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INFLUENCE OF ALTITUDINAL GRADIENT ON SOME PHYSIOLOGICAL AND ECOLOGICAL ASPECTS OF *SOLANUM INCANUM* L. GROWING NATURALLY IN YEMEN

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The study aimed to clarify the effect of altitudinal gradient on some physiological and ecological characters of *Solanum incanum* L. growing naturally in Yemen. The plant samples were collected from four locations ranging in altitude from 1570-2595 meters above sea level in two seasons (Winter and Summer of 2000).

Results indicated that locations 1 and 2 (1570 and 1800 m) had a higher monthly temperature than the other elevations. Moreover, location 3 (2200 m) showed the lowest value of relative humidity. In addition, location 2 had the highest amount of rainfall. The soil associated with *S. incanum* at the highest altitude (2595 m) was characterized usually by the highest values of soil moisture content, EC, K and total anions during the two studied seasons. Additionally, soil of location 3 generally had the maximum amounts of Na, Ca, Mg, Cl as well as total cations in both seasons.

It was found that as altitude increased, K,Ca, Mg, total reducing value (TRV) and protein-N content were increased in the stem of *S.incanum* during winter, while protein-N and total –N contents were increased in summer. Moreover, total soluble-N content decreased in the two studied seasons. In the leaves, with increasing altitude, polysaccharides, total carbohydrates and total soluble-N content were usually lower in winter. In addition, reducing and total soluble sugars values in leaves were increased during summer with increasing altitude. Compared with the lowest altitude, TRV value in fruits of *S. incanum* increased during winter, however, Mg, Fe, polysaccharides, protein-N and total-N contents decreased in winter. Also, high solasodine content was detected in fruits of *S. incanum* at the highest altitude during winter. The result of the gel electrophoretic technique showed that more proteins were synthesized in abundance in the medium elevations (1800 and 2200 m) than at the lowest and the highest ones.

Keywords: *Solanum incanum* L., altitude physiological studies, ecological studies, ion accumulation, metabolic products

Yemen lies in the south western corner of the Arabian Peninsula and it is a country of a number of sharply defined habitats which gives it its floristic richness. Altitude ranges from sea level to over 3000 m above sea level. The altitudinal gradient is associated with variation in a number of environmental factors such as air temperature, precipitation, wind exposure, light intensity, radiation and pressure (Kofidis *et al.*, 2003).

A number of studies dealing with the effect of different elevations on some physiological and ecological aspects of different species were found to be of much relevance and help during this work (Ndamba *et al.*, 1995; Alwadi and Abulfatih, 1996; Hamouz *et al.*, 1999; Venema *et al.*, 1999; Vinay *et al.*, 2002 and Wang *et al.*, 2002).

The aim of this work was to clarify the effect of altitudinal gradient on some physiological and ecological aspects of *S. incanum* growing at four different elevations in Yemen ranging from 1570-2595 meters above sea level in two seasons (Winter and Summer).

MATERIALS AND METHODS

The plant material used in the present investigation was obtained from the selected species (*Solanum incanum* L.) growing at four locations varying in elevation above sea levels (1570, 1800, 2200 and 2595 m).

Climatic data for the four locations were obtained from the Natural Resources Authorities (Yemen) during the period of investigation year of 2000.

Soil samples associated with *S. incanum* were collected from different depths (0-20 cm), (20-40 cm) and (40-60 cm) and some physical and chemical properties were determined according to the methods described by Allen *et al.* (1974).

The plant samples were collected, well washed and separated into leaves, stems and fruits. Then, they were dried at 80°C and ground to fine powder for chemical analysis. Ca, Mg, P and Fe were determined using atomic absorption spectrophotometry, while Na and K by flame photometer according to Allen (1989).

The methods adopted for plant analysis can be summarized as follows: photosynthetic pigments (Metzner *et al.*, 1965), extraction and estimation of carbohydrate fractions (Naguib, 1963 and 1964), nitrogenous constituents according to Naguib (1969) and proline determination by Bates *et al.* (1973).

Sodium dodecyl sulphate polyacrylamide gel electrophoresis (SPS-PAGE) was used to fractionate the proteins in leaves according to molecular weight (Bhatty, 1982; Fullington *et al.*, 1983 and Sharobeen *et al.*, 1991). Quantitative estimation of solasodine was done according to Lancaster and Mann (1975).

The obtained data were subjected to analysis of variance according to Snedecor and Cochran (1989) and L.S.D value at 5% significance was calculated.

RESULTS AND DISCUSSION

Climatic Factors

The climatic conditions prevailing in the study locations during 2000 are presented in table (1). It is clear that locations 1 and 2 had a higher monthly temperature than the others. Moreover, the highest altitudes (2200 and 2595 m) were characterized by lower temperature during the winter months (November-February). This result is in agreement with those of Younis (1992).

It is also of note that the values of relative humidity of the medium altitude (2200 m) were lower than those of other elevations. On the other hand, rainfall was irregular and location 2 (1800 m) had the maximum amount of rainfall. There were two rainy seasons during March to June and from July to September. Such results are in agreement with those obtained by Abulfatih and Al-Ani (1997) and Abulfatih (1999).

Soil Characteristics

Table (2) shows that the soil was of sandy loam texture in all the studied locations. Also, soil moisture content was much greater at the highest altitude compared with the other ones during the studied period. There was a general trend of increasing soil moisture content during summer than in winter.

Table (3) indicates that the soil reaction (pH) of all soil samples, in general, was slightly alkaline and values of EC were very low. Na was the dominant cation followed by Ca, K and Mg at all locations. Data also reveal that Ca, Mg as well as total cations were generally higher in summer than during winter.

TABLE (1). Seasonal variation in climatic factors at the studied locations in 2000.

Month	Location 1 Temperature °C Mean Max.	Location 1 Temperature °C Mean Min.	Location 1 Temperature °C Monthly Mean	Location 1 Relative humidity%	Location 1 Rainfall (mm)	Location 2 Temperature °C Mean Max.	Location 2 Temperature °C Mean Min.	Location 2 Temperature °C Monthly Mean	Location 2 Relative humidity%	Location 2 Rainfall (mm)
January	27.2	22.0	24.6	52	0.0	22.2	16.8	19.5	38	0.0
February	29.0	24.8	26.9	41	0.0	25.5	19.9	22.7	35	0.5
March	30.4	23.8	27.1	43	1.0	31.2	24.8	28.0	30	3.0
April	32.2	27.5	29.9	32	22.5	29.8	27.8	28.8	19	2.0
May	33.0	28.6	30.8	28	15.5	30.1	27.7	28.9	28	19.0
June	34.0	30.6	32.3	29	0.5	32.5	30.7	31.6	31	24.0
July	32.6	25.0	28.8	57	34.5	34.0	31.6	32.8	58	153.5
August	32.7	28.8	30.8	49	65.9	34.2	30.8	32.5	50	127.0
September	31.5	25.8	28.7	35	1.5	30.4	29.4	29.9	31	0.0
October	27.0	23.2	25.1	47	0.5	28.4	22.0	25.2	35	0.0
November	27.0	19.6	23.3	43	0.0	25.0	17.0	21.0	39	0.5
December	27.0	18.6	22.8	50	1.0	24.0	15.2	19.6	37	1.0
Total Annual Mean	30.31	24.9	27.59	42.2	146.4	28.9	24.5	26.7	35.9	330.5

Month	Location 3 Temperature °C Mean Max.	Location 3 Temperature °C Mean Min.	Location 3 Temperature °C Monthly Mean	Location 3 Relative humidity%	Location 3 Rainfall (mm)	Location 4 Temperature °C Mean Max.	Location 4 Temperature °C Mean Min.	Location 4 Temperature °C Monthly Mean	Location 4 Relative humidity%	Location 4 Rainfall (mm)
January	17.2	12.1	14.7	35	0.0	24.6	15.8	20.2	43	0.0
February	19.7	13.7	16.7	20	0.0	25.3	16.3	20.8	30	0.0
March	20.0	15.7	17.9	28	2.7	22.0	18.2	20.1	35	2.0
April	22.7	18.7	20.7	16	0.0	23.9	17.5	20.7	24	9.5
May	24.5	20.8	22.7	13	0.0	22.4	19.4	20.9	20	4.8
June	25.1	21.9	23.5	15	0.0	20.6	19.0	19.8	22	0.0
July	24.4	18.3	21.4	45	41.4	22.6	20.0	21.3	51	24.3
August	24.8	19.7	22.3	31	39.4	23.6	20.8	22.2	20	65.9
September	23.0	18.8	20.9	36	4.0	22.4	19.2	20.8	35	1.5
October	20.2	15.4	17.8	48	4.4	21.1	13.5	17.3	47	2.0
November	17.5	11.6	14.6	37	0.0	20.4	12.2	16.3	40	12.5
December	16.8	9.2	13.0	37	0.0	22.6	15.0	18.8	43	0.0
Total Annual Mean	21.3	16.3	18.9	30.1	91.9	22.6	17.2	19.9	34.2	122.55

Location 1 = Mafhaq (1570 m)
Location 2 = Bait Mufarch (1800 m)
Location 3 = Hadda (2200 m)
Locatoin 4 = Wadi Alqara (2595 m)

TABLE (2). Mechanical analysis of soil associated with *S. incanum* and mean values of soil moisture content during the two seasons in 2000.

Locality & Altitude	Soil depth (cm)	Soil fraction %			Soil texture	Soil moisture content %	
		Sand	Silt	Clay		Winter	Summer
Mafhaq (1570 m)	0-20 20-40 40-60	50.75 67.42 75.85	45.05 28.2 22.4	4.20 4.38 1.75	Sandy Loam Sandy Loam Loamy sand	0.55 0.76 2.46	5.54 7.46 7.55
Bait Mufareh (1800 m)	0-20 20-40 40-60	64.45 72.45 59.6	27.25 23.7 33.75	9.30 3.85 6.65	Sandy Loam Sandy Loam Sandy Loam	2.15 1.78 1.20	3.19 3.19 3.36
Hadda (2200 m)	0-20 20-40 40-60	48.65 51.75 Rocky	45.85 41.85	5.5 6.4	Sandy Loam Sandy Loam Rocky	0.92 0.95 Rocky	13.15 11.61
Wadi Alqara (2595 m)	0-20 20-40 40-60	62.25 87.95 59.75	33.15 10.4 38.5	4.60 1.65 1.75	Sandy Loam Sandy Loam Sandy Loam	2.5 3.7 6.7	15.75 15.0 16.43

The higher altitudes (Hadda, 2200 m and Wadi Alqara, 2595m) had the higher values of EC, Na, K, Ca, Mg, total cations as well as total anions during the two studied seasons with few exceptions (Table 3).

Plant Analysis

Mineral composition

The stem of *S. incanum* contained the highest amount of Ca, Mg and Fe during summer at the lowest altitude (Table 4). Furthermore, fruits had the maximum content of K, Mg and Fe during winter at the lowest altitude. In contrast, Ca, Mg and Fe concentrations in stems (Table 4) reached the maximum values in winter at the highest altitude. In this regard, Liu (1988) stated that concentrations of Mg, Na, K and P in the roots of *Bupleurum falcatum* grown at low altitude (1200 m) were higher than in the roots of plants grown at 2200 m, but Ca content was lower. Moreover, Na and K contents were increased during winter in stems of *S. incanum*. Also, Ca content shows the same trend at the medium elevation (1800 and 2200 m). In this respect, Younis (1992) working on *Pulicaria crispa* and *Peganum harmala* grown naturally in Yemen observed that K, Ca, Mg, Fe and P contents were greater during the winter season.

TABLE (3). Chemical analysis of soil associated with *Solanum incaum* at different locations in summer(s) and winter(w) seasons.

Location (Altitude)	pH		EC. ($dS\,cm^{-1}$)		Cations (ppm)										Anions (ppm)									
					Na		K		Ca		Mg		Total Cations		CO_3		HCO_3		Cl		SO_4		Total Anions	
	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S
Mafhaq (1570m)	8.4	8.7	0.09	0.09	9.2	10.1	3.75	3.15	3.75	5.55	0.6	1.35	17.3	20.2	0	0	7.32	7.32	3.83	4.15	0.09	0.09	11.2	11.6
Bait Mufareh (1800m)	8.3	8.2	0.05	0.05	6.8	8.3	1.55	4.95	4.65	4.65	0.5	0.85	13.5	14.8	0	0	8.05	6.59	4.15	3.51	0.11	0.12	12.3	10.2
Hadda (2200m)	8.4	8.4	0.13	0.14	10.6	9.9	2.05	8.25	8.55	16.30	1.2	1.45	22.4	28.9	0	0	6.59	8.78	4.47	5.11	0.11	0.10	11.2	14.0
Wadi Alqara (2595m)	8.5	8.3	0.18	0.19	10.6	9.8	4.45	6.65	4.80	5.80	0.9	1.95	20.8	24.2	0	0	7.68	10.9	4.79	4.15	0.04	0.10	12.5	15.2

TABLE (4). Seasonal variations in plant mineral content in stems, leaves and fruits of *S. incanum* growing naturally at different locations (mg/g dry wt.).

Altitude)	Na			K			Ca			Mg			P			Fe		
	W	S	LSD	W	S	LSD	W	S	LSD	W	S	LSD	W	S	LSD	W	S	LSD
1570 m																		
Stem	0.24	0.23	0.03	4.35	4.24	0.41	14.36	20.05	16.83	1.70	3.22	3.17	0.17	0.16	0.02	6.29	9.89	10.63
Leave	0.23	0.23	0.04	4.00	4.39	1.03	21.21	20.22	2.67	2.88	3.81	1.22	0.16	0.16	0.03	9.13	13.09	18.01
Fruit	0.47			9.43			22.58			4.32			0.31			19.67		
1800 m																		
Stem	0.24	0.23	0.02	4.89	4.37	0.63	20.23	14.64	18.75	2.91	2.59	1.34	0.16	0.16	0.04	4.35	1.75	5.89
Leave	0.23	0.23	0.02	5.08	4.19	1.38	27.97	22.71	16.05	4.09	3.31	2.68	0.17	0.17	0.03	19.17	13.43	26.76
Fruit	0.43			8.56			24.87			2.99			0.31			14.79		
2200 m																		
Stem	0.25	0.23	0.03	4.62	4.33	0.47	26.07	17.43	23.09	2.30	3.17	3.16	0.16	0.16	0.03	5.31	6.37	11.72
Leave	0.24	0.23	0.03	4.01	4.47	0.44	23.57	19.53	8.69	4.29	3.84	1.59	0.16	0.17	0.07	23.02	16.40	26.45
Fruit	0.43			8.79			16.30			3.01			0.32			12.70		
2595 m																		
Stem	0.22	*		4.80	*		32.38	*		3.26	*		0.17	*		15.40	*	
Leave	0.24	0.23	0.04	3.95	4.26	0.97	17.95	20.87	10.39	2.71	3.79	1.43	0.16	0.16	0.03	5.47	9.87	12.95
Fruit	0.48			9.03			24.61			3.85			0.13			6.69		
LSD 5%																		
Stem	0.02	0.03		0.27	0.58		14.54	19.83		2.25	2.50		0.04	0.01		5.89	10.63	
Leave	0.02	0.03		1.14	0.34		10.26	7.02		1.36	1.65		0.03	0.01		21.24	14.39	
Fruit	0.02			0.75			12.06			1.73			0.01			18.49		

* missing samples. W=Winter. S=Summer

Photosynthetic Pigments

There was a significant and remarkable increase in chlorophyll a,b and carotenoids in leaves of *S. incanum* in summer relative to that in winter at all locations (Table 5). However, Younis (1992) found that chlorophyll a,b, and total chlorophyll were remarkably decreased during summer for two desert plants grown in Yemen. As altitude increased a significant difference in chlorophyll a,b, and carotenoids as well as total pigments were observed in both seasons.

Data indicate that chlorophyll a,b and carotenoids content increased to a peak level at 2200 m and then declined at 2595 m. This result is consistent with those of Sutater *et al.* (1987) and Venema *et al.* (1999). On the contrary, Pocceschi *et al.* (1990) working on *Atropa belladona* grown at 438 and 1750 m, found that the pigment contents increased at lower altitude.

Carbohydrate Contents

Polysaccharides and total carbohydrate content in the stems of *S. incanum* (Table 6) reached their highest values under conditions of the highest altitude during winter. This result is in harmony with those of Lopez *et al.* (2002). However, DRV, polysaccharides as well as total carbohydrates in stem, leaves and fruits (Table 6) in most cases had the highest values during winter at the lowest altitude. On the contrary, Hamouz *et al.* (2000) observed that reducing sugar content was lower in potatoes from dried and warmer low altitude. Reducing sugars increased in summer but polysaccharides as well as total carbohydrates in the stem accumulated in winter. In addition, polysaccharides mostly accumulated during summer in the leaves. Olama and Aly (1994) found that DRV value was increased during summer in both leaves and stems of *Kanahia laniflora* grown in two different habitats in Yemen.

TABLE (5). Seasonal variation of pigments in leaves of *S. incanum* growing at different locations (mg/g fresh wt.)

Altitude	Chl a			Chl b			Carotenoids			Total		
	Winter	Summer	LSD 5%	Winter	Summer	LSD 5%	Winter	Summer	LSD 5%	Winter	Summer	LSD 5%
1570 m	1.12	2.39	0.10	0.33	1.05	0.06	0.27	1.32	0.22	1.72	4.76	0.25
1800 m	1.54	4.22	0.36	0.55	1.53	0.51	0.84	1.44	0.08	2.93	7.19	0.46
2200 m	1.45	5.24	0.23	0.48	1.86	0.07	0.41	2.11	0.18	2.34	9.21	0.41
2595 m	1.29	3.36	0.16	0.84	1.25	1.12	0.38	1.55	0.07	2.51	6.16	0.95
(LSD 5 %)	0.11	0.25		0.66	0.07		0.10	0.14		0.59	0.34	

Nitrogenous Contents

Table (7) shows that protein –N and total –N contents were much higher in leaves than in both stems and fruits of *S. incanum* and in winter than during summer. In addition, total nitrogen in leaves attained the maximum value at the highest altitude during summer and this result was in agreement with those of Suzuki (1998) who found that nitrogen concentration was higher at the higher site than at the lower one for *Sanguisorba tenuifolia*.

With respect to seasonal variations in nitrogen constituents, it is concluded that the values of protein –N and total –N content of stems and leaves were generally higher in winter, whereas total soluble-N content was accumulated during summer. Olama and Aly (1994) found that total nitrogen and soluble nitrogen contents were accumulated in summer in leaves and stems of *Kanahia laniflora* grown in two different habitats in Yemen.

As regards proline content, a significant reduction was detected during summer relative to winter at all locations. Additionally, respect to the lowest altitude, proline concentration was significantly decreased except at the medium elevation (2200 m) where a remarkable and significant increase was found during both seasons (Table 7).

Protein Fractionation

Data represented in table (8) show the results of SDS-PAGE of leaves of *S. incanum* at the four studied altitudes during summer. The molecular weights expressed in rate of flow (RF) ranged between 0.062 and 0.945. Moreover, results show that *S. incanum* had only 9 protein bands at locations 1 and 4 (the lowest and the highest altitudes), whereas there were 17 bands at location 2 and 15 bands only at location 3. This indicated that many proteins (90.18, 43.96, 29, 42 and 7.78) appeared to be synthesized in the leaves of plants grown at the medium elevations than the lowest and the highest ones. The differences may be due to the change in temperature. In this respect, Pareek *et al.* (1995) pointed out that specific stress proteins for instance heat sock protein (HSP) 90 (a group of heat sock soluble protein (HPSS) with molecular weights in the range of 80 and 90 KDa) accumulated under drought stress, heat and salt stress as well as cold stress.

Solasodine

There was a considerable and significant increase in solasodine concentration of stem and leaves in summer with respect to winter at all locations (Table 9).

In leaves, with increasing altitude from 1800 to 2595 m, a significant reduction in solasodine concentration was detected during winter. However, the highest level of solasodine content in fruits was observed at the highest altitude during winter. This result was in accordance with those obtained by Bahuguna *et al.* (2000) who recorded high alkaloid content in four *Aconitum* species in alpine population.

TABLE (6). Seasonal variations of carbohydrate fractions in stems, leaves and fruits of *S. incanum* growing naturally at different locations (mg/g dry wt.)

Altitude	DRV			TRV			Polysaccharides			Total		
	W	S	LSD 5%	W	S	LSD 5%	W	S	LSD 5%	W	S	LSD 5%
1570 m												
Stem	0.77	0.78	0.24	0.90	0.95	0.24	1.58	1.24	0.53	3.25	2.97	0.97
Leave	0.95	0.63	0.50	0.97	0.75	0.29	1.54	1.57	0.24	3.46	2.94	0.54
Fruit	0.92			1.01			1.81			3.73		
1800 m												
Stem	0.76	0.86	0.15	1.30	1.06	0.26	1.34	1.24	0.25	3.41	3.17	0.52
Leave	1.02	0.74	0.05	1.13	0.99	0.09	1.28	1.76	0.49	3.42	3.50	0.52
Fruit	1.12			1.19			1.35			3.66		
2200 m												
Stem	0.67	0.78	0.09	0.93	0.88	0.18	1.66	1.44	0.22	3.25	3.09	0.31
Leave	0.76	0.79	0.27	0.83	0.99	0.16	1.30	1.41	0.25	2.90	3.19	0.29
Fruit	0.81			1.18			1.39			3.37		
2595 m												
Stem	0.76	*		1.17	*		1.97	*		3.90	*	
Leave	0.93	0.74	0.22	1.00	0.77	0.04	1.39	1.43	0.04	3.31	2.94	0.19
Fruit	0.63			1.05			1.60			3.28		
LSD 5 %												
Stem	0.18	0.12		0.19	0.21		0.41	0.19		0.75	0.34	
Leave	0.35	0.09		0.17	0.11		0.25	0.24		0.36	0.32	
Fruit	0.10			0.22			0.35			0.51		

*missing samples W=Winter, S=Summer .
DRV = Direct reducing value TRV = Total reducing value

TABLE (7). Seasonal variations in nitrogen fractions in stems, leaves and fruits of *S. incanum* growing naturally at different locations (mg/100g dry wt.)

Altitude	TS-N			Protein-N			TN			Proline (mg/g)		
	W	S	LSD 5%	W	S	LSD 5%	W	S	LSD 5%	W	S	LSD 5%
1570 m												
Stem	2.19	8.15	1.53	111.43	79.56	94.54	113.62	87.71	93.20	25.06	11.633	3.08
Leave	2.53	2.69	0.50	141.43	138.97	8.545	143.96	141.65	8.50			
Fruit	1.85			112.40			114.25					
1800 m												
Stem	0.82	3.05	0.50	112.20	103.10	55.41	113.02	106.20	55.35	16.50	5.70	1.32
Leave	1.31	4.82	0.98	144.33	142.70	9.37	145.64	147.52	9.32			
Fruit	1.71			109.10			110.81					
2200 m												
Stem	1.22	5.00	0.36	112.57	107.63	1.42	113.79	112.63	1.58	40.83	29.80	2.70
Leave	0.89	2.31	1.10	135.87	128.17	19.64	136.76	130.48	19.57			
Fruit	2.32			110.70			113.02					
2595 m												
Stem	2.01	*		137.30	*		139.31	*		11.30	6.33	2.10
Leave	2.45	3.91	0.80	139.90	145.47	3.16	142.35	149.38	3.05			
Fruit	1.13			111.30			112.46					
LSD 5 %												
Stem	0.35	1.13		2.24	78.83		2.55	77.97		2.12	1.851	
Leave	0.36	0.96		13.31	3.84		13.36	3.43				
Fruit	1.44			3.88			3.80					

* missing samples W=Winter. S=Summer.

TS-N = Total soluble nitrogen Protein-N = Protein nitrogen TN = Total nitrogen

TABLE (8). SDS-PAGE of *Solanum incanum*.

Band No.	Mol. w. Marker	RF.	Location				Mol. w. bands
			1	2	3	4	
1		0.06		+	+	+	124.26
2		0.09			+		115.71
3		0.12	+	+	+		106.48
4		0.13				+	102.75
5	97.40	0.15	+				97.98
6		0.19		+			90.18
7		0.21	+	+	+		84.96
8		0.26		+		+	75.00
9		0.28	+	+	+		71.52
10	66.20	0.33		+	+		61.45
11		0.35	+				59.00
12		0.37		+	+	+	53.66
13	40.00	0.44		+			43.96
14		0.47			+		41.24
15		0.49	+	+	+	+	38.86
16		0.54				+	34.03
17		0.58		+			29.42
18	26.60	0.61	+	+	+	+	22.65
19		0.63		+	+		20.20
20	21.50	0.66	+	+	+	+	18.34
21	14.40	0.72			+		15.32
22		0.75	+	+	+	+	13.91
23		0.85		+	+		10.55
24		0.95		+			7.78

RF = Rate of flow

It may be concluded from the results, that compared with the lowest altitude, K, Ca, Mg, TRV and protein-N contents were increased in stems of *S. incanum* during winter, while protein-N and total–N content were increased in summer. Also, the concentration of total soluble-N was decreased in the two studied seasons. Moreover, with increased altitude, Ca content was decreased during summer.

Concerning leaves, as altitude increased, DRV and TRV values were mostly increased in summer. In contrast, polysaccharides, total carbohydrates and total soluble nitrogen content were decreased in winter compared with the lowest altitude.

Data also reveal that with increasing altitude, TRV value in fruits of *S. incanum* was increased during winter, however Mg, Fe, polysaccharides, protein-N and total-N content were decreased during winter.

TABLE (9). Seasonal variations in solasodine alkaloid in leaves, stems and fruits of *S. incanum* growing naturally at different locations (µg/mg dry wt).

Location (Altitude)	Stem			Leaf			Fruit	
	Winter	Summer	LSD 5%	Winter	Summer	LSD 5%	Winter	Summer
Mafhaq (1570 m)	0.90	3.73	1.02	3.30	4.42	3.42	6.37	**
Bait Mufareh (1800m)	2.50	3.73	1.21	4.20	4.30	1.46	6.50	**
Hadda (2200 m)	0.54	3.61	0.67	1.42	5.39	2.97	5.01	*
Wadi Alqara (2595 m)	1.90	*		2.00	4.13	0.97	9.40	**
LSD 5 %	1.05	0.66		0.98	2.68		2.57	

* missing ** no fruits in summer

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تأثير التدرج فى الارتفاع على بعض السمات الفسيولوجية والبينية لنبات العرصم (سولانم انكانم) النامى فى اليمن

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استهدف هذا البحث دراسة تأثير الارتفاعات المختلفة علــى بعــض الصــفات البينيــة والفسيولوجية لنبات العرصم (سولانى انكانم) النامى فى اليمن . وقد تم تجميع العينات من أربع مواقع مختلفة تتراوح فى الارتفاع من ١٥٧٠–٢٥٩٥ متر فوق سطح البحر خــلال موســمى الشتاء والصيف لعام ٢٠٠٠.

أشارت النتائج إلى أن المناطق الأقل ارتفاعاً (١٥٧٠، ١٨٠٠م) تميزت بدرجات حرارة أعلى من المناطق الأخرى. كما سجلت الرطوبة النسبية أقل قيمة لها فــى الارتفــاع المتوســط (٢٢٠٠م)، وكانت أعلى كمية مطر فى المنطقة الثانية (١٨٠٠م).

اتضح من دراسة التربة المصاحبة للنبات النامى فى أعلى ارتفاع أنها احتوت على أعلى قيم للرطوبة، التوصيل الكهربى والبوتاسيوم بالأضافة إلى محتوى الانيونات الكلية بينما التربــة فى الارتفاع المتوسط (٢٢٠٠م) تميزت بأعلى نســبة للصــوديوم، الكالســيوم، الماغنســيوم ومحتوى الكاتيونات الكلى بالأضافة إلى الكلوريدات خلال فصلى الدراسة

بينت الدراسة أن زيادة الارتفاع أدت إلى زيادة كل من محتوى البوتاسيوم، الكالســيوم، المغانسيوم، السكريات الذائبة والنيتروجين البروتينى فى سيقان نبات السولانم انكانم خلال فصل الشتاء بينما زاد محتوى كل من والنيتروجين الكلى والبروتينى فى فصل الصيف بزيادة الإرتفاع فى حين انخفض تركيز النيتروجين الكلى الذائب خلال فصلى الدراسة مع زيادة الارتفاع.

أشارت الدراسة الى زيادة كمية السكريات المختزلة والذائبة فى فصل الصــيف. بينمــا نقص محتوى كل من السكريات المتعددة والكلية والنيتروجين الكلى فى فصل الشتاء مع زيــادة الارتفاع.

أوضحت النتائج أن هناك زيادة فى تركيز السكريات الذائبة فى الثمــار خــلال موســم الشتاء بينما حدث نقص فى محتوى كــل مــن الماغنســيوم، الحديــد، الســكريات المتعــددة والنيتروجين الكلى والبروتينى فى الثمار مع زيادة الارتفاع.

دلت النتائج على أن أعلى كمية للسولاسيدين وجدت فى الثمار للنبات النامى فى أعلــى ارتفاع فى موسم الشتاء.

أوضحت دراسة التفريد الكهربى لانماط البروتين إلى أن العديد من البروتينات قــد تــم بناؤها بوفرة فى مواقع الارتفاعات المتوسطة (١٨٠٠، ٢٢٠٠م) إذا ما قورنت بأقــل وأعلــى ارتفاع.