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## Distribution Behaviour and Seed Germination of *Alkanna orientalis* Growing in Saint Catherine Protectorate

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**Abstract:** Seeds of *Alkanna* were tested to determine the germination behavior and dormancy (if present). Four treatments of temperature (5, 10, 15 & 20), soaking in boiled water (till cooling), chilling (2-5°C for one week) and mechanical scarification by sandpaper (for 5 min) were used to investigate the best germination percent. A set of alternations of temperature and light was applied. The results revealed that greatest germination percent occurred at combination of temperature and light with two degrees of temperature, 5 °C with light off and 20 °C with light on whereas the lowest germination percent occurred at constant low temperature (5°C). The ordination diagrams revealed that *Alkanna orientalis* occupies a great position between arrows of soil conditions and landform types which indicates that *Alkanna* affected by soil texture (fine sand fraction), moisture content and organic matter of the soil and boulders. Soil pH and coarse sand fraction were very close to *Alkanna*'s position in the ordination diagrams but statistically they did not show any significant meaning. In the meantime, eighteen associated species were distributed clearly between the environmental arrows in three layers around the center of the ordination.

**Key words:** Ordination, soil condition, Saint-Catherine, nature of soil surface, Sinai, landform types

### Introduction

Boraginaceae is a relatively large family, ranging from annual to perennial herbs, shrubs and trees. About 30 genera are used as ornamentals and several species are of medicinal value (Heywood *et al.*, 1978). Boraginaceae is distributed mainly throughout temperate and subtropical areas and less frequent in cool temperate and tropical regions. Fifty-two species of nineteen genera belonging to the family Boraginaceae, were recorded in Egypt, of which twenty-seven species were recorded in Sinai (Täckholm, 1974).

In Saint Catherine, area six genera belonging to family Boraginaceae are distributed commonly in the wadi and slope habitats (*Alkanna*, *Trichodesma*, *Paracaryum*, *Anchusa*, *Echium*, and *Myosotis*). *Alkanna* has two species in Egypt, *A. tinctoria* and *A. orientalis*. Many important landmarks in the ecological research of Sinai have been done by Migahid *et al.* (1959), Zahran (1967), Halevy and Orshan (1973), Danin (1986), Helmy *et al.* (1989), Ramadan (1988), Moustafa (1990), Moustafa and Zaghloul (1993), Abdel-Wahab (1995) and Zaghloul (1997). Most of these ecological studies provided general qualitative and quantitative assessments of the distribution behavior of plant species and their association in relation to the main physiographic factors in different ecosystems of Sinai.

Several phytochemical studies were made on different species of *Alkanna* (Vorvagalis, 1972; Afzal and Tofeeq, 1975; Papageorgiou, 1980). On the other hand, Semida (1994) studied the insect-plant interaction from the pollination point of view. He found that Anthophora bees have certain structural attributes, enabling them to exploit and collect the floral nectar from the tubular corolla of *Alkanna orientalis* flower. In fact not many ecological studies have been done concerning the autecology of *Alkanna orientalis* except that study by Moustafa (2001) focussed on the effect of grazing intensity and human disturbance on the population dynamics of *Alkanna orientalis* in Saint Catherine area. The main aim of the present study was (1) to investigate the germination process of *Alkanna orientalis*, (2) to study the distribution behaviour of *Alkanna* through the environmental gradients and (3) to address the question: why the vegetation of *Alkanna* is very restricted to these narrow and closed wadis of Saint Catherine?

### Materials and Methods

**Study area:** The study was carried out in St. Catherine area (south Sinai) at an elevation of 1500 to 2624 m a. s. l. which include the main mountains in the area, Gebel El-Rabah (1800 m), Gebel Safsafa (1880 m), Gebel Mousa (2285m). Gebel Catherine represents a series of mountains at different elevations with four large valleys, (W. El-Esbae'a, W. Rutig, W. El-Arbaie'en and W. Tala'a). Said (1962) described the study area as predominantly

smooth - faced granite outcrops forming mountains such as Gebel Serbal and Gebel Ras Safsafa. Black mountains consisting of old volcanic rocks are rather common. Generally, the area is formed of igneous and metamorphic rocks, chiefly granites are intensely dissected and rugged (Said, 1962). Two main wadis were chosen for surveying *Alkanna orientalis*, Wadi El-Arbaie'en, and W. El-Deir (Fig. 1). The geomorphology of Saint Catherine area forms a part of highly rugged mountains with acid plutonic and volcanic rocks belonging to the Precambrian basement complex of the southern part of Sinai Peninsula. The landscape of the study area has four landform types, slopes, gorges, terraces, and ridges. The mountains of this area are dissected by faults and joints that play an important role in the movement of the ground water (Moustafa and Klopatek, 1995).

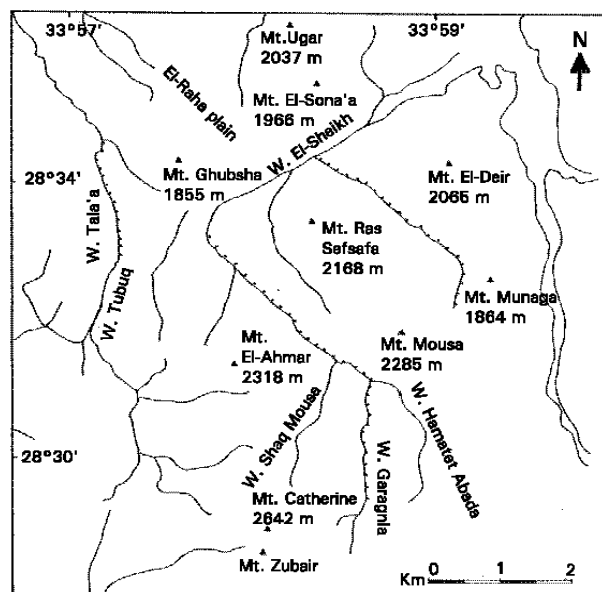


Fig. 1: Location map of the study area, Saint Catherine Protectorate, South Sinai, Egypt.

Sinai in the arid belt of North Africa and belongs to Saharan Mediterranean area with a true desert climate (Logan, 1968). In the study area, the climate is extremely arid with long, hot and rainless summers and cool winters. The mean annual precipitation in Saint

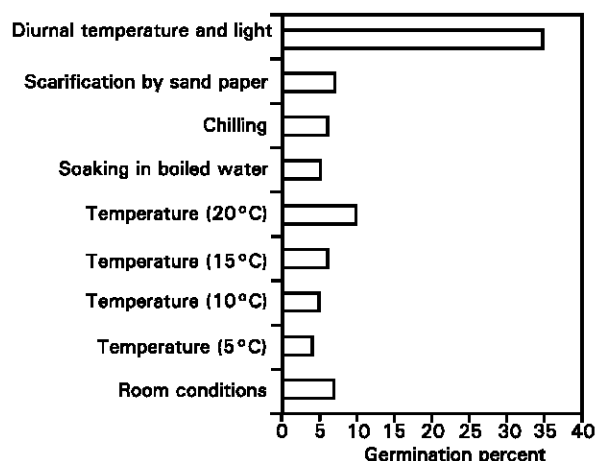


Fig. 2: The germination percent of *Alkanna* seeds under different treatments.

Catherine area over 25 years (1970-1994) is 45 mm per year, the high mountains receive more precipitation (100 mm/year) as rain and snow. In some parts of this area, floods resulting from connective rains have been observed during the winter and spring. The mean air temperature extremes ranged from 5.4 to 25.1°C with the lowest temperature in January and February and the highest temperature in July and August (Moustafa and Kamel, 1996).

**Seed germination:** Seeds were collected during summer 1999 after ripening and stored in optimized laboratory conditions. The viability of seeds was measured by tetrazolium test (Lakon, 1949). A preliminary germination test was carried out to determine the germination behavior and dormancy (if present) of seeds. Untreated seeds were tested for germination using moistened filter paper at 25 °C for 30 days. Four treatments of temperature (5, 10, 15 & 20), soaking in boiled water (till cooling), chilling (2-5°C for one week) and mechanical scarification by sandpaper (for 5 min) were used to investigate the best germination percentage. A set of alternations of temperature and light was applied as well. The light (two-white florescence lamp 20 watts) was turned on diurnally with temperature of 20°C at day (for 12 hours) and turned off at 5°C during night (for 12 hours). Ten-plastic cups lined by piece of cotton each containing ten seeds were used in each treatment.

#### Environmental parameters

**Localities and plot selection:** Thirty-five plots with size of (5x5 m<sup>2</sup>) were selected randomly (19 plots were located at W. El-Arbaie'en and 16 plots located at W. Deir) to study the distribution behaviour of *Alkanna orientalis*. The homogeneity of each plot and vegetation type were the main factors in selection of each locality and determination of its area. The number of *Alkanna* individuals, the percent of plant cover and the list of associated species with *Alkanna* were recorded in each plot. The nomenclature of plant species was according to Täckholm (1974) and updated by Boulos (1995). In each plot, the following factors were measured: slope degree, nature of soil surface (sand< 2mm, gravel 2-75 mm, cobbles 75-250mm, stones 250-600mm, boulders> 600mm) and landform type. The latter was determined according to Moustafa and Klopatek (1995) as gorges slopes, wadi beds, terraces, and flood channels.

**Soil sampling and analyses:** Three replications of soil samples were collected as mixture from each plot at the depth of 0-15 cm to determine their physical and chemical characteristics. Gravimetric methods were used to determine moisture content, whereas

organic content was determined by loss-on-ignition (LOI), where loss was calculated in percent of the oven-dried sample (Wilde *et al.*, 1972).

**Data treatment:** Multivariate statistical analysis were carried out to allow summarizing the large complex data sets, aiding the environmental interpretation and hypothesis generation, and refining models of community structure (Vlazquezm, 1994). To interpret the species / environment relationship, ordination was carried out using CANOCO computer program (Ter Braak, 1990). Canonical Correspondence Analysis (CCA) is a multivariate technique developed to relate community composition to known the variation in environment. In CANOCO, ordination axes are chosen in the light of known environmental variables by imposing the extra restriction, that the axis be linear combinations of environmental variables (Palmer, 1993). In the ordination diagram, the stands and species are represented by points and environmental variables represented by arrows (Ter Braak and Looman, 1986).

#### Results

**Seed germination:** The results showed that greatest germination percent occurred at combination of temperature and light with two degrees of temperature, 5 °C with light off and 20 °C with light on. On the other hand, the lowest germination percent occurred at treatment of constant low temperature (5°C) and it increased gradually with increase in temperature (Fig. 2).

**Site characteristics and *Alkanna* coverage:** Table 1 provides a species list of the identified species that were found associated with *Alkanna* in the study area. Sixty-one species were identified belonging to twenty-two families. Compositae and Labiatae were the most represented families followed by Caryophyllaceae and Graminae. On the other hand, twelve families are represented by only one species (e.g. Asclepiadaceae, Boraginaceae, Capparaceae, Convolvulaceae and Dipsacaceae). However, the results revealed that the number of genera (53) included 44 perennial and only 10 annuals. It was also clear that the ratio of genera/ family is higher than ratio of species/genera in both numbers of perennial and annuals (Table 2).

Environmental factors include two main types: soil conditions and the landform types. The first one is represented by the soil conditions including physical characteristics (nature of soil surface, soil texture, soil moisture contents and organic matter content) and chemical characteristics, (pH and electric conductivity). The second one is represented by that main landform types, dominated by dense vegetation of *Alkanna* such as slopes, terraces, wadi bed and flood channels (Table 3). The variations in the presented factors between two main localities were statistically tested by ANOVA analysis (Table 3). The results indicate that *Alkanna* coverage, land form types and fine sand fraction showed the highly significant values followed by silt + clay fraction, stones, and soil moisture content (Table 3). Two factors only did not show any significant variation between two studied wadis (soil organic matter and pH).

The correlation results did not show a complete view for this relation where only soil moisture content was positively significant with *Alkanna* coverage ( $R = 0.673$ ,  $P = 0.001$ ). On the other hand, the regression analysis showed a clear linear relationship between *Alkanna* coverage and the significant factors that include soil moisture content, organic matter, soil texture (medium sand fraction) and nature of the soil surface (gravel and cobbles) (Table 4).

**Composition gradients:** Ordination increasingly used for gradient analysis, canonical correspondence analysis identifies the environmental basis for community composition that can be explained by the environmental variable (Ter Braak, 1990). The ordination diagram allows the following interpretation (Ter Braak and Looman, 1986): each arrow determines a direction or axis in the diagram, obtained by extending the arrow in both directions.

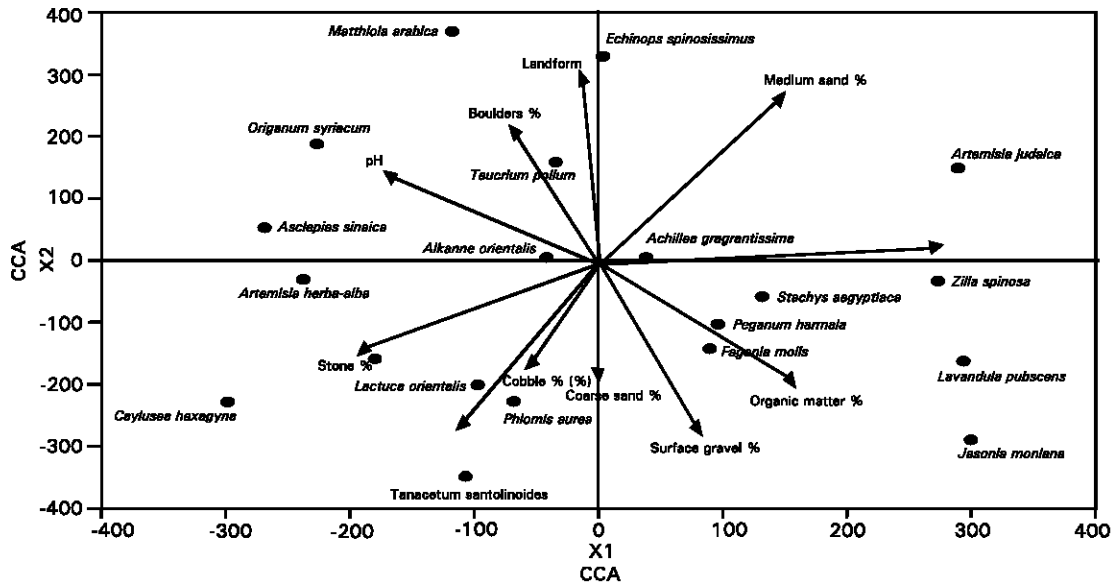


Fig. 3: Ordination diagram (CCA) with species represented by points and environmental variables as arrows on the first two axes.

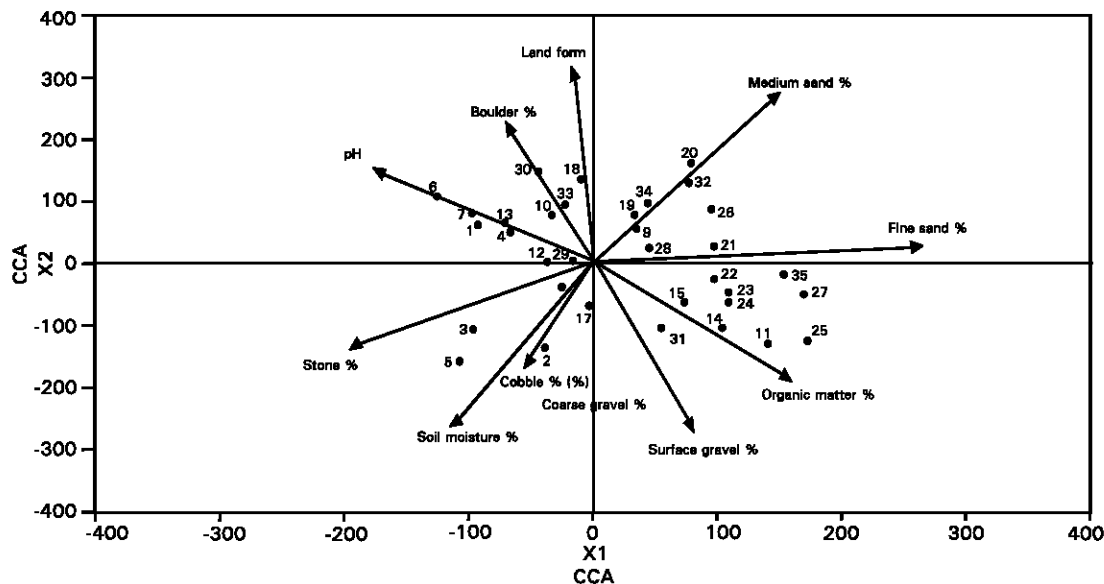


Fig. 4: Ordination diagram (CCA) with stands represented by points and environmental variables as arrows on the first two axes.

From each species-point, one may drop a perpendicular line to the environmental axes that are representing various factors. The end-point of this perpendicular indicates the relative position of the centers of the species distributions along that axis or more precisely, they indicate in an approximate ranking of the weighed average for a particular environmental variable.

In the ordination diagram (Fig. 3), *Alkanna orientalis* occupies a great position between these arrows. It means that *Alkanna* is affected by a group of factors in its distribution, as soil texture (fine sand fraction), moisture content and organic matter of the soil and boulders are much more close to *Alkanna's* position than other factors (Fig. 3). However, two arrows of soil pH and coarse sand fraction located close to *Alkanna's* position but statistically they did not show any significance. In the same ordination diagram, nineteen associated species were distributed clearly between the environmental arrows. One can conclude that the

distribution of associated species can be described as three layers around the center of the diagram. The central layer, that is a group of species distributed close to the center of the figure included only two species *Alkanna orientalis* and *Achillea fragrantissima*. This group includes *Stachys aegyptiaca*, *Paganum harmala*, *Fagonia mollis*, *Phlomis aurea*, *Lactuca orientalis*, *Teucrium polium* and *Zilla spinosa*. The outer layer of associated species includes *Echinops spinosissimus*, *Artemisia judaica*, *Lavandula pubescens*, *Jasonia montana*, *Tanacetum santolinoides*, *Caylusea hexagyna*, *Artemisia herba-alba*, *Asclepias sinaica*, *Origanum syriacum* and *Matthiola arabica* (Fig. 3).

**Stands-environmental relationship:** Thirty-five plots were arranged in the ordination diagram that shows the position of each plot and its interrelation with environmental factors (Fig. 4). The distribution of plots on ordination diagram can be described

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Table 1: Number of genera and species in each family recorded during the study in Saint Catherine area

Family	Species	Perennial		Annual		Total no. of species
		Genera	Species	Genera	Species	
Asclepiadaceae	<i>Asclepias sinaica</i>	1	1	0	0	1
Boraginaceae	<i>Microparacaryum intermedium</i>	1	1	0	0	1
Capparaceae	<i>Capparis sinaica</i>	1	1	0	0	1
Caryophyllaceae	<i>Arenaria deflexa</i>	4	6	1	1	7
	<i>Bufonia multiceps</i>					
	<i>Gymnocarpus decander</i>					
	<i>Silene leucophylla</i>					
	<i>Silene odontopetala</i>					
	<i>Silene shimperiana</i>					
	<i>Spergula fallax</i>					
Compositae	<i>Achillea fragrantissima</i>	8	9	2	2	11
	<i>Artemisia herba-alba</i>					
	<i>Artemisia judaica</i>					
	<i>Echinops spinosissimus</i>					
	<i>Jasonia montana</i>					
	<i>Lactuca orientalis</i>					
	<i>Launaea spinosa</i>					
	<i>Onopordum ambiguum</i>					
	<i>Pulicaria arabica</i>					
	<i>Pulicaria crispa</i>					
	<i>Tanacetum santolinoides</i>					
Convolvulaceae	<i>Convolvulus arvensis</i>	1	1	0	0	1
Cruciferae	<i>Diploaxis harra</i>	2	2	1	1	3
	<i>Matthiola arabica</i>					
	<i>Zilla spinosa</i>					
Dipsacaceae	<i>Pterocephalus sanctus</i>	1	1	0	0	1
Euphorbiaceae	<i>Andrachne aspera</i>	1	1	0	0	1
Graminae	<i>Avena barbata</i>	3	3	2	2	5
	<i>Cynodon dactylon</i>					
	<i>Poa sinaica</i>					
	<i>Stippa parviflora</i>					
	<i>Stippagrostis raddiana</i>					
Juncaceae	<i>Juncus acutus</i>	1	2	0	0	2
	<i>Juncus rigidus</i>					
Labiatae	<i>Ballota kaiseri</i>	8	10	0	0	10
	<i>Ballota saxitilis</i>					
	<i>Ballota undulata</i>					
	<i>Lavandula pubescens</i>					
	<i>Mentha longifolia</i>					
	<i>Nepeta septamcrenata</i>					
	<i>Origanum syriacum</i>					
	<i>Phlomis aurea</i>					
	<i>Stachys aegyptiaca</i>					
	<i>Teucrium polium</i>					
Leguminosae	<i>Lotononis platycarpa</i>	0	0	2	2	2
	<i>Trigonella stellata</i>					
Malvaceae	<i>Alcea rosa</i>	1	1	0	0	1
Moraceae	<i>Ficus palmata</i>	1	1	0	0	1
Plantaginaceae	<i>Plantago sinaica</i>	1	1	0	0	1
Resedaceae	<i>Caylusea hexagynae</i>	0	0	1	1	1
Rubiaceae	<i>Gallium sinaicum</i>	1	1	0	0	1
Scrophulariaceae	<i>Celsia parviflora</i>	3	3	1	1	4
	<i>Kickxia aegyptiaca</i>					
	<i>Verbascum sinaiticum</i>					
	<i>Veronica anagalis-aquatica</i>					
Solanaceae	<i>Lycium shawii</i>	2	2	0	0	2
	<i>Solanum nigrum</i>					
Umbelliferae	<i>Deverra triradiata</i>	1	1	0	0	1
Zygophyllaceae	<i>Fagonia arabica</i>	2	3	0	0	3
	<i>Fagonia mollis</i>					
	<i>Peganum harmala</i>					
Total	61	44	51	10	10	61

Table 2: Number of families, genera, species and percentage of species to genera and genera to families in the Saint Catherine area

	Perennials	Annuals	Total
Family	20	7	22
Genera	44	10	53
Species	51	10	61
Species/Genera	1.16	1.00	1.15
Genera/Family	2.20	1.43	2.41

as three groups of plots associated to different environmental arrows according to their site condition and species composition as well. The first group is very closed attaching to pH, boulders, and extension arrow of soil organic matter. It includes ten plots (1, 4, 6, 7, 10, 12, 13, 29, 30, 33) located at the upper left corner of ordination diagram. The second group that is very close attaching to coarse sand fraction, stones, moisture content and cobbles is located at the vertical line and extend down to the end of left

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Table 3: Shows site conditions, *Alkanna orientalis* vegetation cover and analysis of variance (F-ratio and their significance). Note: Landform was abbreviated into number followed to Moustafa and Klopatek (1995) as follows; slope= 1, terrace= 2, wadi bed = 3, and flood channel = 4

Site	Locality	<i>Alkanna</i> coverage %	Moisture (%)	Organic matter	Coarse sand %	Medium sand %	Fine sand %	Silt and Clay %	EC	pH	Gravel %	Cobbles %	Stones %	Boulders %	Land form
1	Wadi El-Arbaie'en	16.00	3.82	3.86	45.87	21.84	17.08	15.19	358	7.95	50	20	20	10	3
2		16.30	7.50	1.18	86.59	3.40	4.78	5.21	280	8.02	30	60	5	5	4
3		14.31	5.62	1.38	74.05	14.39	8.17	3.38	160	8.20	55	20	15	10	1
4		12.30	5.27	3.55	44.65	19.95	20.57	14.81	244	7.89	40	25	25	10	1
5		15.00	3.64	5.06	41.96	22.82	24.36	10.85	415	7.87	40	20	30	10	1
6		10.00	2.17	2.34	37.84	32.47	21.71	7.96	494	7.70	30	20	30	20	4
7		12.00	2.99	2.19	60.41	23.15	10.58	5.84	516	7.85	40	30	20	10	4
8		8.81	3.22	1.70	57.48	25.61	11.98	4.91	251	7.96	20	10	20	50	1
9		15.00	2.79	2.30	46.67	22.62	19.65	11.04	306	8.30	80	10	10	0	3
10		15.00	1.61	1.61	72.04	18.49	7.60	1.85	545	8.14	50	10	20	20	3
11		12.00	4.32	7.06	47.34	23.17	23.71	5.76	388	7.17	90	8	2	0	1
12		11.51	3.18	4.74	55.73	23.67	14.55	6.04	428	7.99	98	1	1	0	2
13		14.30	4.20	3.13	35.18	49.10	11.63	4.07	380	8.23	85	3	2	10	2
14		25.50	5.53	6.80	47.91	24.38	21.70	6.00	443	7.88	85	5	0	10	1
15		17.20	10.31	6.46	41.40	22.88	28.77	6.93	169	7.79	10	80	10	0	1
16		10.00	3.43	2.19	60.86	23.57	12.40	3.16	130	8.28	80	10	7	3	3
17		12.00	2.99	1.08	78.17	15.01	5.52	1.29	89	7.89	80	0	10	10	3
18	Wadi El-Deir	11.51	2.39	1.29	63.76	24.23	8.73	3.26	233	8.15	75	10	10	5	3
19		5.00	4.14	1.38	65.02	25.73	7.76	1.47	125	8.24	25	10	5	60	1
20		3.20	5.10	3.35	37.19	33.93	26.46	2.40	249	8.28	60	10	0	30	3
21		4.20	1.64	0.96	68.72	23.39	5.72	2.16	575	8.04	80	10	5	5	1
22		3.00	3.31	2.99	50.25	23.09	17.04	9.60	224	7.91	80	10	10	0	1
23		2.21	1.18	1.40	50.25	24.77	16.95	8.02	304	7.89	90	0	5	5	3
24		3.10	5.02	4.58	48.63	26.46	18.55	6.34	704	7.82	70	15	10	5	1
25		2.51	0.46	1.03	39.99	32.32	22.88	4.79	165	7.95	60	20	20	0	3
26		3.16	1.55	1.27	71.05	20.65	5.66	2.62	152	7.78	40	5	5	50	4
27		5.58	1.35	0.99	65.70	23.96	8.43	1.89	115	7.72	40	40	20	0	3
28		6.31	2.59	1.70	47.45	26.65	20.83	5.24	319	7.77	65	20	15	0	3
29		3.41	1.25	1.54	49.45	9.59	4.11	36.83	178	7.91	70	10	20	0	3
30		2.51	4.70	2.39	32.73	49.98	14.29	2.98	340	7.73	95	0	3	2	4
31		3.20	2.70	8.93	47.60	22.40	22.30	7.68	205	7.83	90	5	5	0	1
32		2.11	1.87	4.57	30.67	36.80	25.87	6.64	873	8.15	90	0	5	5	3
33		3.19	1.28	3.20	32.51	40.82	21.25	5.40	345	7.60	85	0	5	10	3
34		3.04	3.22	4.99	43.17	33.86	22.93	0.02	439	7.74	70	0	20	10	4
35		3.17	2.18	1.73	34.65	27.89	31.63	5.81	215	7.64	70	20	10	0	3
F-Ratio		97.98	7.818	1.756	3.76	3.333	12.406	9.163	11	2.12	4.01	5.18	7.932	4.11	12.55
p-value		0.000	0.009	0.194	0.061	0.077	0.000	0.000	0.00	0.154	0.050	0.000	0.000	0.000	0.000

Table 4: Simple regression analysis *Alkanna orientalis* vegetation cover and site conditions

Factor	Regression coefficient	R	T-test		ANOVA	
			T-value	p	F - ratio	p
Soil moisture content %	2.002	0.673	5.226	0.000	27.316	0.000
Organic matter %	2.064	0.454	2.928	0.000	8.572	0.006
Coarse sand %	0.079	0.193	1.129	0.260	1.275	0.267
Medium sand %	-0.224	0.353	-2.171	0.030	4.712	0.037
Fine sand %	-0.010	0.014	-0.078	0.930	0.006	0.938
Silt and Clay %	0.381	0.244	1.446	0.15	2.092	0.158
EC	-0.006	0.173	-1.008	0.320	1.016	0.321
pH	4.656	0.186	1.085	0.280	1.178	0.280
Surface gravel %	-0.089	0.365	-2.250	0.030	5.064	0.031
Cobbles (%)	0.181	0.52	3.494	0.000	12.205	0.001
Stones (%)	0.054	0.078	0.451	0.650	0.203	0.655
Boulders (%)	-0.017	0.042	-0.244	0.800	0.06	0.809
Landform types	-1.240	0.242	-1.434	0.160	2.057	0.161

corner side of the ordination diagram. This group consists of only six plots (2, 3, 5, 8, 16, 17) that all occurred at W. El-Arbaie'en. The third group lies on the right hand side between the two arrows of medium sand fraction and gravel. It is the largest group of plots and it includes eighteen plots distributed down the arrows of fine sand and organic matter content. This group is mainly represented by most plots occurred at W. El-Deir (31, 15, 14, 11, 25, 24, 23, 22, 27, 35, 21, 28, 26, 9, 19, 34, 32 & 20) except no. 11 and 14 occurring at W. El-Arbaie'en.

### Discussion

The present study examined the germination process and the restricted distribution behaviour of *Alkanna orientalis* in two wadis in Saint Catherine area, South Sinai. The study area is characterized

by sparseness of plant cover, a limited number of plant species and associations and paucity of trees (Moustafa and Zaghloul, 1996). The rocky habitats of this region permit the growth of species adapted to root penetration, shallow soils and low water content (Moustafa and Zaghloul, 1996).

In the terrestrial vegetation, seeds and seedlings are implicated in various ecological phenomena. These extend beyond population processes (persistence, dispersal, genetic variability) to influence upon the distribution, dynamics and diversity of much larger units of vegetation (communities, landscapes, local floras) (Zaghloul, 1997). In the life history of higher plants, the seedling stage is the most vulnerable and is usually accompanied by extremely high mortality (Harper, 1983) while the seed stage is uniquely resistant to various environmental stresses. Since the process of

germination links these two stages showing such greatly differing risk levels, any physiological mechanism confining germination only to circumstances associated with a high probability of sound seedling establishment would have a great adaptive value (Washitani and Kabaya, 1988). Therefore, the germination behaviour of *Alkanna* was addressed.

The results indicate that seeds of *Alkanna* has a very strong dormancy and with these different treatments applied, one could reach only 35% as a maximum percent of germinated seeds. The greatest germination obtained at combination of temperature and light with two degrees of temperature, 5 °C with light off and 20 °C with light on.

A great number of *Alkanna orientalis* has been flourished due to overgrazing and human cutting effects (Moustafa, 2001). Field observations indicate that many species besides *Alkanna orientalis* are listed as by-product of grazing intensity such as *Teucrium polium*, *Origanum syriacum*, *Andrachne aspera*, *A. telephioides*, *Verbascum species* and *Onopordum ambiguum*. However, *Alkanna* is the first plant commencing its vegetation at early fall (October) and start early flowering in March (Moustafa, 2001). Although, *Alkanna* is not a complete edible plant (due to that dense spiny hairs on leaves) and is not collected by Bedouins but still animals grazed the appropriate parts of *Alkanna* due to its early flowering.

In agreement with many studies (Moustafa, 1990; Moustafa and Zaghloul, 1993, 1996; Zaghloul, 1997; Moustafa, 2001) soil moisture and organic matter were the most important factors affecting the high dominance of *Alkanna* in study area. The effect of moisture regime on the distribution of plants has been emphasized by many studies (Ayyad and Dix, 1964; Whittaker and Neiring, 1965; Noy-Meir *et al.*, 1973; Marks and Harcombe, 1981, and Schwaegerl and Bazzaz, 1987). Moisture in the form of rainfall is the most decisive factor controlling productivity, plant distribution and life form in arid lands (Zohary, 1973). The ecological conditions of the study area were dominated by climatic aridity. The life-form patterns of desert plants were reflected by the rainfall, topography and landform types (Kassas and Girgis, 1965; Zohary, 1973; Danin and Orshan, 1990). Most of the study area receives less than 50-mm precipitation per year (Moustafa and Zayed, 1996).

In general, the total amount of precipitation falling in an ecosystem does not always give a clear picture of the availability of moisture to the plants. The precipitation type, intensity and annual variation, soil deposits, topography, and vegetation physiognomy influence the availability of moisture furnished by precipitation to the plants.

The factorial approach to analyze the plant distribution emphasizes that this distribution is controlled by the interaction between several environmental factors capable of independent variation (Waring and Major, 1964). The ordination analysis emphasized that soil texture (fine sand fraction), moisture content and organic matter of the soil and boulders are the most significant factors controlling the dominance of *Alkanna orientalis* in two main localities. In general, the effect of the nature of soil surface (boulders, stones, cobbles and gravel) and its roughness is related to its capacity for water storage (Moustafa and Zaghloul, 1996). This relation depends on the volume of water resources and the depth of surface deposits. Clearly, shallower deposits store less moisture (Hillel and Tadmor, 1962). Although the arrows of soil pH and coarse sand fraction located very close to *Alkanna's* position but statistically they did not show any significant meaning. However, eighteen associated species were distributed clearly between the environmental arrows and revealed the association between *Alkanna* and other species as well.

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