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GROWTH PERFORMANCES OF *Pinus brutia* (TURKISH PINE) AND NUTRIENT LEVELS IN NEEDLES, LITTER FALL AND SOIL PROPERTIES OF AFFORESTED SEMI ARID AREAS IN THE EASTERN MEDITERRANEAN, JORDAN

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ABSTRACT

Growth performance and nutrient levels in needles, litter fall and soil properties at two soil depths in Wasfi Tal forest in Jordan were studied. Two factors, aspects (North, South, East, West) and slope positions (Upper, Middle, Lower) were studied. Aspects showed significant effect on height and Diameter Breast Height (DBH), northern and eastern exhibited a higher height and DBH growth compared to southern and western slopes. In contrast, slope positions showed insignificant effect after passing stand pole stage. Whereas available water is the limiting factor for plant growth. The concentration of macro nutrients N in Turkish pine trees was about at adequate level, where as P, K and micro nutrients of Fe, Zn and Cu were bellow normal ranges whereas Ca and Mg were two folds more abundant than normal levels in needles. This indicates that, pine adapted to poor soil, high pH , and low fertility. Furthermore, nutrient concentrations in litter decreased in the order of E >S >N > W as in the needles. The accumulation of nutrients in the needles during life cycle was accompanied by similar accumulation in forest floor.

A significantly higher concentration of N, K, and Zn in soil depth of 0-5 cm was found compared to the depth of 5-30 cm. Other elements showed the same tendency but not-significant. Likewise, the pH, ECE and OM detectable, yet showed a similar pattern.

***Key words**: afforestation, needles, nutrient levels, Pinus brutia, semiarid, soil properties.*

1. INTRODUCTION

Arid and semiarid lands cover more than 40 % of the global surface and one half of this is affected and threatened by desertification (Deichmann and Eklundh 1991; Vero'n *et al.*, 2006). Human pressure and environmental constrains are the main causes of land degradation in these areas (Schlesinger *et al.*, 1990). Rehabilitation and restoration of such areas attract attention world wide as a measure to protect soil through afforestation. Introducing native or exotic species in afforestations is increasing worldwide. These species have to be adapted to prevailing harsh climatic, edaphic and topographic conditions in eastern Mediterranean areas. Planting selected tree species in specific sites is vital to promote the growth of natural vegetation or as a management option for reviving degraded land (Katyal and Vlek 2000).

Tree plantation was the most widespread forest administration management policy in Jordan since (1948) to rehabilitate and recover the vegetation for soil conservation and minimize the effect of erosion in steep areas. Moreover, afforestion is an important effective measure used in controlling desertification and restoring of desertified areas. This measure has additional positive impacts such as promotion of biodiversity in degraded areas particularly those close to urban centers (Al Omary 2011).

Afforestation in general increases green areas where limited natural forests existed in the country. Afforestations in the Mediterranean countries in general and Jordan in particular rely on specific tree species, which they are pioneer, grow rapidly and survive harsh climatic conditions.

The most widely used tree species in Jordan is *Pinus halepensis* Mill. This is distinct to *Pinus brutia*. They are adapted to drought and nutrient deficiencies. *Pinus brutia* (Turkish red pine) which was used in this study is an exotic species used in afforestation programs in Jordan. It is native to the east Mediterranean region, occurs most abundantly in the semi-arid and sub-humid zones (Quézel 2000; Boydak 2004). *P. brutia* has stricter rainfall requirement than *P. halepensis*.

P. brutia is well adapted to the Mediterranean-type climate in several physiological and morphological characteristics and is a drought resistant species (Thanos and Scordilis 1987; Grunwald and Schiller, 1988; Dirik 1994; Boydak 2004). The adaptabilities of its provenances to drought varied (Dirik, 2000), but *P. brutia* generally achieves its optimum growth in regions receiving more than 900–1000 mm of annual precipitation. It has a wider hypsometrical and ecological range and young seedlings are well adapted to adverse conditions during the first years of growth. In addition, it has a high growth rates and straight logs in comparison with *P. halepensis* (Tsitoni and Karagiannkidou, 2000).

Climatic conditions and soil depth have significant impact on growth and survival of afforestation in Jordan (Abdelrazzag, 1986). The main abiotic determinants of vegetation communities are altitude and exposition and these variables determine the site suitability for *P. brutia, P. nigra, Abies cilicica* and *Cedrus libani*. (Fontaine *et al.,* 2007).

Afforestation with *P. halepensis* and *Acacia saligna* in marginal rangeland (100 to 200 mm year^{-1}) in Jordan showed positive impact on biodiversity and biomass production and as such proved successional in combating desertification (Razzag and Flsterb, 2002). Soil rehabilitation through afforestation in semi arid regions with *Prosopis juliflora, Dalbergia sisso* and *Eucalyptus* sp. plantation in sodic soils showed that, the soil reaction, organic matter (OM), N, P and K had increased in all planted areas (Mishra *et al.,* 2003). Querejeta *et al.,* (2000) found that in afforested areas in Spain terracing has a negative effect on some soil physical properties in the top or near surface soil layers, where mechanical terracing increased water storage and soil moisture.

Aspect and slope positions are probably the main topographic features in Jordan which may have pronounced effect on growth of afforested areas as well as on nutrient dynamics. However, no information is available regarding the significance of these factors on the availability of nutrients and water during life span of afforestation and their effect on growth. Gong *et al.* (2007) found out in Mongolia that productivity of north facing slopes was higher than the south facing slopes, productivity on south oriented slopes was depressed while it was increased on north facing compared to that on flat sites, north facing slopes had high productivity.

In Jordan, such studies regarding afforesation growth assessments are missing.

The objective of the present study was to examine both aspect and slope position impacts on afforestation growth performance and nutrients concentration levels in *P. brutia* needle, litter fall and soil properties to gain information in order to evaluate their impacts on restoration and to integrate them in a frame work of site classification to identify the basic scientific knowledge for future management plans. Moreover, it provides a link between climatic factors as influenced by water balance and growth characteristics in semi arid areas where water shortage is the main limiting growth factor.

2. MATERIALS AND METHODS

2.1. Study area

The study area was Wasfi-Tal Forest (500 ha), 10 km north west of Amman with an elevation range from 400-850 m above sea level. The prevailing climate is semi arid Mediterranean with pronounced winter precipitation and drought predominates in summer. From 1974 to 2008, the mean annual temperature at Baqa Meteorological Station (the closest station) was ranging from 3.6 ^{0}C in (January) to. 32.4 ^{0}C in (August) with mean annual precipitation of 400 mm year^{-1} (34 year records). Limestone is the dominant parent material there. The soil is sand clay loam texture, its depth varied with exposition and slope positions. The plantation has not yet managed, although some pruning in outer edges has been practiced. It is documented that no fire events occurred in the study area (Personnel Communications).

Former land use was open rangeland with high livestock grazing pressure as communal land use tenure. Main vegetation consisted of low grasses *Poa* spp, *Hordeum* spp, and *Poterium spinosum*, no natural forest trees or shrubs existed during plantation time. Plantation activities were implemented in the period of 1975-1977. Seedlings were planted on pits prepared on gradonies with 3×4 m spaces. The species used in plantation was mainly *P. brutia* and occasionally with *P. halepensis, Acacia cyanophylla* and *Pinus pinea.* The planted seedlings were raised at the Forestry Department Nurseries close to the site.

2.2. Data collection

Data were collected during July to September, 2008. To maximize spatial variation in the dataset, a factorial arrangement randomized complete block design (RCBD) with (4x3) with 3 replicates in 36 plots were used. Each plot was about 360 m^2 laid out on 4 exposure directions (North, South, East, West) which were determined by a compass. Transects were laid out along each selected aspect through out the study area. Transects principally were oriented from Wadi bottom to ridge, perpendicular to the contour line. Each transect was divided into three parts, the first of the transect was on the upper site (slope position=upper), the second the middle (slope position=middle) and the third was on the lower (slope position=bottom). Plant heights and diameter breast height (DBH) in each plot sample were measured with three replications selected proportionally through slope position chosen with random intervals. The distance between plots was regulated by slope length which was separated in three parts (Upper, Middle and Bottom), ensuring sample independence. In each plot, trees with height <10 m were measured with a telescopic meter, trees higher than10 m were measured using Blume Leiss Meter and (DBH) with a caliper.

To quantify nutrient levels in the plants, current year twigs with needles were sampled from the first and second order side of the branches from four directions of randomly selected standing of 3-4 trees, from each one from four directions (North, South, East and West). The compound twig samples were collected. Three samples in each slope position in each sampled plot for the studied species *P. brutia* were collected, twigs were dried at 68^0C until needle fell off. Needles from each compound samples were ground in stainless mill. Forest floor which was 2-8 cm thick took place simultaneously with data collecting. Accumulation of ground litter beneath trees was determined on randomly distributed positions within each plot. Samples of forest floor were obtained by pressing a steel sheet frame (25x25 cm) with (8 cm deep) into the forest floor and collecting all organic material above the mineral soil in plastic container. Mineral soil was removed before grinding and sieving and oven dried to constant weight at 68 ^{0}C.

A soil sample of the top soil pH layer (0-30 cm) underneath the canopies was randomly sampled with auger or by using a hoe, separated into two depths (0-5 cm) and (5-30 cm). In each sample plot, needles litter, and soils were collected. Sub samples were combined and analyzed in the laboratory. Soil and electrical conductivity (EC) were measured at 1:5 (W/V) ratio using a Glass Electrode pH and electrical conductivity (EC) meter according to Chapman and Pratt (1961). Nitrogen percentage was determined by using Kjeldahl method (Fleige *et al.*, 1971). The available phosphorus (P) contents of 5 gm of soil were extracted by Olsen's ($NaHCO_3$) method using spectrophotometer (Watanabe and Olsen 1965). Available potassium (K) contents of 5 gm of soil were extracted by 1N ammonium acetate and determined by flame photometer (Meiwes *et al.* 1984). Total soil organic matter (SOM) was estimated by the Walky-Black wet oxidation method (Allison, 1965). Iron, Mn, Zn and Cu were extracted using a solution (pH 7.3) containing 0.005 M diethylenetriaminepentaacetic acid (DTPA), 0.1 Mtriethanolamin (TEA) and 0.01 $CaCI_2$ with a 2 h shaking time (Lindasy and Norvell 1978). The concentrations of these elements in the extracts were determined by atomic absorption spectrophotometer.

Data were analyzed using SAS (1991). The ANOVA was used to determine significant differences. Means were compared by using Duncans Multiple Range Test (DMRT) at 5% level (Lentner and Bishop, 1993).

3. RESULTS

3.1. Stand growth

The results showed that, aspects and slope positions had significant effect on *P. brutia* height and DBH (P<0.0001), meanwhile slope position showed significant effect only on plant height (Tables 1 and 2). On the other hand, the combined effect of the two factors was significant on height and DBH values (P<0.0001).

Growth performance of aspects and slope positions

The highest *P. brutia* was obtained on western and northern aspects with heights of 12.73 and 12.63 m, respectively. These values differ significantly from those on eastern and southern aspects with extra heights of 28.04 and 23.11 %, respectively. Meanwhile, there were no significant differences between southern and eastern aspects (Table 2). Aspect showed a significant effect on DBH, in the order of west > north > south> east

Table (1): Effect of aspect (Exposure) and slope positions on *Pinus brutia* height and DBH (ANOVA results).

Source of variation	Growth parameter	df	MS	F value	Pr < F
Aspect(Exposure)	Height (m.)	3	467.95	118.28	< 0.0001
Slope Position		2	40.13	10.14	< 0.0001
Aspect*Slope Position		6	121.18	30.63	< 0.0001
Aspect(Exposure)	DBH (cm.)	3	2185.14	80.72	<0.0001
Slope Position		2	10.61	0.40	0.6726
Aspect*Slope Position		6	141.6	5.30	0.0001

Table (2): Height and DBH performances in different aspects and slope positions.

Aspect Exposures	Height (m.)	DBH (cm.)
North	12.63 a	19.38b
South	9.71b	15.43c
East	9.16b	13.19d
west	12.73a	21.94a
Slope Position		
Upper	11.1bb	17.66a
Middle	11.87a	18.31a
Bottom	11.41b	17.67a

Means with the same letters did not show significant differences (LSD test at 95%).

Table (3): Mean height and DBH within aspects and slope positions.

ASP*Slop. Pos	Heights (m.)		DBH (cm.)	
	Mean	Standard deviation	Mean	Standard deviation
NU	EF(11.13)c	1.5	C(17.88)b	4.27
NM	A(14.43)a	3.22	AB(20.89)ab	7.26
NB	CD(12.33)b	2.45	BC(19.14)b	5.83
SU	GH(8.84)b	0.99	D(14.87)b	3.93
SM	G(9.16)b	0.89	D(14.18)b	3.27
SB	EF(11.13)a	1.56	C(17.26)a	4.02
EU	F(10.95)a	2.03	D(14.23)a	3.66
EM	G(9.64)b	1.19	D(14.23)a	2.58
EB	H(8.27)c	0.89	E(11.11)b	2.64
WU	BC(12.88)ab	2.36	A(22.05)a	6.72
WM	ED(11.92)b	1.99	AB(21.36)a	5.46
WB	B(13.50)a	2.57	A(22.57)a	5.98

Means with the same letters did not show significant differences(LSD test at 95%). Small letters in the right column showed significant differences between slope positions within each aspect, capital letters in the left column significant differences aspects by slope positions.

with values of 21.94, 19.38, 15.43 and 13.19 cm, respectively.

Slope positions showed a significant effect on height. The highest DBH value was obtained on middle slope positions with 3.55and 3.50 % higher than those on upper and bottom slope positions, respectively, although statistically not significant.

3.2. Growth performances within aspects and slope positions

Table (3) shows the mean height and DBH within aspects and slope positions. Plant height was significantly affected by slope positions. The pronounced height growth was obtained in the middle slope positions with 14.43 m on northern aspects, followed by the bottom slope with 12.33 m and then upper slope with 11.13 m. On southern aspect, the same trend was observed: the highest height growth was on the bottom with 11.13 m, followed by the middle and upper slope positions without significant differences between them with values of 9.2 and 8.84 m, respectively (Table 3). On the east aspect, results showed a significant different trend with the highest height value resulted on upper slope position, followed by the middle and bottom with 10.95, 9.64 and 8.27 m, respectively.

On western aspect, values showed similar trend as the northern aspects with most significant height value resulted on lower, followed by upper and middle slope positions with 13.5, 12.88 and 11.92 m, respectively (Table 3). The largest DBH values were found on the bottom and middle slopes on all aspects and significantly differ compared to the upper slope positions with exception on western slopes which not significantly differ.

ANOVA test results showed that, higher trees were found on Northern and West aspects in the order of NM> WB > WU > NB> WM > NU > with 14.43, 13.5, 12.88, 12.33, 11.92 and 11.13 m, respectively. Trees with lower heights were found on eastern and southern aspects in the order of SB> EU > EM> SM> SU> EB with 11.12, 10.95, 9.64, 9.16, 8.84 and 8.27 m, respectively. Likewise, DBH results showed the same trend with lower values ranged between 11.11-17.26 cm for the eastern and the southern aspect. Meanwhile, higher tree height and large DBH values were obtained on northern and western aspects located primarily on middle and bottom slopes.

3.3. Nutrient levels in Green needle (Foliar)

Table (4) shows that there was no significant effect of aspects or slope position on nutrient concentration levels in the needles. Their combined effect also showed no significant effect on the nutrient concentrations, except on Fe and Cu ($P<0.05$ and $P<0.01$, respectively).

By using DMRT, the results showed that, K concentration differed significantly among aspects with the following sequence:

South>East>North>West and the concentration were: 4257.3, 4227.3, 3631.9 and 3372.1 ppm, respectively Nitrogen percentage values showed also significant differences in slope positions with the following order: Middle>Bottom>Upper, these were 1.6, 1.4 and 1.2 %, respectively (Table 5).

3.4. Content of nutrients in Litter

The effects of aspect on litter nutrient concentration was found to be not significant except for Ca. Southern aspects had the highest litter Ca concentration (50793 ppm), with the slopes western and northern slopes with values 38798 and 24083 ppm, respectively (Table 6). On the other hand, the slope positions showed significant effect on differences in litter content of N%, P, Ca, Fe, Zn, and Cu concentrations. The highest nutrient concentration of the above minerals were found on bottom positions which differ significantly from the middle and bottom position. The N% showed no significant difference between upper and middle positions, the highest N% was 1.24% on bottom followed by middle (1.03%), where it was on the upper position (0.93%). Phosphor content in litter showed also significant differences on slope position, the highest P concentrations were on bottom position, followed by upper then middle with the values of 667.1, 565.0 and 429.1 ppm, respectively. The same trend was obtained for Ca, Mg, Fe, Zn and Cu in litter (Table 6). Their concentrations in the bottom slopes were 50796, 6401, 8243, 69.9 and 412.2 ppm, respectively. However, the combined effect of aspects and slope positions showed no significant impact on litter nutrient concentrations.

3.5. Soil properties underneath *P. brutia* afforestation

Soil properties underneath pine trees did not differ among the various aspects; the northern aspects, however slightly differed significantly from the other aspects. However, K, Cu and pH values showed significant differences among aspects. Meanwhile, pH was the highest, particularly on aspects with high concentrations of K, Na, Ca, Mg and low levels of OM (Table 8). On the other hand,

Table (4): Effect of Aspect (Exposure) and Slope positions on *Pinus brutia* needle nutrient levels (ANOVA results).

Source of variation	Nutrients in Green Needles	df	MS	F value	pf< F
Aspect (Exposure)	N%	3	0.88	0.89	0.45
Slope position		2	0.217	2.19	0.13
Exp*Slope Pos.		6	0.067	0.68	0.67
Aspect (Exposure)	P	3	3154.076	0.09	0.96
Slope position		2	12445.79	0.34	0.72
Exp*Slope Pos.		6	23776.667	065	0.68
Aspect (Exposure)	K	3	1178380.45	1.95	0.50
Slope position		2	583285.365	0.96	0.39
Exp*Slope Pos.		6	903779.915	1.49	0.23
Aspect (Exposure)	Na	3	109154.087	0.71	0.55
Slope position		2	9922.185	0.06	0.93
Exp*Slope Pos.		6	201022.558	1.30	0.29
Aspect (Exposure)	Mg	3	95991.279	0.38	0.77
Slope position		2	3030146.42	1.19	0.32
Exp*Slope Pos.		6	427666.240	0.17	0.98
Aspect (Exposure)	Ca	3	10922265.400	0.19	0.90
Slope position		2	3970395.40	0.07	0.93
Exp*Slope Pos.		6	45700646.5	0.79	0.08
Aspect (Exposure)	Fe	3	138407.58	2.54	0.43
Slope position		2	47014.74	0.86	0.04*
Exp*Slope Pos.		6	148751.54	2.33	0.24
Aspect (Exposure)	Zn	3	1316.101	1.47	0.24
Slope position		2	448.141	0.50	0.63
Exp*Slope Pos.		6	1061.611	1.19	0.34
Aspect (Exposure)	Cu	3	184.70	1.72	0.079
Slope position		2	19.72	1.74	0.760
Exp*Slope Pos.		5	1019.409	3.47	0.0038*

Table (5): Effect of aspects and slope positions on the content of nutrient in *Pinus brutia* needles.

Aspect (Exp.)	Nutrient level								
	N %	P Ppm	K ppm	Na ppm	Ca ppm	Mg ppm	Fe ppm	Zn ppm	Cu ppm
North	1.6a	509.2a	3631.9ab	825.7a	14628.0a	3198.0a	365.1	33.4a	21.0a
South	1.4a	546.1a	4257.3a	1042.0a	11717.0a	2486.5a	616.50a	45.9a	34.6a
East	1.3a	526.4a	4227.3a	860.0a	14558.0a	3010.7a	513.0a	56.2a	30.7a
West	1.3a	545.8a	3372.1b	1038.0a	1341.0a	2811.3a	461.0a	29.3a	29.3a
Slope position									
Upper	1.2b	532.5a	3619.5a	930.6a	12812.0a	2835.3a	517.8a	42.8a	27.2
Middle	1.6a	489.1a	3398.7a	950.7a	14060.0a	2443.8a	495.8a	34.7a	35.2a
Bottom	1.4ab	569.8a	4066.8a	916.3a	14049.0a	3413.5a	441.3a	46.2a	23.6a
Asp. * Slope Pos.	ns	ns	ns	ns	ns	Ns	ns	ns	ns

In each sampling, the same letters in the same column showed insignificant differences at level (p <0.05).

Table (6): Effect of aspect and slope positions in litter nutrient levels.

Aspect (Exp.)	Nutrient level								
	N%	P ppm	K ppm	Na ppm	Ca ppm	Mg ppm	Fe ppm	Zn ppm	Cu ppm
North	1.06a	507.1a	2954.0a	978.9a	24083b	4269a	5194a	43.28a	259.7a
South	1.10a	648.2a	2133.7a	649.0a	50793a	4393a	4846a	50.80a	292.4a
East	1.10a	491.3a	2176.5a	554.4a	50647ab	5609a	5194a	65.61a	282.0a
West	0.90a	576.0a	3021.3a	955.5a	38798ab	4807a	8651a	54.35a	42.8a
Slope position									
Upper	0.92b	565.0b	2599.6a	858.2a	41340ab	4783ab	6124ab	50.3ab	305.8ab
Middle	1.03ab	429.1ab	2161.6a	873.4a	2987ab	3078.5b	3536b	39.6b	176.8b
Bottom	1.24a	667.1a	2947.9a	623.7a	50796a	6401a	8243a	69.9a	412.2a
Asp. * Slope Pos.	NS	NS	NS	NS	NS	NS	NS	NS	NS

In each sampling, the same letters in the same column showed insignificant differences at level ($p < 0.05$).

soil properties with higher concentrations of N, K, Zn and Cu were found in 0-5 cm soil depths and showed significant differences with 5-30 cm soil depth.

In this investigation, it was found that N, K & Zn were higher in the upper soil layer,0-5 cm., compared to lower depths 5-30cm., (Table 8).

4. DISCUSSION

Height and DBH were variable, among the studied plots, mean height of 36 plots averaged 11.43 m, ranging from 6.0 m to 19.0 m, mean DBH averaged 17.88 cm ranging from 6.0 to 42.0 cm. Both variables were correlated significantly (Pearson $r=0.71$, $P<0.0001$). Height and DBH for *P. brutia* afforested sites were clearly higher on north and west aspects. This can be attributed to the fact that southern and eastern aspects receive much more solar radiation than north-facing aspects during rainy season. This means that potential evapotranspiration is much larger on the southern slopes, lending to drier soils there. Although located only a few hundred meters apart, the microclimatic conditions on the slopes vary drastically. Moreover, slope positions showed significant effect on tree heights with middle and bottom slopes showed the highest values. Under semi arid conditions with limited rainfall and shallow soils, annual tree growth, manifested by DBH and height was very small. This may reflect a state of balance between canopy covered and other tree properties and dominant micro –climatic conditions prevailing over various slopes and aspects. Over the top upper slopes, soils are usually thin which means that water available for plants is limited and also potential evapotranspirations are higher due to windy conditions. It can also attributed to that after sapling stage no more run off as occurring from middle towards bottom slopes due to forest stand crown protections and accumulation of organic matter. Height growth in the study area was similar or slightly higher than those found in *P. halepensis* plantations in Heusca, Spain with 410 mm $year^{-1}$ rainfall. Site index for 40 years old trees was 4.8

Table (7): Needle concentrations of *Pinus brutia* (mg gr-1 dry weight), mean and range-minimum and maximum in afforested area in Wasfi –Tal (Jordan), Yesta and Calasparra. (Spain).

Nutrient	Wasfi Tal Forest Jordan Rainfall 400 mm year $^{-1}$		Yesta-Spain Rainfall 530 mm year $^{-1}$	Calasparra Spain Rainfall 290 m year-^{1}	*P.halepensis*		*Pinus genera*
	mean	range	Mean[a] (Range)	Mean[a] (Range)	Adequate ranges (mean)[b]	Normal ranges (Mean)[c]	Ranges for medium (second)[d] class
N	13.9	10.3-28.4	9.52 (6.0-14)	10.7 (6.6-15.9)	10-20	9.88-14.98 (12.13)	12.0-17.0
P	0.5	0.25-1.07	0.72 (0.5-1.4)	0.71 (0.5-1.2)	1-2	0.60-1.07 (0.87)	1.0-2.0
K	3.8	0.9- 2.2	2.81 (1.5-7.6)	3.6(1.9-5.7)	> 8	3.57-6.88 (4.91)	3.5-10.0
Mg	2.9	0.3-7.9	2.7 (1.3-4.9)	2.02(0.9-3.0)	1-1.9	1.49-2.73 (2.01)	0.6-1.5
Ca	13.6	8.0-45.5	7.01 (2.7-11.2)	7.54(4.0-11.0)	3.6[e]	3.28-7.22 (5.15)	1.5-4.0
Fe	0.49	0.11-.99	-		1.23 [e]	-	
Zn	0.04	0.009-0.01			3.6 [e]	-	
Cu	0.024	0.006-0.09			0.01 [e]	6-10	
Na	0.94	0.49-2.6					

[a] Mean and ranges reported in Lo´pez Serrano *et al.* (2005).
[b] Ranges reported in Fürst (1997) and Bergman (1993), both cited in Tausz *et al.*, (2004) and López-Serrano *et al.* (2005).
[C] Ranges and means reported by FFCC for *P.halepensis*. Spain, Annexure (Stefan *et al.*, 1997). Cited by López-Serrano *et al.* (2005).
[d] Classification suggested by the FFCC (Stefan *et al.*, 1997), cited by Lo´pez -Serrano *et al.*, (2005)
[e] Means reported by EC-UN/ECE cited by Michopouluos *et al.* (2007).

Table (8): Effect of Aspects and Slope positions on soil Properties in 0-5cm. and 5-30cm.soil depths.

Aspect	N %	P ppm	K ppm	Na ppm	Mg ppm	Ca ppm	Fe ppm	Zn pmm	Cu pmm	PH	EC	C	OM
North	0.76ab	184.1 a	618.8a	121.2a	846.0a	18733a	2.8a	0.62a	1.09a	8.14ab	2.6a	2.7ab	2.7ab
South	0.66b	143.0a	393.8b	94.6ab	753.3a	11045a	2.0a	0.45a	0.45a	7.96c	2.4a	3.2a	3.2a
East	0.88a	154.a	353.2b	72.1b	596.4a	10346a	2.6a	0.54a	0.54a	8.21a	2.2a	3.1a	3.1a
West	0.88a	198.0a	539.3a	91.4ab	636.4a	11912a	2.0a	0.59a	0.59a	8.05bc	2.7a	2.4b	2.4b
Soil depth													
0-5cm	0.86a	189.3a	561.2a	104.1a	775.7a	14593a	3.1a	0.76a	1.0a	8.13a	2.5a	2.8a	4.83a
5-30cm.	0.60b	149.9a	395.8b	87.1a	652.2a	11788a	2.5a	0.34b	0.67b	8.06a	2.4a	3.02a	.2a
Aspect*Soil	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns		

In each sampling, the same letters in the same column show insignificant differences at level (p <0.05).

to 11.7m compared to 6 or 9 for the present study area. (Olarieta *et al.,* 2000). Height and DBH obtained in the present study area was larger by 2 fold compared to those found in afforested marginal areas with 200-300mm year $^{-1}$ in Jordan (Razzag and Flsterb 2002). The slow growth rates observed in this study are not only because this a slow-growing species but because as a rule *P. brutia* are suited on poor and degraded soils in arid and semi arid climates which do not usually foster rapid growth of most plant species (Montero *et al.,* 2001). These results are agree with Fontaine *et al.* (2007) who found that elevation and exposition rather than soil type determine communities and site suitability in Mediterranean mountain forests in Turkey. Gong *et al.* (2007) reported that northern slope aspect determine productivity and species composition in Mongolia.

Macro nutrients concentrations in needle planted *P. brutia* were higher for (Mg and Ca) , around average for (N) and slightly lower for (P and K) than the adequate levels **(**Bergmann 1993; Furst 1997; cited in Tauz *et al.,* 2004). The high levels of Ca concentration of *P. brutia* in the needle, litter and in soil indicate that this pine is well-adapted to poorly soils with high pH values and low fertility (Table 7). According to Stefan *et al.* (1997), N of *Pinus genera* fall within the medium second class P and K below adequate mean ranges. Ca and Mg above adequate mean ranges.

However, these results are agree with the findings of López-Serrano *et al.* (2005) in Calasparra Spain, in which reported a result of (6.6-15.9 for N, 0.5-1.2 for P, and 1.9-5.7 for K). Meanwhile, Mg concentrations are 7% higher and Ca is one fold more than in Spain and 5 fold than normal ranges in *P. halepensis,* consequently more higher than in *P. genera* (Table 7). (Bergmann 1993; Furst 1997; cited in Tauz *et al.* 2004). On the other hand, the needle Fe concentration was 0.620 similar to Tauz *et al.* (2004) results in which Fe concentrations were found to be 0.637 in *P. canariensis* in Tenerife Island. Zinc and Cu concentrations are also in agreement with Tauz *et al.* (2004) findings. These concentrations in the *P. canariensis* were 2.55 and 24, consequently. Compared to those species, N levels in *P. brutia* needles in Wasfi Tal were close to normal ranges in spite of prevailing harsh conditions of mineralization. These results could be achieved as a result of well protections and no disturbance happened during last 34 years of stand establishment or to its compulsory mycorrhizal symbiosis (Rincon *et al.,* 2006) which could be found in this area (further investigation is needed). Low P content could be attributed to high soil carbonate contents which found in this study area because plants have little access to the soil phosphate. Furthermore, low K contents often happened in carbonate sites (K/Ca antagonism) and sandy clay loam textured soil. Ca and Mg values were higher than the normal reported values because of prevailing dry conditions of the soils that exist on calcareous bedrocks, with a result of richness in Mg and Ca. Moreover, these findings can be explained by that Ca and Mg are immobile inside the plant (Marschner 1986) and accumulate for along time span in the needles.

The micronutrient concentrations of Fe, Zn and Cu showed different trend as presented in Table (8). Iron and Zn were equal to 40.1% of concentration found in Spain. While Cu was twice higher in our study area than it was found in Spain (Michopoulos *et al.* 2007), but all within adequate ranges. Moreover, Na which is not essential plant nutrients was over the adequate level. Fe, Zn and Cu concentrations in the needles can be explained by change of environmental conditions, which led to very slow process of decomposition of organic matter release of these nutrients as organic origin. Generally, for all the macro and micro nutrient concentrations in the needles, there were significant differences between aspects and slopes position as shown in Table (4), which mainly reflect differences in microclimatic conditions.

Nutrient concentrations in the forest floor had the same pattern as needles (Table 8). They were within the ranges reported by Kavvadias *et al.* (2001) for black pine in Greece and by other authors for conifer litters (Bockenheim *et al.,* 1983; Klemendson 1987; Fried *et al.,* 1990; Kavvadias *et al.* 2001).

The accumulation of nutrients in the needles during life cycles of the ecosystem is accompanied by a similar accumulation in forest floor, derived from the dead plant matter on the sites (Table 8).

There was a trend of decreasing nutrient concentrations on forest floor from E>S>N>W, although not-significant, where high significant differences found on slope positions. Meanwhile, higher nutrient concentrations of N , P, Fe, Zn and Cu were on bottom followed by middle and upper slopes. These results can be explained by better microclimatic conditions due to better water availability in soil which can be used by plants and can induce and hasten decompositions of litter fall.

Soil properties (total amount of nutrients) under afforested areas with *P.brutia* were related to aspects and soil depths (Table 8). Calcium and Mg were the most abundant macronutrient in the soil depth 0-30 cm followed by K, P, Na and N. Micro nutrient had the same trends, the most abundant micro nutrient was Fe followed by Cu and Zn. These nutrients concentrations were higher on the northern and eastern aspects comparing with other aspects. These results can be explained by better prevailing micro site climatic conditions regarding soil water availability due to lesser irradiation time dominating in such micro-site. In addition, stands were established on soils derived from calcareous bed rocks which they have more Ca and Mg elements. These were accompanied with high pH of 8.14 and low organic matter of 2.7%. These findings agree with Alifragis *et al.* (2001). Furthermore, substantial significant differences on N, K, Zn, and Cu nutrient concentrations in soil depths of 0-5cm which were higher than soil depth 5-30 cm (Table 8), can be probably attributed to the substantial increase of initially decomposed organic matter produced by stands consequently mixed in the upper surface layer.

In conclusion, studying the site factors and their effect on growth, nutrient levels in needle, litter fall and soil properties are a useful tools for information gathering on nutrient dynamic in a semi arid land ecosystem. This information can provide basic knowledge and guides for management practices in a conservative or no interference of silvicultural practices. Nutrient concentration ranges described here provide a baseline survey of normal values at natural and vital stands. Therefore, applying sivicultural practices such as pruning and thinning, or adapting silvipastoral systems may improve nutritional status of afforestation by increasing the decomposition of accumulated litter fall and decrease fire hazards in such ecosystem. Particularly, emphasis should be given to mycorrhizal symbiosis studies under such ecosystem and allelopathie under *P. brutia* due to rarely or absences of undestroyed vegetation in these areas which lead to maintain biodiversity sustainability and decrease fire hazards.

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نمو الصنوبر البروتي ومستوى العناصر الغذائيه في الاوراق الابريه ومتبقيات الاشجار وصفات التربه للتشجير في المناطق الجافه لشرق البحرالابيض المتوسط

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ملخص

تم دراسة نمو الصنوبر البروتي ومستوى العناصر الغذائيه في الاوراق الابريه ومخلفات الاشجار وصفات التربه لمناطق مشجره كانت سابقا مناطق مفتوحه للرعي المستمر في غابة وصفي التل في الأردن . درس عاملان: هما المعرض (شمال،جنوب،شرق،غرب) وموضع المنحدر (مرتفع، متوسط، منخفض) . بينت النتائج ان المعرض الشمالي والشرقي ذا تأثير معنوي على النمو الطولي وعلى قطر الاشجار عند الارتفاع الصدري بالمقارنه مع المعرض الجنوبي والغربي، بالمقابل تبين أن موضع المنحدر ليس له تاثير معنوي على النمو بعد تجاوزمرحله الأعمدة للمشجر في المناطق والذي تعتبر بها المياه هي العامل المحدد للنمو.

كانت مستويات النتروجين حول المعدلات العامة المقبولة ، بينما عناصر الفسفور والبوتاسيوم والعناصر الصغرى للحديد والزنك والنحاس فكانت تحت المستويات المقبولة والمثلى بينما كان تركيزعناصرالكالسيوم والمغنيسيوم ضعفي المستويات المقبولة مقارنه مع مناطق مشابهة في اليونان واسبانيا وهذا يعني أن هذا النوع من الصنوبر يتأقلم مع ظروف التربه الفقيره ذات المستوى العالي من pH والخصوبة المتدنية. وجد أن مستوى العناصر في متبقيات الاشجارعلى سطح الارض يتناقص بالاتجاه شرق < جنوب < شمال < غرب حيث ان تراكم العناصر في بقايا النباتات على سطح التربة هو نتيجه لتراكمها في الاوراق الابرية. وجد أن هناك تراكيزات عالية وذات فروق معنوية لعناصر النتروجين والبوتاسيوم والزنك في عمق التربة صفر- 5 سم مقارنة مع عمق التربة 5-30 سم بينما العناصر الاخرى تسير بنفس الاتجاه ولكن بدون فروق معنوية وهذا ينطبق على كل من pHوالتوصيل الكهربائي ومحتوى التربة من المادة العضوية.

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