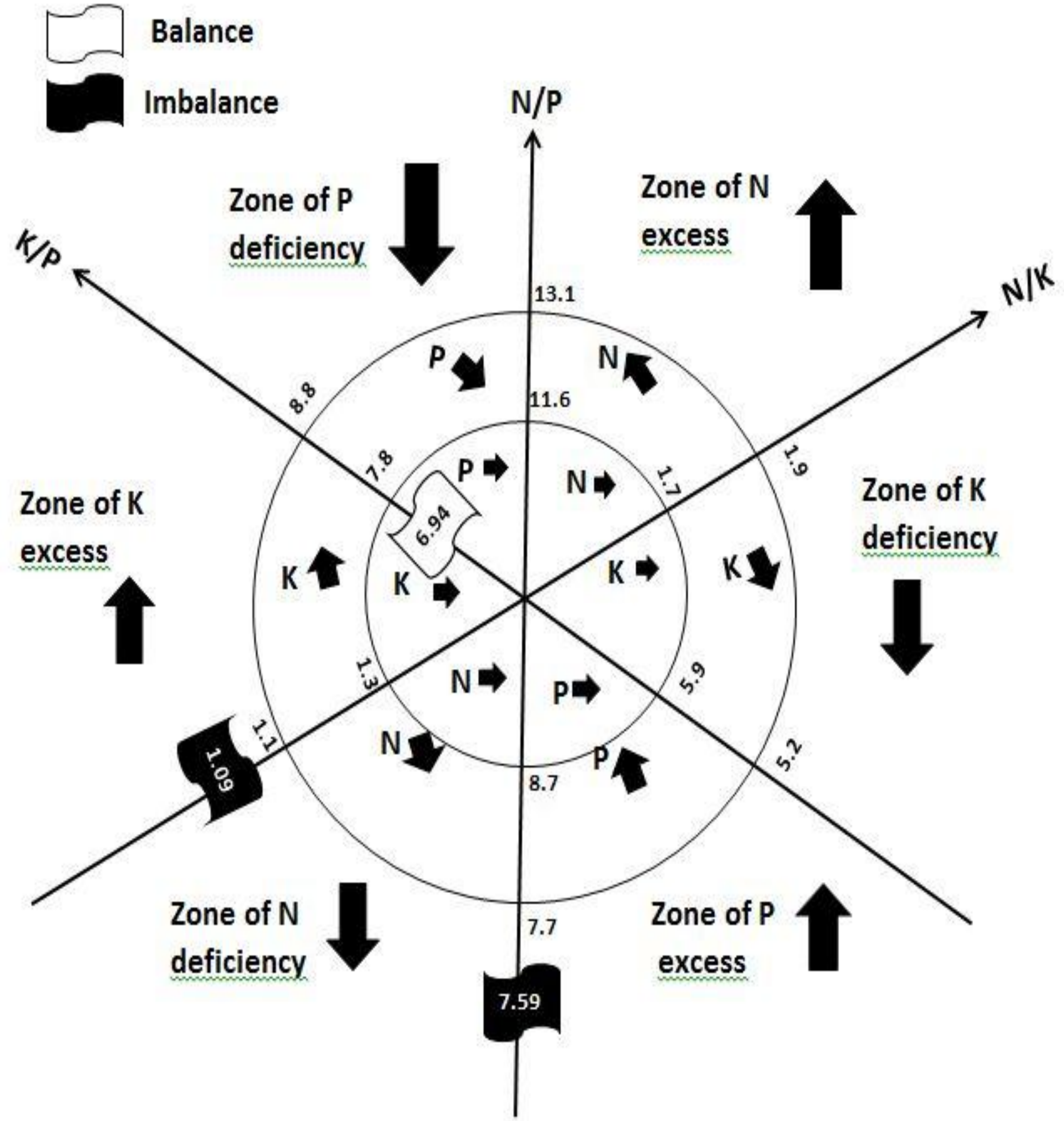

Figure 4: Shows tree nutrient balance at south west exposure.

Table 1: *The expos*res, blocks, size of blocks, elevations and coordinate systems of the study area.

Site	**Block**	**Size of block**	**Elevation (m)**	**Latitude (N)**			**Longitude (E)**		
				D°	**M'**	**S"**	**D°**	**M'**	**S"**
NE	B1	1,200m^2	887	36	23	33.486	44	17	7.3
	B2		907	36	23	34.1	44	17	9
	B3		919	36	23	34.7	44	17	11
SW	B1	1,200m^2	890	36	23	31.8	44	17	6
	B2		905	36	23	31.1	44	17	4.2
	B3		922	36	23	30.6	44	17	2.3

Table 2: The exposures, blocks, no. of trees, and no. of replication of leaves of oaks.

Site	**Block**	**Tree Selected**	**Leaf sample for a tree**	**Total of leaf samples**
NE	B1-B2-B3	15	3	45
SW	B1-B2-B3	15	3	45
Total	**6**	**30**	**6**	**90**
NE=North-East, SW=South-West, B=Block				

Table 3: Explains the routine analysis for some physico-chemical properties of soil at both exposures.

Soil parameters		**Hijran forest**		**Comments**
		North east	**South west**	
		Mean		
pH		7.09	7.03	Neutral soil
dS.m^{-1}	**EC**	0.45	0.45	No saline soil
%	**Total Nitrogen**	0.15	0.16	High
ppm	**Available Phosphorous**	4	3	Low
meq/L	**Soluble Potassium**	51	53	Low
	Available Magnesium	12	6.48	Medium
Cmol.kg^{-1}	**Available Calcium**	65.4	74	High
%	**CEC**	23.54	27.74	Medium
	Organic Matter	2.84	2.85	High
	$CaCO_3$	7.54	13.26	Calcareous
	Saturation point	63.43	65.32	
	Field capacity	34.85	37.89	
	Wilting point (W.P)	18.74	20.38	
	Available water	16.11	17.51	
Texture		Clay loam	Clay loam	

Table 4: Effect of exposures on some growth characteristics of *Quercus aegilops* at Hijran forest.

<table>
<tr><td colspan="3" rowspan="3">Parameters</td><td colspan="2">Hijran (oak forest)</td></tr>
<tr><td colspan="2">Exposures</td></tr>
<tr><td>North east (NE)</td><td>South west (SW)</td></tr>
<tr><td rowspan="8">Mean</td><td rowspan="4">M</td><td rowspan="2">Elevations</td><td>904.33</td><td>905.67</td></tr>
<tr><td colspan="2">P- value = 0.924</td></tr>
<tr><td rowspan="2">Tree height</td><td>4.48</td><td>3.22</td></tr>
<tr><td colspan="2">P- value = 0.000</td></tr>
<tr><td rowspan="2">Cm</td><td rowspan="2">Stem diameter</td><td>11.03</td><td>4.64</td></tr>
<tr><td colspan="2">P- value = 0.000</td></tr>
<tr><td rowspan="2">cm^2</td><td rowspan="2">Leaf area</td><td>39.60</td><td>25.78</td></tr>
<tr><td colspan="2">P- value = 0.000</td></tr>
</table>

Significant occurs when P- value is ≤ 0.005.

Table 5: shows the mean of nitrogen (N), phosphorus (P) and potassium (K) content of oak trees, their ratio and their critical values at north east.

<table>
<tr><td colspan="2">Tree content</td><td>Mean values</td><td>Ratio</td><td>Values</td><td>Critical values</td><td>The difference</td></tr>
<tr><td rowspan="3">%</td><td>N</td><td>1.16</td><td>N/P</td><td>7.25</td><td>8.7 - 11.6</td><td>0.45</td></tr>
<tr><td>P</td><td>0.16</td><td>N/K</td><td>0.97</td><td>1.3 - 1.7</td><td>0.13</td></tr>
<tr><td>K</td><td>1.20</td><td>K/P</td><td>7.5</td><td>5.9 - 7.8</td><td>-1.6</td></tr>
</table>

Table 6: shows the mean of nitrogen (N), phosphorus (P) and potassium (K) content of oak, their ratio and their critical values at south west exposure.

<table>
<tr><td colspan="2">Tree content</td><td>Mean values</td><td>Ratio</td><td>Values</td><td>Critical values</td><td>The difference</td></tr>
<tr><td rowspan="3">%</td><td>N</td><td>1.29</td><td>N/P</td><td>7.59</td><td>8.7-11.6</td><td>0.11</td></tr>
<tr><td>P</td><td>0.17</td><td>N/K</td><td>1.09</td><td>1.3-1.7</td><td>0.01</td></tr>
<tr><td>K</td><td>1.18</td><td>K/P</td><td>6.94</td><td>5.9-7.8</td><td>-1.04</td></tr>
</table>

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