

Contents

1	The Desert Biome, Survival Adaptations and Strategies of Annual Plant Species	1
1.1	Introduction	1
1.1.1	The Environment in Deserts and Arid Zones	1
1.1.2	Deserts with Winter or Summer Rain	2
1.1.3	Classification of Semi-Arid and Arid Zones According to the Amounts of Rain and Vegetation Zones	3
1.1.4	Annuals in Deserts and Survival Adaptations Throughout the Stages of Their Life Cycles	3
1.2	Plant Adaptation and Survival Strategies	4
1.3	The Negev Desert	10
1.3.1	Rain Amounts and Distribution	13
1.3.2	Amounts of Runoff Water After an Intense Rainfall Affected by Soil Crust, Stones and Slope Gradient . . .	16
1.3.3	Biotic Activity, Diggings, Distribution of Runoff Water and Plant Succession	18
1.3.4	Temperatures in Winter or Summer	22
1.3.5	Temperatures, Relative Humidity and Rain Efficiency for Seed Germination	29
1.3.6	Day Length, Date of Seed Germination, Plant Development, Flowering and Plant Life Span . .	29
1.3.7	Dew During Winter or Summer Affecting Plant Adaptation	30
1.3.8	The Annual Environmental Factors and Life Cycle of Annual Plants	31
1.3.9	Seed Collectors	32
1.4	Conclusion	36

2	Flowering Strategies	37
2.1	Introduction	37
2.2	Flowering Adaptations and Strategies of Perennial Plants	41
2.3	Flowering Adaptations and Strategies of Selected Annual Plants	47
2.3.1	One-Seasonal Winter Annuals	47
2.3.1.1	Facultative Long-Day Response for Flowering (FLD)	48
2.3.1.2	The Day Length Independent Response for Flowering (DIF)	54
2.3.1.3	Intermediates	57
2.3.1.4	Single-Season Summer Annuals	58
2.3.2	Bi-seasonal Plants	59
2.3.2.1	Long-day (LD) Response for Flowering	60
2.3.2.2	Flowering Under Short Days and High Temperatures	61
2.4	Conclusion	62
3	Strategies of Phenotypic Plasticity of Germination During Seed Development and Maturation	65
3.1	Introduction	65
3.2	Environmental Factors Affecting Phenotypic Germination Plasticity	66
3.2.1	Seed Maturation Dates in a Natural Environment Affecting Germination	66
3.2.2	Day Length During Plant Development and Seed Maturation	70
3.2.2.1	Long or Short Days Affecting Seed Coat Permeability to Water	70
3.2.2.2	Day Length and Plant Age Affect Seed Plasticity of Germination	75
3.2.2.3	Short-Term and Long-Term Seed Banks	75
3.2.2.4	Quantitative Short-Day Effect	76
3.2.2.5	Quantitative Long-Day Effect	77
3.2.2.6	Day Length Effect on Short-Term and Long-Term Seed Banks	81
3.2.2.7	Day Length Affects Seed Germination of Plant Species with Soft Fruit	82
3.2.2.8	The Ecological Importance of the Critical Time During Seed Maturation at Which Day Length Affects Seed Germination	86

3.2.3	Influences of Light Quality During Seed Maturation on Seed Germination	87
3.2.4	Water Stress During Seed Maturation Affecting Seed Germination	89
3.2.5	Water and Temperature Stresses	91
3.2.6	Temperatures During Maturation Affecting Seed Germination	93
3.2.7	Plant Age, Seed Size and Germination Plasticity . . .	95
3.3	Seed Position on the Mother Plant During Seed Development and Maturation Affecting Seed Germination	97
3.3.1	Seed Position in the Capsules, Pods and Fruit	97
3.3.2	The Effect of Position of Capsules or Pods in the Plant Canopy on Seed Germination	100
3.3.2.1	Central or Peripheral Capsules	103
3.3.3	Position of Pods in the Upper and Lower Part of the Inflorescence	103
3.3.4	Position of the Fruits, Dimorphism and Germinability	104
3.3.5	Position, Heteromorphism and Germination	105
3.3.6	Seed Position in Inflorescences That Are Also Dispersal Units	105
3.3.6.1	Position and Heteroblasty in <i>Pteranthus dichotomus</i>	106
3.3.6.2	The Heteroblasty of the Caryopses of Synaptospermic, Lignified Dispersal Units	108
3.3.6.3	The Influences of the Order of the Caryopses on Germination Percentage, Plant Development, Flowering and the Number of Tillers and Spikelets .	113
3.3.6.4	The Influence of the Order of the Caryopses on the Size and Germination of the Caryopses of the Following Generation	114
3.3.7	Position in Burr – a Synaptospermic Dispersal Unit .	116
3.3.8	Position of Achenes in the Capitulum Whorls Affecting the Time Distribution of Dispersal and Germination (serotinas)	116
3.3.9	Position Effect on Seed Germinability and Seedling Survival of Female and Hermaphrodite Flowers in Inflorescences	118
3.3.10	Position of Achenes in Umbels Affecting Germinability	118
3.3.11	Position of Aerial and Subterranean Inflorescences Affecting Dispersability and Germinability	119
3.4	Desiccation Tolerance of Maturing Seeds	122
3.5	Conclusion	125

4	Strategies of Phenotypic Plasticity of Germination: Dormancy After Seed Maturation	127
4.1	Introduction	127
4.2	Post Maturation Environmental Influences on Dry Seed Primary Dormancy (After-Ripening)	132
4.2.1	<i>Hordeum spontaneum</i>	132
4.2.2	<i>Schismus arabicus</i>	139
4.2.3	<i>Stipa capensis</i>	141
4.2.4	<i>Ammochloa palaestina</i>	142
4.2.5	<i>Plantago coronopus</i>	143
4.2.6	<i>Spergularia diandra</i>	145
4.3	Periods of Storage of Dry Seeds at High Temperatures Affecting Primary Dormancy in Seeds of Different Plant Species	145
4.3.1	Short Periods of Dry Seed Storage at High Temperatures Increases Germination	146
4.3.2	Long Periods of Dry Seed Storage at High Temperatures	146
4.3.2.1	<i>Portulaca oleracea</i>	146
4.3.2.2	<i>Hirschfeldia incana</i>	147
4.3.3	“Bet Hedging” Germination	148
4.3.3.1	<i>Asteriscus hierochunticus</i>	148
4.3.3.2	<i>Mesembryanthemum nodiflorum</i>	148
4.4	Post Maturation Phenotypic Germination Plasticity of Hard Seeds	150
4.4.1	Day Length During Seed Maturation Affecting Hard Seeds	150
4.4.2	Temperature Amplitude During Summer Affecting Hard Seeds	150
4.4.3	Gradual or Sudden Increase of Relative Humidity Affecting Hard Seeds	152
4.4.4	Low Relative Humidity Affecting Seed Germination	156
4.5	Post-Maturation Supra-optimal Temperatures Affecting Germination of Wet Seeds, and Thermodormancy	156
4.5.1	<i>Lactuca serriola</i>	156
4.5.2	<i>Lactuca sativa</i>	159
4.5.3	<i>Cheiridopsis</i>	166
4.6	Conclusion	167

5	Seed Dispersal Adaptations and Strategies	169
5.1	Seed Consumption, Plant Adaptations and Strategies of Seed Dispersal	169
5.2	One-Season Winter Annuals and Seed Dispersal Seasons	174
5.2.1	Dispersal of Lignified, Synaptospermic, Multi-Seeded Dispersal Units at the End of the Season with Rains	174
5.2.2	Entangled Lignified Dispersal Units	175
5.2.3	Dry Unopened, Lignified Pod as a Dispersal Unit . .	176
5.2.3.1	Multi-Seeded Dispersal Unit	176
5.2.3.2	Single-Seeded Lignified Sections of a Pod	176
5.2.4	Lignified Aerial Seed Banks with Delayed Seed Dispersal by Rain (Serotinous and Hygriescence) . .	177
5.2.4.1	Dispersal by Rain of Aerial Protected Non-mucilaginous Seeds that 'Escape' into the Soil Seed Bank	177
5.2.4.2	Aerial Lignified Seed Banks with Mucilaginous Seeds, Seed Dispersal by Rain During the Season or Seasons Following Maturation	180
5.2.4.3	Shooting of Seeds to a Distance from the Mother Plant Triggered by Rain or Flood Water	188
5.2.4.4	Seeds Released by Rain and Dispersed by Wind . . .	200
5.2.5	Subterranean Lignified, Protected Seed Banks, Germination in Situ	200
5.2.6	Escape Dispersal Adaptations and Strategies of Tiny Seeds	201
5.2.6.1	Tiny, Dust-Like Seeds	201
5.2.6.2	Dispersal by Wind of Small Seeds with Pappus or Corolla	204
5.2.6.3	Dispersal by Wind and Boring Hydrochastic Mechanisms	204
5.2.6.4	Dispersal by Wind of Mucilaginous Seeds During the Dry Season	204
5.2.6.5	Dispersal by Wind of Polymorphic Mucilaginous and Non-mucilaginous Achenes	204
5.2.6.6	Delayed Seed Dispersal and Ballistic Dispersal by Wind	205
5.2.6.7	Seed Dispersal from Exploding Hydrochastic Pods Under Dry Conditions	207
5.2.6.8	Delayed Achene Maturation to the Season with Rain and Dispersal by Wind	207
5.3	Bi-seasonal Annuals and Seed Dispersal by Wind . .	207

5.3.1	Winged Diaspores Matured Shortly Before the Season with Rains	207
5.3.2	Achenes Matured and Dispersed Daily in Small Portions During the Summer	208
5.4	Conclusion	208
6	Germination Adaptations, Strategies and Influences on Germination During Seed Wetting	211
6.1	Introduction	211
6.1.1	“Bet Hedging” Germination Strategies	211
6.1.2	Germination Strategies in Deserts with Winter and Summer Rains	213
6.1.3	Germination Strategies of Seasonal Genotypes	213
6.2	Fitness to Habitats and Range of Temperatures for Germination of some Plants Occurring in the Negev	214
6.2.1	Geophytes: Temperature for Germination and Habitat Location	214
6.2.2	Adaptation to Temperatures and Salinity in Germination of Two Plants Occurring on Opposite-Facing Slopes of One Hill, in the Negev Desert Highlands	216
6.2.2.1	<i>Medicago laciniata</i> var. <i>laciniata</i> and <i>M. laciniata</i> var. <i>brachycantha</i>	216
6.2.2.2	<i>Helianthemum vesicarium</i> and <i>H. ventosum</i>	216
6.2.3	Germination Adaptations of Local Genotypes at Different Elevations	218
6.2.4	Local Genotypes According to Environmental Factors	219
6.2.5	Exposure of Wet Seeds to Supra-optimal Temperatures and the Imposition of Secondary Dormancy According to Location in the Soil or in Depressions	220
6.2.6	Repair Mechanisms by Short Periods of Wetting, and Seed Germination	220
6.2.7	Environmental Factors Affecting the Phenotypic Plasticity of Germination	221
6.2.8	Germination and the Minimum Amount of Precipitation required	224
6.3	Environmental Factors During Seed Wetting and Germination During the Season with Rain	225

6.3.1	Amounts of Rain, Cautious or Opportunistic Germination Strategies of Low or High Risk, Slow or Fast Germinating Seeds.	226
6.3.1.1	Plants with Cautious Strategies of Seed Germination	227
6.3.1.2	Plants with Opportunistic Strategies of Seed Germination	229
6.3.2	Speed of Germination	229
6.3.2.1	Strategies of Rapidly Germinating Seeds	230
6.3.2.2	Strategies of Slowly Germinating Seeds	230
6.3.2.3	The Presence of Germination Inhibitors as 'Rain Gauges'	231
6.3.3	Species with Mucilaginous Seeds (Myxospermy) as an Adaptation and Part of the Complementary Sets of Survival Strategies	232
6.3.3.1	Mucilaginous Seeds That Are Dispersed by Rain . . .	235
6.3.3.2	Mucilaginous Seeds That Are Dispersed During the Dry Summer	238
6.3.3.3	Mucilaginous and Light-Sensitive Seeds	238
6.3.3.4	Mucilaginous Seeds on the Soil Surface and Water Conditions Required for Germination . .	238
6.3.3.5	Mucilaginous Seeds Dispersed by Adhering to Mammals and Birds	239
6.3.3.6	Dispersal of Mucilaginous Seeds in Edible Fruit (Endozoochory)	239
6.3.4	Germination Under Mild Winter Temperatures and High Daytime Relative Humidity Compared with High Summer Temperatures and Low Daytime Relative Humidity.	239
6.3.4.1	The Amount of Rain in Mild Winter Temperatures and High Relative Humidity Affecting Seed Germination in a Natural Desert Area near Avdat . .	240
6.3.4.2	Amounts of Water in Summer Required for Germination at High Temperatures and Low Relative Humidity.	244
6.3.5	Range of Temperatures for Germination in Light or Dark	256
6.3.5.1	<i>Schismus arabicus</i>	257
6.3.5.2	<i>Spergularia diandra</i>	260
6.3.5.3	<i>Plantago coronopus</i>	262
6.3.6	Seed Location on the Soil or in the Soil Seed Bank Affecting Seed Germination, and Soil Turnover Influences.	262
6.3.6.1	Seeds on the Soil Surface	264
6.3.6.2	Seeds Buried in the Soil	265

6.3.7	Thermodormancy of Winter Germinating Plant Species	266
6.3.8	Light During Seed Wetting and Germination	267
6.3.8.1	Seed Location in Soil and Germination Regulation by Light	268
6.3.8.2	Influences of the Visible Light Spectrum on Seed Germination	272
6.3.9	Germination Regulation by Soil Inhibitors	274
6.4	Conclusion	280
7	Embryo and Seedling Survival and Plant Development	281
7.1	Introduction	281
7.1.1	Embryo Drought Resistance	281
7.1.2	Seedling Drought Resistance	284
7.2	Seedling Drought Tolerance and Survival	284
7.2.1	<i>Hordeum spontaneum</i> Effects of Seedling Developmental Stages and Local Genotypes	284
7.2.2	<i>Schismus arabicus</i>	288
7.2.2.1	Effects of Seedling Developmental Stages and Caryopsis Size	288
7.2.2.2	Duration of Dry Storage Affecting Seedling Survival and Genotypic Differences	289
7.2.2.3	Size Groups of Caryopses and Re-growth of Seedlings After Rehydration	290
7.2.2.4	Seedling Regrowth After 48 h Affected by Caryopsis Size	291
7.3	Amounts of Water Affecting Seedling Survival	292
7.3.1	Irrigation Affecting Seedling Density and Survival	292
7.3.1.1	Different Amounts of Water Affects Seedling Emergence and Survival	292
7.3.1.2	Water Distribution Affects Seedling Emergence and Survival	293
7.3.1.3	Seedling Emergence and Survival After Single Irrigations with Different Amounts of Water	294
7.3.1.4	Seedling Survival After Irrigation with 10 mm of Water on 9 to 20 days	294
7.3.1.5	Survival of Three Main Species According to Different Apportioning of the 200 mm of Water	295
7.3.1.6	The Number of Seeds (Schizocarps) Produced by <i>Malva aegyptia</i> as Influenced by Irrigation in Summer	295

7.3.2	The Amount of Precipitation in Winter Affecting Seedling Emergence and Survival	296
7.3.2.1	<i>Schismus arabicus</i>	296
7.3.2.2	<i>Gymnarrhena micrantha</i>	296
7.3.3	Inter-Specific and Intra-Specific Competition and Survival	299
7.4	Conclusion	301
8	Summary of the Complementary Sets of Survival Strategies of Some Common Species of the Negev Desert That Have Been Studied in Detail	303
8.1	Introduction	303
8.2	The Complementary Sets of Adaptation and Survival Strategies	304
8.2.1	<i>Schismus arabicus</i>	304
8.2.1.1	Flowering Facultative Long-Day Response	304
8.2.1.2	Influences During and After Maturation on Phenotypic Plasticity of Germination	305
8.2.1.3	Escape Seed Dispersal Strategies	305
8.2.1.4	Opportunistic Germination Strategies in Mild Winters and Cautious Germination Strategies in Hot Summers	305
8.2.1.5	Seedling Drought Tolerance	306
8.2.2	<i>Spergularia diandra</i>	307
8.2.2.1	Flowering	307
8.2.2.2	Phenotypic Plasticity of Germination by Day Length, and Seed Position Effect, During Seed Development and Maturation	307
8.2.2.3	Genotypes and Seed Dispersability	307
8.2.2.4	The Opportunistic Strategy of Seed Germination	307
8.2.2.5	Light, Temperatures and Germination	308
8.2.2.6	Dry Storage Duration and Seed Germinability	308
8.2.2.7	Germination in Summer	308
8.2.2.8	Soil Turnover	308
8.2.2.9	Time of Rainfall	309
8.2.3	<i>Blepharis</i> spp.	309
8.2.3.1	Flowering – Day Length Independent	309
8.2.3.2	Seed Dispersal by Rain or Floods from the Protected Aerial Seed Bank and Cautious Germination Strategy	309
8.2.3.3	Regulation of Germination by the Mucilaginous Layer Surrounding the Seeds	310

8.2.3.4	Connection of the Seeds to the Soil by the Mucilage	310
8.2.3.5	Fast Germination of the Dispersed Seeds	310
8.2.4	<i>Plantago coronopus</i>	311
8.2.4.1	Flowering	311
8.2.4.2	Influence of Day Length During Seed Maturation on Seed Numbers, Biomass and Germinability	311
8.2.4.3	Post-Maturation Temperatures and Primary Dormancy (After-Ripening) of the Protected Aerial Seed Bank	311
8.2.4.4	Dispersal of Mucilaginous Seeds by Rain (Myxospermy)	311
8.2.4.5	Phenotypic Plasticity of Germination	312
8.2.5	<i>Hordeum spontaneum</i>	312
8.2.5.1	Biodiversity Among Local Genotypes	312
8.2.5.2	Biodiversity of Primary Dormancy	313
8.2.5.3	Biodiversity of Seedling Drought Tolerance	313
8.3	Conclusion	313
 References		315
 Index of Latin Names		337
 Subject Index		341

Survival Strategies of Annual Desert Plants

Gutterman, Y.

2002, XX, 348 p., Hardcover

ISBN: 978-3-540-43172-5