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Some Aspects of Germination of Desert Seeds

By

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With 5 Figures

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1. Introduction

The characteristics of seeds on germination present a number of highly interesting problems and as WAREING 1963 denotes, still there are some recent and less well-established aspects of the subject. Careful study of the factors controlling germination and of the complex interactions which may occur between these factors reveals many important bearings and could clarify many ecological aspects. WAREING 1963 stressed that further studies in this field would be well worth while.

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Of valuable reports on germination of seeds which may be cited here are Crocker & Barton 1948, Barton & Crocker 1948, Toole & al. 1956, Went 1949, 1957, Mayer and Poljakoff-Mayber 1963 and Wareing 1963. In regard to our desert seeds some investigations on germination have already been carried out, from which may be mentioned, Hammouda & Shalaby 1957, Abd-Elrahman & Batanouny 1959 and El-Ghonemy 1960.

The present investigation has been planned out to give a picture of factors playing major roles on germination of a number of our desert seeds. A study on these seeds of physio-ecological nature was felt worth proceeding as it presents a broad understanding of the involved features of the subject.

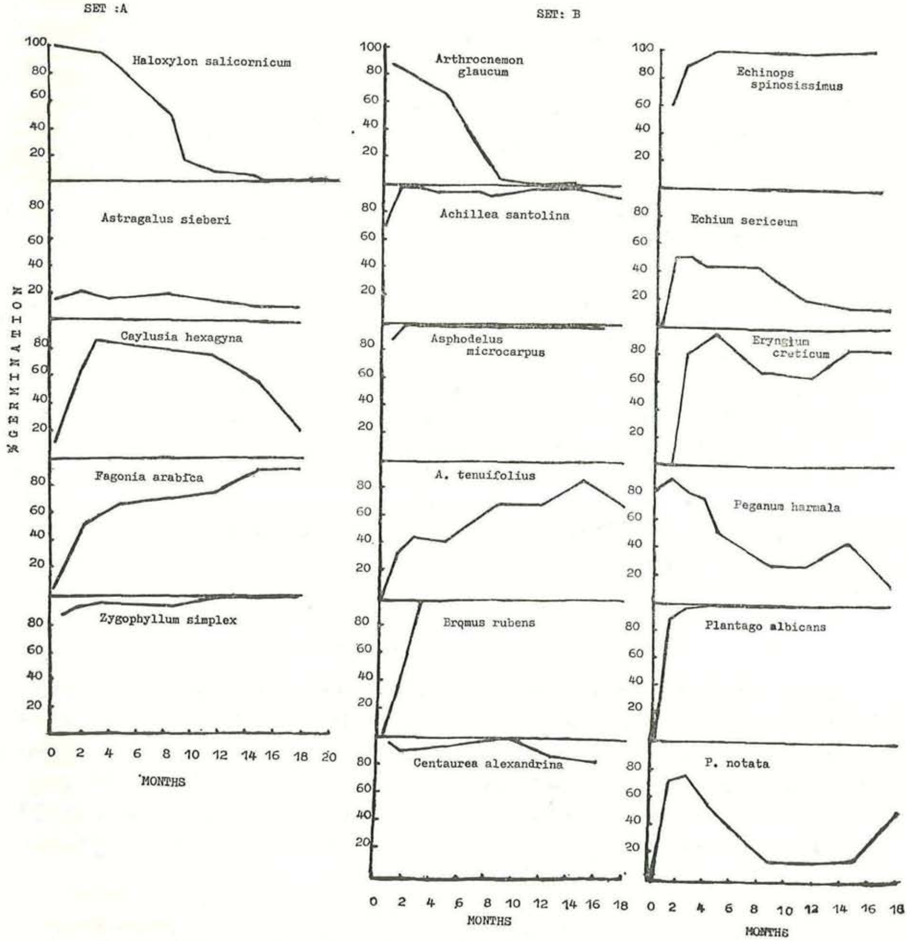

Fig. 1. The change of seed viability with time (left: Set **A**, right: Set **B**).

2. Materials and Methods

Two sets of ripe seeds were harvested from two main regions: a- the desert region east of Cairo and b- the semi desert Mediterranean coastal region (Burg el Arab, 34 km west of Alexandria).

The first set of seeds (set **A**) comprised 12 species and the second set (set **B**) comprised 29 species.

Germination was conducted in incubators, either in petri-dishes on moist cotton or filter paper, or on natural soil in small pots. Experiments were conducted varying the intensities of the different factors. In some experiments, pots with the experimental seeds were left in the open or in the laboratory. Daily counts of germinated seeds were made, marked by exit of the radicle and of the plumule. Counts continued usually for 14 days.

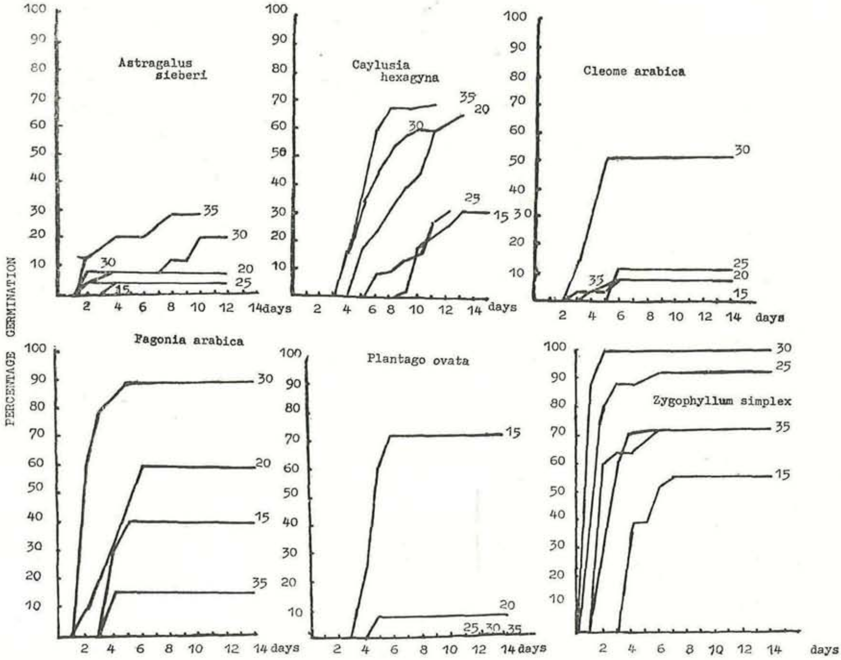

Fig. 2. Effect of temperature on germination of seeds of Set **A**.

3. Results

3.1. Seed Viability and Longevity

Germination of the two seed sets began from time of harvest and were repeated regularly at intervals covering two and half years. Fig. 1 (**A & B**) represents some examples of change of seed viability with time and denotes

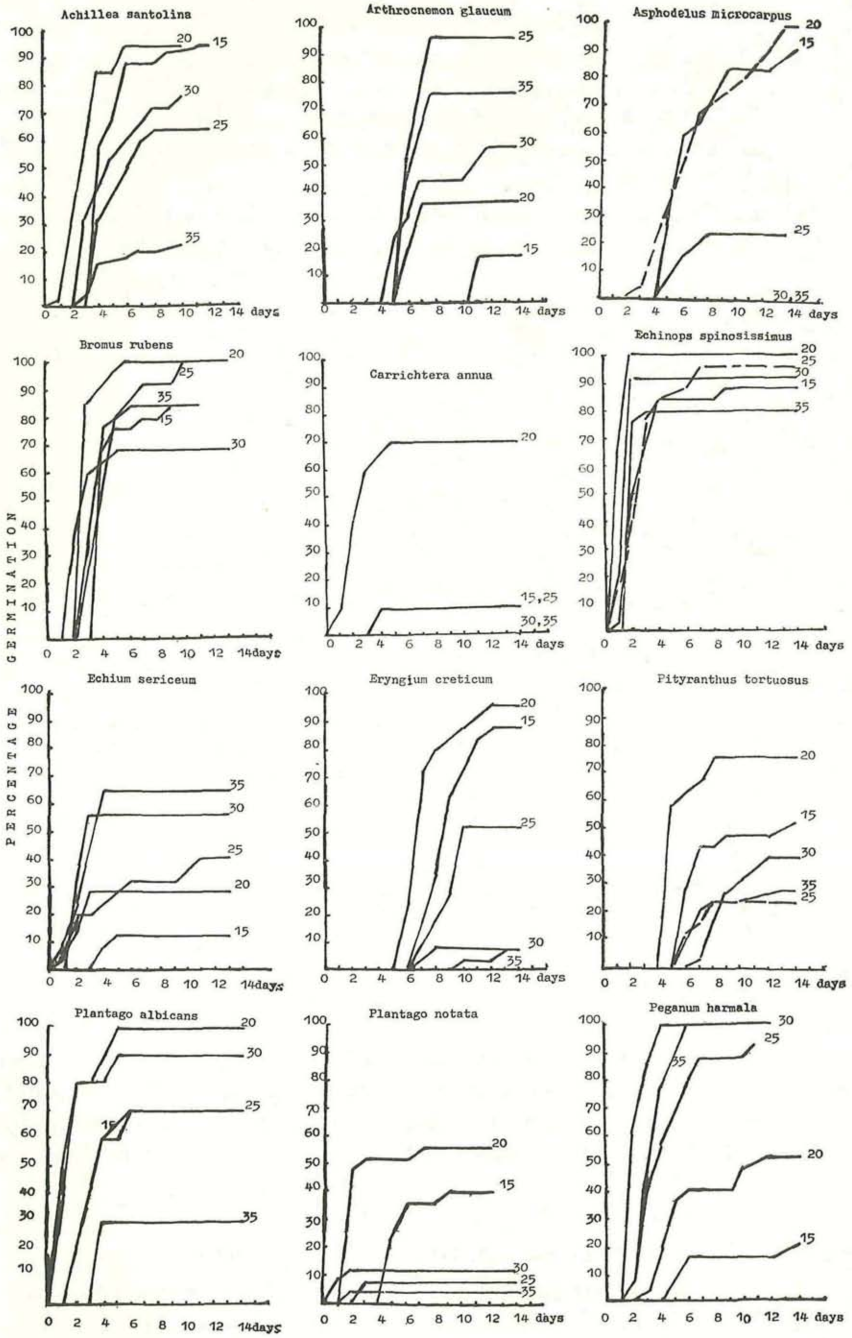

Fig. 3. Effect of temperature on germination of seeds of Set **B**.

seed longevity. It has been revealed that seeds of majority of species have retained their viability for over one year. Nevertheless, some species showed a slight decline of seed viability with time while seeds of some other species, mostly succulent plants or halophytes e. g. *Haloxylon salicornicum* and *Arthrocnemon glaucum* almost lost viability before the lapse of one year or a period around that.

3.2. Roles of External Factors Affecting Germination

3.2.1. Temperature

I. Range of temperature, optimal temperature and season of germination: Fig. 2 and Fig. 3 represent the effect of temperature (range 15°—35° C) on germination of some seed examples of the two sets already referred to. It is evident that seeds vary in regard to their suitable range of temperatures of germination, as well as to their optimal temperatures of germination. A picture could be also viewed from Table 1, in which species are assorted according to ranges of temperature — wide or narrow — and level of optimal temperature for germination; low (15° C), mild (20°—25° C) and high (30°—35° C).

The results clearly show that actually various seeds varied in their temperature requirements for germination. Germination of few seeds is favoured by low temperature (15° C), germination of others, mostly of set **A**, is optimal at high temperatures (30—35° C) while a high majority, mostly of set **B**, have mild optimal temperatures (20—25° C). The range of temperatures of germination varied for various seeds. It has been noticed also that the optimal temperature of germination may shift with time from harvesting, and this would be connected with ripening of the seeds. The experiment of temperature range and optimal temperatures, made here twice, firstly in November and lately in March, showed some cases worth of mention; the presented features may have some bearing on regulation of germination of the seeds concerned. *Fagonia arabica* has 30° C as optimal temperature for germination in November and 25° C in March. *Echium sericeum* seeds show better germination in November at 35° and 30° C, in March better germination occurs at 30° C and 25° C and for *Eryngium creticum* optimal temperature is 20° C in November and 15° C in March. For *Centaurea alexandrina*, seeds germinate in November better at 20° C while in March best germination is at 30° and 35° C.

In nature, germination is highly regulated by temperature when rainfall is not limiting. Table 2 gives the percentage emergence of seedlings of some species during a mid period of the rainy season under temperature fluctuations of Cairo, water (rainfall) being not limiting as the soil was regularly moistened, and Table 3 gives temperature and rainfall data for the period Oct. 1967—April 1968, for the two regions: desert (near Cairo) and semi-desert (Mersa Matruh, west of Alexandria).

Table 1

Germination of various seeds in the range of temperatures 15°—35° C and optimal temperatures

		Optimal temperature		
		Low: 15° C	Mild: 20° & 25° C	High: 30° & 35° C
Wide Range	A	*Haloxylon salicornicum*	*Aizoon canariensis*	*Astragalus sieberi* *Caylusea hexagyna* *Fagonia arabica* *Trigonella stellata* *Zygophyllum simplex*
	B	*Echinops spinosissimus**)	*Achillea santolina* *Arthrocnemon glaucum* *Bromus rubens* *Centaurea alexandrina**) *Echinops spinosissimus* *Erucaria microcarpa* *Hedypnois rhagadioloides* *Hippocrepis cyclocarpa* *Medicago sativa* *Pityranthus tortuosus* *Plantago albicans* *Scorpiurus sulcata* *Trigonella maritima*	*Astragalus hamosus* *Centaurea alexandrina* *Echium sericeum* *Peganum harmala*
Narrow Range	A	*Plantago ovata*		*Cleome arabica*
	B	*Asphodelus microcarpus**) *Eryngium creticum**)	*Asphodelus microcarpus* *A. tenuifolius* *Carrichtera annua* *Eryngium creticum* *Plantago notata*	*Enarthrocarpus strangulatus* *Mesembryanthemum crystallinum* *Onopordon alexandrinum*

It could be seen that ample germination of considerable number of species occurs during the two low temperature months January and February if water was available. The temperature prevailing in these two months is not much suitable for species such as *Cleome arabica*, *Fagonia arabica*, *Asphodelus tenuifolius*, *Echium sericeum* and *Onopordon alexandrinum*.

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*) in March.

Table 2

Emergence of different seedlings during the period 17. Dec. 67—23. Feb. 68 (soil being kept moist)

	31. 12. 67	17. 1. 68	23. 2. 68
A	%	%	%
Astragalus sieberi	6	14	36
Caylusea hexagyna	22	76	
Cleome arabica	6	6	6
Fagonia arabica	10	10	
Haloxylon salicornicum	16	16	
Hyoscyamus muticus	64	84	100
Plantago ovata	56	56	56
Trigonella stellata	32	44	44
Zygophyllum simplex	84	84	
B			
Achillea santolina	76	76	76
Arthrocnemon glaucum	32	64	64
Asphodelus microcarpus	88	100	100
A. tenuifolius	0	0	0
Bromus rubens	54	54	54
Centaurea alexandrina	50	50	50
Echinops spinosissimus	84	84	84
Echium sericeum	0	8	8
Enarthocarpus strangulatus	10	10	10
Erucaria microcarpa	10	10	10
Eryngium creticum	4	76	76
Mesembryanthemum crystallinum	16	34	34
Onopordon alexandrinum	0	10	20
Plantago notata	56	56	56

II. Alternating temperatures: Seeds of a number of species exhibited remarkable increase of their germinability under alternating temperatures rather than maintained constant temperatures. Noticeable examples are *Hyoscyamus muticus* and *Erucaria microcarpa* as seen from Table 4.

III. Resistance of seeds and stimulation by high or low temperatures: Aside the direct effect of temperature on germination, and as seeds mostly lie on the surface soil which temperature rises highly on hot summer days (may even reach 65° C in the desert east of Cairo), examination of such effects as pretreatments was done; a set of results being presented in Table 5.

The results indicate the capability of seeds for resistance of high temperatures as well as the effects on breaking dormancy which will be referred to later.

Pertreatment of dry seeds with low temperature (0° C) for varying periods (repeated 2 hours—40 hours) did not show clear, or sometimes only slight, effects on their germinability.

Table 3

Temperature and rainfall data for the two regions: **A.** desert and **B.** semi-desert

	Oct. 1967	Nov.	Dec.	Jan. 1968	Feb.	Mar.	Apr.
A. Desert (near Cairo):							
Mean temp. of day °C	22.6	17.7	14.0	11.0	12.1	13.5	18.4
Night-time mean temp. °C	19.8	15.2	10.6	8.5	8.1		
Day-time mean temp. °C	25.5	20.2	16.4	13.6	15.9	17.8	
Soil temp. (depth 2 cm):							
highest °C	48.4	41.6	34.7	30.9	35.9	38.4	52.7
lowest °C	20.1	11.2	6.2	3.9	6.0	10.1	15.0
Rainfall total (mm)	2.0	6.9	0.7	5.5	0	5.0	2.6
Max. rainfall in day (mm)	2.0	2.2	0.7	4.3	0	3.0	2.5
B. Semi-desert (Mersa Matruh):							
Mean temp. of day °C	21.3	18.0	14.3	12.2	13.7	14.1	17.6
Night-time temp. °C	19.0	16.3	11.8	10.4	11.5		
Day-time mean temp. °C	23.7	19.7	17.0	14.0	15.5	16.8	
Soil temp. (depth 2 cm):							
highest °C	37.5	29.0	23.6	20.9	31.1	30.3	41.9
lowest °C	16.2	11.1	7.6	5.3	7.1	10.4	12.9
Rainfall total (mm)	10.2	49.0	17.8	18.4	1.2	7.0	0
Max. rainfall in day (mm)	4.4	16.8	15.5	19.2	0.8	6.2	0

Table 4

Alternating and constant temperatures as affecting germination

	% germination (after 12 days)			
	20° C	25° C	30° C	Alt. 20° & 30° C
A. *Hyoscyamus muticus*	36	28	18	86
B. *Erucaria microcarpa*	12	0	0	25

3.2.2. Water

Table 6 presents the responses of germination to different artificial rainfall levels (5, 10 and 20 mm) of the magnitude of that occurring in nature (see also Table 3), together with 5 and 10 mm with extra addition of a daily amount of 1 mm. This extra amount could account for moistening of the soil surface due to light showers or dew condensation. The results show that 5 mm rainfall alone at 15°—20° C is insufficient for germination of all tested seeds. It is only when the surface soil was moistened daily by an extra 1 mm, that ample germination occurred. A rainfall of 10 mm at the mentioned temperatures is quite efficient in stimulating germination of most seeds, the percentage germination commonly rose also by a 1 mm

Table 5

Germination of seeds pretreated by high temperatures

	% germination (after 12 days)				
	Control	pretreatment: 2 hours for 7 days			pretreatment: 20 hours for 7 days
		60° C	70° C	80° C	60° C
Astragalus hamosus	0	0	0	10	0
Erucaria microcarpa	0	40	—	20	10
Hippocrepis cyclocarpa	0	0	10	10	0
Malva parviflora	0	5	80	75	40
Trifolium resupinatum var. *minus*	0	0	64	0	0

Table 6

Responses of germination to different rainfall levels

	germination % (12 days, 15° C)				
	5 mm	5 mm + suppl. 1 mm	10 mm	10 mm + suppl. 1 mm	20 mm
A. *Caylusea hexagyna*	0	14	0	16	7
Centaurea aegyptiaca	0	50	0	30	20
Haloxylon salicornicum	0	4	10	14	16
Hyoscyamus muticus	0	40	2	52	35
Zygophyllum simplex	0	20	30	44	64
B. *Achillea santolina*	0	7	10	23	51
Carthamus glaucus	0	10	12	20	28
Centaurea glomerata	0	40	10	55	10
Peganum harmala	0	17	18	30	14
Plantago albicans	0	16	32	44	40
Plantago notata	0	0	16	36	68
		(12 days, 20° C)			
Arthrocnemon glaucum	0	0	0	0	70
Asphodelus microcarpus	0	96	68	68	76
Bromus rubens	0	58	70	60	60
Centaurea alexandrina	0	50	50	60	50
Echinops spinosissimus	0	72	72	64	56
on dune soil:					
Echinops spinosissimus	0	32	4	16	40
Echium sericeum	0	30	10	40	50
Pityranthus tortuosus	0	48	32	40	60

daily supplement. Still higher germination in most cases occurred under 20 mm rainfall. In case of *Arthrocnemon glaucum*, 20 mm rainfall at least, are needed for germination to be ensued. The efficiency of rainfall in regard to germination, is controlled mainly by the evaporating factors as well as soil moisture characteristics, especially for the surface layer. Fig. 4 gives a picture of the moisture content in the used types of soil in the upper centimeter and at 2—3 cm depth for 20 days after rainfall. It is seen that retention of moisture is higher in the loamy soil than in the sandy soils of both the desert or the semi-desert regions. The effect is reflected on germination percentages.

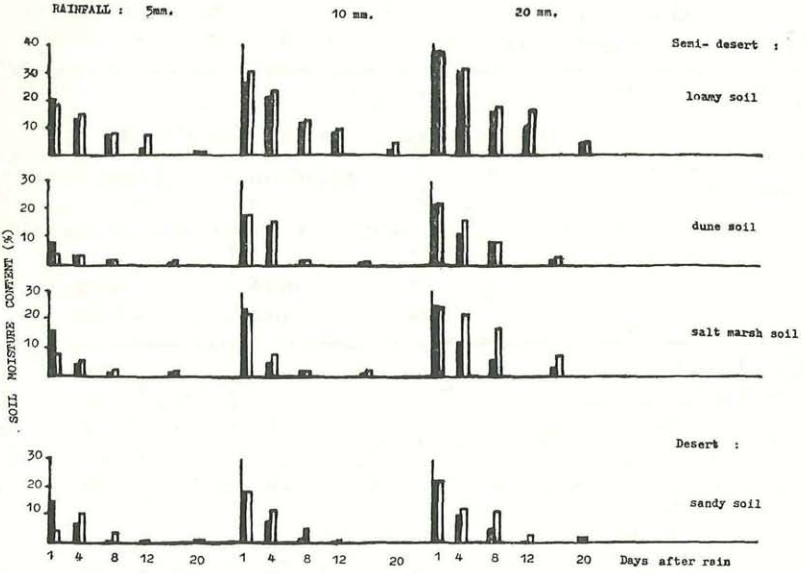

Fig. 4. Moisture content percentage in different soils used in the upper centimeter and at 2—3 cm depth as changed with time after rainfall.

3.2.3. Light

Light sensitive seeds out of the two sets, have been detected by comparing germination in dark and in light; Table 7 gives some results on the response to light. As seen from the table some seeds are sensitive to light in such a manner that their germination may be either promoted by light, e.g., *Caylusea hexagyna*, *Hyoscyamus muticus*, *Achillea santolina* and *Arthrocnemon glaucum*, or retarded by it, e. g., *Echium sericeum* and *Eryngium creticum*. It is noticed that seeds promoted by light are all small sized.

The effect of wave length of the visible light on germination could be seen from examination of germination percentages of some light sensitive seeds in red and blue light. While in most cases red light showed a promot-

Table 7

The response of seeds to light

a) Germination favoured by light:

	germination % (Temp.: 20° C)					
	Light			Dark		
	3 days	6 days	11 days	3 days	6 days	11 days
A. *Caylusea hexagyna*	0	22	46	0	0	0
Hyoscyamus muticus	0	10	10	0	0	0
Zygophyllum simplex	16	16	16	12	12	12
B. *Achillea santolina*	62	92	96	8	24	24
Arthrocnemon glaucum	0	40	50	0	0	0
Plantago notata	28	28	28	0	10	10

b) Germination favoured by dark:

A. *Astragalus sieberi*	4	8	12	0	8	28
Haloxylon salicornicum	4	8	8	12	20	32
B. *Asphodelus microcarpus*	12	32	88	4	88	92
Centaurea alexandrina	40	40	40	50	50	70
Echinops spinosissimus	80	85	85	90	100	100
Echium sericeum	12	12	16	30	50	50
Eryngium creticum	0	8	52	0	36	72
Enarthrocarpus strangulatus *)	20	20	20	20	100	100
Erucaria microcarpa *)	0	0	0	80	80	80

c) Seeds indifferent to light: remainder species.

*) pericarp removed.

Table 8

The effect of blue and red light on germination

	germination % (temp. 20° C)			
	blue		red	
	7 days	11 days	7 days	11 days
A. *Caylusea hexagyna*	42	50	60	68
Hyoscyamus muticus	6	6	14	14
B. *Arthrocnemon glaucum*	8	8	24	28
Asphodelus microcarpus	0	0	88	92
Enarthrocarpus strangulatus	100	100	40	40
Erucaria microcarpa	100	100	40	40

ing effect and the blue zone of the spectrum showed a retarding effect, in case of *Enarthrocarpus strangulatus* and *Erucaria microcarpa*, blue light seems to stimulate germination.

Some seeds have shown a sort of photoperiodic response. Greater germination percentages were recorded for *Asphodelus microcarpus*, *Echium sericeum* and *Eryngium creticum* by short days or continuous darkness. On the contrary *Arthrocnemon glaucum* gives higher germination percentages by long days or continuous light.

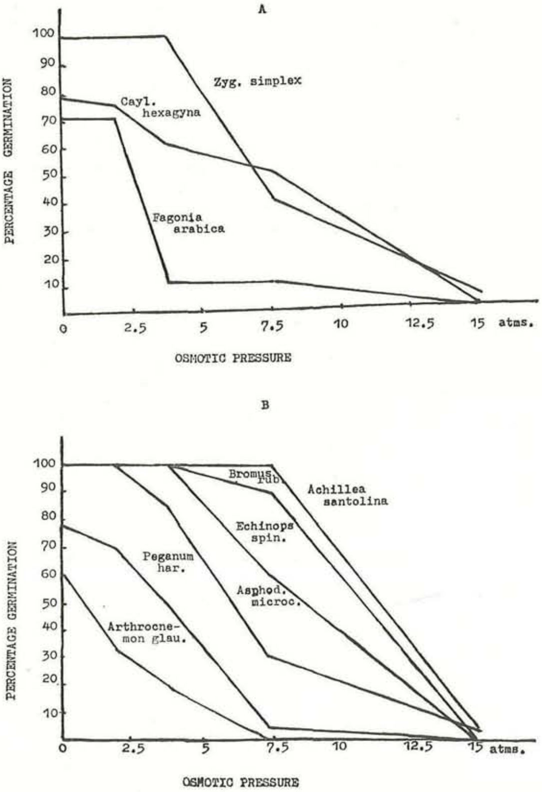

Fig. 5. Effect of salinity on germination of seeds (above: Set **A**, below: Set **B**).

3.2.4. Salinity

The effect with respect to germination, of different salt concentrations of the germinating solution, Na Cl being used, presents some other implied evidence specially for saline habitats. From set **A**, as can be seen from Fig. 5, *Zygophyllum simplex* and *Caylusea hexagyna* seeds on germination could tolerate (approx. 50% germination) salinity equivalent to 7.5 atms. osmotic pressure. *Fagonia arabica* shows weaker tolerance to salinity.

For set **B**, seeds of species such as *Achillea santolina, Bromus rubens* and *Echinops spinosissimus* show, on germination higher tolerances towards salinity (germination above 50% at osmotic pressure 7.5 atms.) while those of species such as *Asphodelus microcarpus*, *Peganum harmala* and the halophyte *Arthrocnemon glaucum* show low tolerances toward salinity. Germination becomes greatly inhibited or fail completely at salinity equivalent to 15 atmospheres.

Table 9

Germination of dormant seeds as affected by different chemical or mechanical treatments

	germination % (12 days)						
	Control	Treatment					
		Conc. H_2SO_4			Scarification	Impaction	Pericarp removal
		3 min.	10 min.	15 min.			
Astragalus hamosus	0	0	0	0	100	—	—
A. sieberi	5	70	70	80	100	32	—
Hippocrepis cyclocarpa	0	0	10	10	100	5	—
Medicago sativa	0	20	20	60	100	7	—
Scorpiurus sulcata	5	0	0	20	100	26	—
Trifolium resupinatum	5	20	40	60	100	20	—
Trigonella maritima	0	60	50	50	100	26	—
Asphodelus tenuifolius	10	0	80	50	—	20	—
Malva parviflora	0	20	20	10	—	0	0
Onopordon alexandrinum	5	40	20	20	—	60	—
Enarthrocarpus strangulatus	0	—	—	—	—	—	100
Erucaria microcarpa	0	—	—	—	—	—	100

3.3. Seed Dormancy

3.3.1. Need for after-ripening

It has been found, (see also Fig. 1), that some seeds could germinate directly after they were shed, while others commonly needed some period of after-ripening during which period the seeds were dormant. This period varies from few weeks to few months. Examples of such type of short dormancy is that of *Caylusea hexagyna* and *Plantago ovata* (one month), *Bromus rubens*, *Plantago notata*, *P. albicans*, *Asphodelus tenuifolius*, *Echium sericeum* and *Onopordon alexandrinum* (one month) and *Eryngium creticum* (2½ months).

3.3.2. Hard seed coats

Many leguminous seeds and others having hard seed testa or persistent pericarps show prolonged marked dormancy. As seen from Table 9, chemical or mechanical treatments which soften the seed coat by the use of conc. sulphuric acid or by scarification lead to germination of most of the treated dormant seeds. Impaction alone, i. e., vigorous shaking, may give some positive result in few leguminous or other seeds, e. g., *Scorpiurus sulcata* and *Trigonella maritima* and also *Onopordon alexandrinum*.

Removal of the hard pericarp is essential for germination of seeds such as *Enarthrocarpus strangulatus* and *Erucaria microcarpa*.

3.3.3. Light requirement

Seeds of *Achillea santolina*, *Arthrocnemon glaucum*, *Caylusea hexagyna* and *Hyoscyamus muticus* noticed to be light sensitive; are almostly dormant in dark but germinate readily when exposed to light. Conversely, it has been also noticed that seeds of *Enarthrocarpus strangulatus* and *Erucaria microcarpa* separated out of their pericarps do not germinate under prolonged light conditions but germinate easily in dark.

3.3.4. Need for high temperature

Freshly stored *Malva parviflora* seeds were dormant for a year and they could not germinate unless they were heated daily — for two hours — at high temperature (60°—80° C). Another example is *Trifolium resupinatum* which showed response to high temperature (70° C).

3.3.5. Removal of germination inhibitors

In *Trigonella stellata* germination was accelerated by continuous washing of seeds by water for 7 days; germination percentage rose to 25% as compared with nil for the control. This response is likely due to removal from the seed of an inhibitory substance for germination.

4. Discussion

The results reported herein throw some light on the germination behaviour of the seeds tested and present evidence of ecological significance. In the desert are present short-lived seeds, their chance of germination is of a short period, a limit of one year or so. Together with these, exist seeds with extended longevity, and dormant seeds which have their germination chances extended to even some years. Examples of the first type are *Haloxylon salicornicum* and *Arthrocnemon glaucum*; of the second type, a big variety of species including leguminous and hard seed-coated species.

Germination occurs when favourable conditions are attained. Various seeds need various temperature requirements for their germination. The range of temperatures for germination may be wide (majority of species) or otherwise narrow and more defined. Optimum temperature may be low, a feature characterizing many seeds germinating in cold weather e. g. *Haloxylon salicornicum*, *Achillea santolina*, *Asphodelus microcarpus*, *Eryngium creticum* and *Echinops spinosissimus*, or rather higher as found in species, the seedling of which appear on the onset of warmer weather after rains e. g. *Cleome arabica*, *Fagonia arabica* and *Zygophyllum simplex* in the desert and *Onopordon alexandrinum* in the semi-desert.

Much as important for germination is the water supply which is a limiting and regulating factor. Seeds vary in their responses to hydration affected by rainfall, conditions of soil moisture and other operating factors. As has been already noticed, 5 mm rainfall is insufficient for germination of desert seeds under 15°—20° C except when little supplements of water are added to the soil surface, but 10 mm and 20 mm rainfall justify the germination needs of most seeds. Germination does not occur therefore under very light showers of rain specially when they are spaced by time, but there seems to exist some sort of adaptation in the sence that germination would preferably occur under conditions of rainfall efficient too for the later requirements of seedling survival.

Combination of both factors, temperature and rainfall interprets several aspects of the natural habitats. Seeds having wide range of temperature for germination germinate whenever the chance of efficient rain occurs. Few seeds have narrow range of temperature for germination, and thus their germination is confined to the time of their favourable temperatures.

Morever, some seeds are sensitive to alternating temperatures e. g. *Hyoscyamus muticus*; seeds of which give weak germination or fail to germinate at constant temperatures. Seeds of *Malva parviflora* are apt to need high temperature in daily intervals before they can germinate. It is suggested that such temperature fluctuations would involve certain changes of some characteristics of the seed or of the seed coat leading to easy germination.

Certain seeds have been proved to be light sensitive, such as *Achillea santolina*, *Arthrocnemon glaucum*, *Caylusea hexagyna* and *Hyoscyamus muticus*; their germination is stimulated or promoted by light. As these seeds are all small sized, light sensitivity may be regarded as an adaptation;

seeds lying on the soil surface germinate readily while seeds that fall below the soil surface will lie dormant and have their germination postponed to the time they are exposed again to the surface. Some tested seeds showed responses to different zones of light spectrum, red light promoting and blue light generally inhibiting germination. This is in agreement with results of some other investigators e. g. FLINT & McALISTER 1937. BORTHWICK et al. 1952, 1954 and BUTLER & al. 1959 studied the light sensitivity on seeds (lettuce) and plant tissues and the outcome of their researches is the recent postulation of existence of the photoreceptor system, phytochrome. It is a protein fraction with a red infra-red interconvertible absorbing form and is responsible of the light absorption effect. In light-promoted seeds the effect of red is supposed to predominate and in dark-promoted seeds, the inhibitory effect of infra-red predominates.

Certain seeds have shown some sort of photoperiodic responses. Seeds such as *Asphodelus microcarpus*, *Echium sericeum* and *Eryngium creticum* giving greater germination percentages by short days or in complete darkness, and *Arthrocnemon glaucum*, germinating better by long days or in continuous light, serve as examples. It may be stated here that WAREING 1963 maintains that the effects of day length on seeds is not certain of being strictly comparable to photoperiodism in leafy plants.

High salinity has an inhibitory action on germination. The tested seeds responded on germination variably in regard to their tolerances to salinity. The inhibitory action is explained to be attributed both to osmotic effects and, to some extent to toxicity. Seeds of species such as *Zygophyllum simplex*, *Caylusea hexagyna*, *Achillea santolina*, *Bromus rubens* and *Echinops spinosissimus* show higher tolerances while those of *Fagonia arabica*, *Asphodelus microcarpus*, *Peganum harmala* and *Arthrocnemon glaucum* are less tolerant. Few seeds could hardly germinate at 15 atms. osmotic pressure. It is noticed that although *Arthrocnemon glaucum* plant is salt tolerant, nevertheless, the early germination stage is highly untolerable. Seeds and soil of this species should be leached by rain water before the seeds could germinate. Light sensitivity of *Arthrocnemon glaucum* could be regarded in this connection as being perhaps an adaptation for germination regulation since seeds which will lie at the soil surface will receive as well, light necessary for germination. Results on the effects of salinity presented are concordant with those of other investigators e. g. BEEDLE 1952, UHVITS 1946, and UNGER 1962.

Dormancy in desert seeds could be considered too as adaptation to meet the hard conditions of the natural habitats. It may be effected by variable causes. Need for after-ripening is noted for some species e. g. *Bromus rubens*, *Plantago notata* and *Eryngium creticum*, the period needed varies from few weeks to few months at most. Hard seed coats cause dormancy in many leguminous seeds such as *Astragalus hamosus*, *Scorpiurus* *sulcata* and *Hippocrepis cyclocarpa* and other species, the coats being impermeable to water. Such hard coats could be softened by chemical or mechanical treatments and in the natural habitats they are softened by the action of soil microorganisms in the wet season. Dormancy due to light or heat requirements, already referred to, could play roles in the mechanisms of germination regulation in the desert seeds. The same also applies to dormancy due to presence of germination inhibitors in the seed or the seed coat. Though no attempt has been tried here to identify germination inhibitors, nevertheless, the case of *Trigonella stellata* postulates that a germination inhibitor is likely to be present on the seed and could be removed by washing. WENT 1957 believes that in desert seeds, germination inhibitors play important roles and these should be removed by the necessary amount of rainfall specific to each species.

The slow germination rate as observed for *Astragalus sieberi* and prolonged germination periods noticed for several species could be also regarded as adaptations to let some seeds germinate at a certain time leaving others for future germination chances. Best chances should be regarded as those fulfilling germination requirements and seedling survival. However, this does not always occur in nature, adverse conditions may occur after germination. Destructive agents such as strong heat, killing frost, drought or strong storms operate in a direction opposite to the constructive action of germination.

5. Summary

A study of germination of two sets of seeds from the desert east of Cairo, (12 species) and the semi-desert, west of Alexandria, (29 species) was made. Laboratory experiments in incubators together with observations on pots in the outside were made.

The roles of different factors including temperature, rainfall, light and salinity were elucidated. Seeds varied for their requirements of temperature for germination. Some seeds showed a wide temperature range for germination (15° C—35° C) while others showed narrow range. Optimum temperatures for germination varied with species, some have low optimum (15° C), others have higher optimum (30°—35° C) while the majority have mild optimal temperatures (20°—25° C). Germination of seeds of a considerable number of species commonly occur in winter months, if rain water is available.

Rainfall requirements varied for various seeds. Rainfall of 5 mm is insufficient for germination of all seeds unless supplemented by little amounts moistening the soil surface, but 10 mm and 20 mm rainfall suffice the needs of most seeds for germination.

Some seeds have been proved to be light sensitive e. g. *Achillea santolina*, *Caylusea hexagyna*, *Arthrocnemon glaucum* and *Hyoscyamus muticus;*

their germination is stimulated by light. Germination of some other species, e. g., *Eryngium creticum*, *Enarthrocarpus strangulatus* and *Erucaria microcarpa*, is promoted by darkness. The feature of light sensitivity in seeds has been discussed.

Salinity affects germination, seeds on germination show variable tolerances to salinity. Species such as *Zygophyllum simplex*, *Echinops spinosissimus* and *Bromus rubens* show high tolerances while species such as *Fagonia arabica*, *Asphodelus microcarpus* and *Arthrocnemon glaucum* show low tolerances. Very little seeds can germinate at osmotic pressure 15 atmospheres.

Seeds exhibiting dormancy were studied and factors involved were analysed. The roles played by different factors in the mechanisms of germination regulation were discussed.

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