ECO – PHYSIOLOGY OF SEED GERMINATION IN SELECTED PLANT SPECIES

A THESIS

SUBMITTED IN PARTIAL FULFILMENT FOR THE DEGREE OF MASTER OF PHILOSOPHY IN BOTANY

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SUBMITTED BY
REGI. NO : 295
SESSION : 2001-02

MARCH 2009

DEDICATED TO

MY LOVING CHILDREN

CERTIFICATE

This is to certify that the research work embodying the result of the thesis entitled "ECO – PHYSIOLOGY OF SEED GERMINATION IN SELECTED PLANT SPECIES" was carried out by the author herself in the Ecology and Environment Laboratory, Department of Botany, University of Dhaka, under my supervision and the style and contents of this thesis is suitable for the partial fulfilment of the Degree of Master of Philosophy in Botany.

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ACKNOWLEDGEMENT

The author expresses her profound sense of gratitude and indebtedness to her supervisor Professor, A. K. M. Nazrul-Islam (Ph.D. University of Sheffield, U.K.), Department of Botany, University of Dhaka, for his continuous supervision, encouragement, valuable advice, inspiration, affection, blessing and indispensable guidance in the execution and completion of this research work and also constant help in the preparation of the thesis.

The author is also grateful to Dr. M. Shamim Ahmed and Dr. Rakha Hari, Professor, for helping her to work in the Dark room and Dr. Abul Hasan, Present Chairman, Department of Botany, for providing all laboratory facilities. Thanks are also due to all teachers of the Department of Botany, University of Dhaka. The author is also thankful to her senior, junior and fellow batch mates who helped the author a lot on many occasions during the course of the work. The author is grateful to her all members of family particularly her husband and parents for their affectionate moral support, encouragement and appreciation which inspired her to do this work. The author has the pleasure to thank her younger brother Sajib for his excellent computer typing. Finally, Thanks go to Almighty "Allah" the most merciful and compassionate, for enabling the author in the completion of this thesis.

The Author
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C O N T E N T S

ABSTRACT

In the present study, an attempt has been taken to study the behavior of *Cassia tora* in the field to know their tolerance limit for explaining the mechanism of adaptation and distribution in the natural environment.

An investigation was done in the Botanical garden of the Curzon Hall Campus (D. U.) and in the laboratory of the Department of Botany. The study was carried out with reference to seed germination under laboratory and in the field conditions, growth analysis from successive harvests of plants grown in the field and the field experiment of seedling growth in the summer season.

The plant *Cassia tora* is widely distributed in Bangladesh and is commonly found to grow both in sun and shade habitats.

Seed viability remained high through out the study. Seeds of *Cassia tora* do not germinate immediately after dispersal and they germinate in spring and summer when light and soil moisture are not limiting. Two or four months age old seeds break their dormancy. Seeds of *Cassia tora* showed high percentage of germination with the increase of age and temperature.

The plant *Cassia tora* showed significant increase of shoot height in the summer season. The species exhibited significant shoot and root dry weight; flower and fruit formation.

Growth analysis was done in the plants grown in the Botanical garden of Curzon Hall Campus. Growth analysis was counted from 1^{st} harvest to 5^{th} harvest. The relative growth rate was increased in the 4^{th} harvest and then declined.

CHAPTER -1

GENERAL INTRODUCTION

GENERAL INTRODUCTION

Ecology is very much a modern field, but by no means a recent innovation. The word 'Ecology' is derived from the Greek word Oikos (a dwelling or more literally homestead) and logos (study). Ecology may be defined as the study of the interrelationship between living organisms and their environment. It is concerned with the web of interactions involved in the circulation of matter and the flow of energy that makes possible on earth and with the adaptation of organisms to the condition under which they survive (Larcher 1975).

(1) Ecology can be divided into Autecology (Ecological geo – botany or Eco –physiology; Muller-Dumbois and Ellenberg 1974) and
(2) Synecology (Sociologic Geo-botany; Muller-Dumbois and Ellenberg 1974).

The first one deals with the ecology of individual species (Clapham 1956) and is also known as physiological ecology i.e. adaptation, distribution and abundance of plants in relation to their function (Bannister 1976). One should know the ecological life history of a plant to understand the ecology of community (Baskin and Baskin 1972, 1973, 1988).

Hence, autecology is of necessity the foundation upon which a sound study of synecology can be built. Salisbury (1928) stressed the necessity of compiling a "Biological Flora of the British Isles" wrote such autecological data are of great value for their own sake and the progress of study of the plant communities is greatly hampered by the lack of information relating to the life history and biotic relations of their constituent species . Further until such data are available it is less valuable to attempt to unroll complex tangle of factors involved in the phenomena of competition. A correct assessment of the ecological niches of any plant can be gained by the study of its autecology. Tansely (1939), Misra (1957), Olmsted (1941) and Duncan (1952) laid much emphasis on the importance of autecological studies to the applied plant species, especially forestry, range management, soil conservation and weed control.

Tansley (1939) even went to the extent of remarking that thorough knowledge of a community cannot be acquired without close study of the autecology of its dominants. It has frequently been stated or implied that vegetation provides a measure of the environment or may be used as an indication of the total environment. The character of the individual plant and the conditions under which it grows have much to do with the distribution of the species (Clapham 1956).

The "Biological flora of the British Isles" published in the journal of ecology from 1941 made an important contribution of autecology (Baker 1947, Adams 1952; Beddows 1959, 1961, 1967, 1973; Bannister 1965; Bell and Tallis 1973). Autecological studies of selected plants were done by Montasir (1950); Bakshi (1952, 1954), Baksi and Kapil (1952).
Plants are most important organisms on earth .They are the form of life on which all other living things depend, the earths basic food study. Every living thing on this planet is fueled by the energy that arrives as light from the sun, but animals cannot use sunlight itself as fuel. First it must be transformed to usable energy and plants are the transformers. They are able to capturc the sun's energy and to transform it into a form of fuel are called food.

Light plays a very important role in plant life. Nearly all the aspects of plant life like structure, form, shape, physiology, growth, reproduction, development and local distribution are controlled by it. Based on light factor alone plants can be divided into two groups: shade tolerant species (sciophytes) and shade intolerant species (heliophytes).

The intensity and direction of light have a great effect on shape of the plants grown in insufficient light or in the total absence of light produces maximum amount of growth hormones as a result of which they are elongated with weak pale yellow stem and very few branches.

Growth is a most common manifestation of life. In strict sense growth implies the permanent accumulation of materials utilized by the plant for the building up of new tissues.

According to Krebs (1999), light does not act as a limiting factor in geographical distribution of plants. Light does however, play an important role in determining local distribution of plants. Plant species become adapted to live in a certain kind of habitat and in this process evolve a series of characteristics (e.g. shade tolerant and shade intolerant spp.) which prevent them from occupying other habitats. Grime (1966) 'suggested that light may be one of the major components directing these adaptation. However, the distribution of plants is affected by the duration and intensity of light'. The flat areas of wet mud (mudflats) that become available for plant colonization when some bodies of fresh water recede via drought or drawdown are of interest to biologist. Studies in Britain (Salisbury,1921,1970); Manitoba, Canada (Galinato and Van der Valk, 1986); Kenya (Gaudet,1977);Utah (Smith and Kadlec,1983); Iowa (Van der Valk and Davis,1978); Alabama (Webb *et al*,1988); Tennessee

(Webb *et al,* 1988; Chester 1992); Kentucky (Chester,1992) USA, showed that mudflats exposed during the growing season may become covered with newly germinated seedlings of various species .

Many of the species that appear on mudflats are annuals or ephemerals (Salisbury, 1970; Chester, 1992) and some are perennials that behave as annuals (Salisbury, 1970; Van der Valk, 1981; Chester, 1992).

The plant *Cassia tora* is widely distributed in Bangladesh and is commonly found to grow both in sun and shade habitats.

In the present study, an attempt has been taken to study the behavior of *Cassia tora* in the field to know their tolerance limit for explaining the mechanism of adaptation and distribution in the natural environment.

The present study of the above mentioned species was carried out with reference to the followings:-

(1) Seed germination under laboratory and in the field conditions.
(2) Seedling growth.
(3) Growth analysis from successive harvests of plants grown in the field.

CHAPTER -2

SEED GERMINATION UNDER LABORATORY AND IN THE FIELD CONDITIONS

2.1 INTRODUCTION

The process of germination leads eventually to the development of the embryo into a seedling. Generally germination is identified as protrusion of some part of the embryo from the seed coat which is a result of growth. Germination naturally is a major factor in the establishment of a plant community, as Went (1954) has investigated in some details.

In order to germinate a seed, it must be placed in environmental conditions favorable to this process. Among the conditions required is an adequate supply of moisture, suitable temperature and composition of the gases in the atmosphere, as well as light for certain seeds.

For an annual species to persist at a site, even if it has a long –lived seed bank, environmental conditions must be at least occasionally be favorable for germination and completion of the life cycle. In some habitats, this favorable period is unpredictable, while in other it is highly predictable. Studies on germination responses of seed exhumed after various period of burial under natural temperature conditions in humid, temperate climates have shown that annual species is unpredictable vs. predictable habitats differ in their germination characteristics.

The primary difference is that seeds of annuals in unpredictable habitats are non-dormant (i.e. are capable of germinating over a wide range of conditions) or conditionally dormant (i.e. can germinate over a narrow range of conditions) through the year (e.g. Baskin 1981, 1983a, 1984a; Roberts and Neilson 1982a, b), while those in predictable habitats exhibit annual dormancy/ non dormancy cycle (e.g. Baskin and Baskin 1983b, 1984b). Dormant seeds do not germinate under any conditions. Thus in habitats that become favorable for germination and completion of the life cycle at unpredictable times, seeds can germinate through out the growing season for a species but in predictable habitats germination is most likely to occur at the start of the favorable season-usually in either autumn or spring.

Timing of germination occurs when environmental conditions are favorable for seedling establishment and survival is critical to the success of annuals in a particular environment. In some annuals germination occurs immediately after seed dispersal because environmental conditions are favorable and the seeds are non dormant. In other annual species germination is delayed for some time after seed dispersal. Where there is a delay in germination, conditions of the environment following seed dispersal usually are such that seedling establishment and survival would not occur for that particular species. Delay in germination by plants growing in a habitat where this occurs, therefore, can be considered to be an adaptation to that type of habitat. The delay in germination following seed dispersal is caused by:

1) A period of true dormancy, i.e., some internal mechanism (s) within the seed prevents germination, and / or

2) By a period of quiescence, i.e., unfavorable environmental conditions cause a delay of germination.

A dormant seed is a live seed that does not germinate under its natural or artificial media even though environmental conditions are favorable. Seed dormancy delays germination and distributes it over time and therefore, it is of great significant as a survival mechanism. The primary mechanism of dormancy in grasses may be impermeability of the seed coat or pericarp to oxygen (Delouche 1976, Mikkelsen and Sinha 1961) water soluble substances from rice hulls diffuse into the seed and inhibit germination and to make the seed germinable, the inhibitory substance needs to be oxidized or removed.

Takahashi (1967) and Navasero *et al* (1976), noticed that the degree of seed dormancy in rice was controlled by two factors; the permeability of the outer membrane and the quality of inhibitors (inhibitory substance) present in the seed.

In most species investigated there is a change in ability to germinate as the seed ages; after a period of storage the seeds give a higher total germination and or a faster rate than do fresh seeds under the same conditions. In most species this change in germination ability is related to physiological changes in the seed (after ripening).

The date of germination is controlled by an interaction of soil moisture, temperature and the changing temperature response of the seed as it ages, but differences in germination date between years are probably due predominantly to differences in soil moisture. Soil moisture also plays an important part in controlling the germination date.

Vegetation composed of annual affords special opportunities for the investigation of dynamic aspects of plant populations. Plant responses to induced and natural environmental variation show up rapidly, because germination, establishment, seed production and death occur in each growing season.

Equilibrium of species composition, rather than developing over decades as with vegetation composed of longer-lived plants, may be reached within a single growing season. Early patterns of establishment by several important annual plant groups determine the overall yearly and seasonal changes in vegetation, because survival of seedlings in the early part of the growing season permits them to live through the rest of the growth year.

One reason for the formation of seed banks is that seeds of many mudflats species require light for germination (Salisbury,1970), but temperature, oxygen and other factors may be important in regulating germination. Although seeds of many annuals have been observed to germinate on mudflats, the germination eco physiology of these species has received little attention (Salisbury, 1970). Studies on summer annuals that grow in habitats that are not subject to inundation show that seeds of some species, e.g. *Ambrosia artemiseifolia* L. (Baskin and Baskin, 1981), can only germinate in the spring. If seeds do not germinate in the spring, they re-enter dormancy (secondary dormancy) in the late spring –early summer. However, seeds of summer annuals e.g. *Portulaca smalli* (Baskin and Baskin, 1988), can germinate in the spring or summer. Seeds that fail to germinate in the spring do not re-enter dormancy and can germinate at any time during the growing season, if condition becomes nonlimiting .It was hypothesized that seeds of the summer annual mudflat species also remain nondormant during the summer.

In nature the *Cassia tora* generally occurs as weed. *Cassia* belongs to the family Leguminosae, subfamily Caesalpiniodae. It is a large and predominantly tropical genus of 580 species of herbs, shrubs and trees with about 20 representatives in India.

Cassia tora is widely distributed in Bangladesh and commonly found to grow both in open and closed habitats. *Cassia tora* (Hindi and Benglai name is Chakunda) ephemeral (summer annual) grows profusely in fallow and derelict land and begins to grow in the field just after the first rain i.e. in the middle of March or first week of April and is generally found up to October. This plant species is economically important as well as possess medicinal value. The seeds of *Cassia tora* are used as coffee substitute (Burkill 1935) and are also reported to be used in indigo dyeing and a protein rich feed for livestock. The leaves are also useful in skin disease.

2.2 MATERIALS AND METHODS

2.2.1 Materials

Seeds of *Cassia tora* collected in October in 2006, 2007, were used in the present investigation. Mature fruits were collected from the above plant growing in the natural habitat of Dhaka University Campus, Mirpur and Uttara. Seeds were separated from the fruits, dried in the sun and stored in plastic containers in the laboratory at room temperature until used.

2.2.2 Methods

Germination tests were performed in the laboratory and in the experimental plot of Botanical garden of Curzon Hall Campus.

In the laboratory germination tests were performed in petridishes (8.8 cm diameter) with distilled water. A batch of 25 healthy seeds of each year was placed on Whatman no.1 filter paper moistened with distilled water. The filter paper was not allowed to dry and the dishes were slowly watered by wash bottle when necessary. The maximum and minimum temperatures were recorded during the experimental period.

Four replications were used for each treatment. Germination tests were done for freshly harvested seeds.

Germination record was noted after 24 hour intervals. Seeds were considered to be germinated when the radical immerged out from the seed coat. Number of seeds germinated in each day was counted and the percentage of germination was calculated. The seedlings were allowed to grow in the petridishes for 15 days. Then germination percentages were calculated.

2.3 RESULTS

2.3.1 Laboratory experiment

The germination behavior of weed *Cassia tora* can be affected by the season, age of seeds. Seeds were set in October'06 to July'07 for germination test and the germination percentage was recorded after 15 days. The results of the germination tests are presented in Table -2.1.

In freshly harvested seeds, there was very little germination. Seeds (2006) tested in October; all the seeds gave very low percentage (8%) of germination.

In the month of February (2007) the percentage of seed germination was very low (11%).
In the month of July (2007) the highest percentage (41%) of seed germination with record of the nine months old seed. There were very little germination percentage (10% and 14%) in dark room and in growth room experiments.

Table-2.1: Germination rate (%) in *Cassia tora* after 15days under laboratory condition.

Date of collection	Date of sowing	% of seed germination
12.10.06	28.10.06	8%
	06.02.07	14%
	10.02.07	11%
	11.02.07	41%
	26.02.07	10% (Dark room)
	27.02.07	14%(Growth room)

2.3.2 Field experiment

This experiment was done in the Botanical garden of Curzon Hall Campus. There were four plots, the length and breadth of each plot was 48"×36"; No. of rows were four and No. of seeds sown were 40 (per row).The distance from row to row was 8″and from seed to seed was 1″. Germination record was counted up to one month.

In the month of March (2008) germination occurred with the 15 months old seed of *Cassia tora*. Germination percentage was recorded after 1 day (2.18%), 7 days (20.15%), 15 days (56.25%), and 30 days (71.56%). In the month of March the maximum temperature was 34°C and minimum temperature was 24.2°C and the humidity was 73.3%.

Results of the field experiment study are given in Table: 2.2

Most of the seeds showed germination within four weeks. Since the seeds were sown 1 cm below the soil hence to show germination on the top layer it took long time. However, in the petridishes in the laboratory most of the seeds showed germination within two weeks.

Table 2.2: Germination rate (%) in *Cassia tora* after sowing in the field at different days.

Date of Collection of seed	Date of sowing	Environmental conditions Temperature/ Humidity	Days after germination	% of seed germinated
12.10.06	25.03.08	Maximum- 33.5°C Minimum- 24.2°C Humidity-73.3%	1	2.18%.
			7	20.15%
			15	56.25%
			30	71.56 %

2.4 DISCUSSION

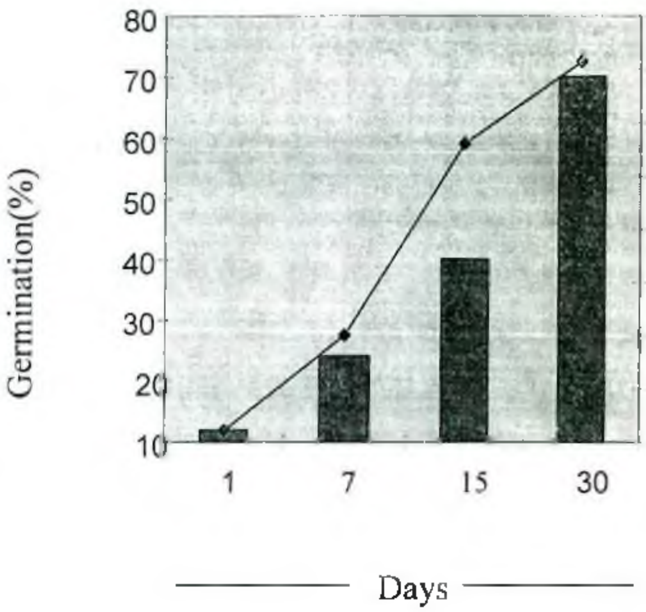
Seed viability remained high through out the study. During experiments two or three germinated seeds were found in each petridishes of exhumed seeds; these were discarded and not counted in the results of the germination tests.

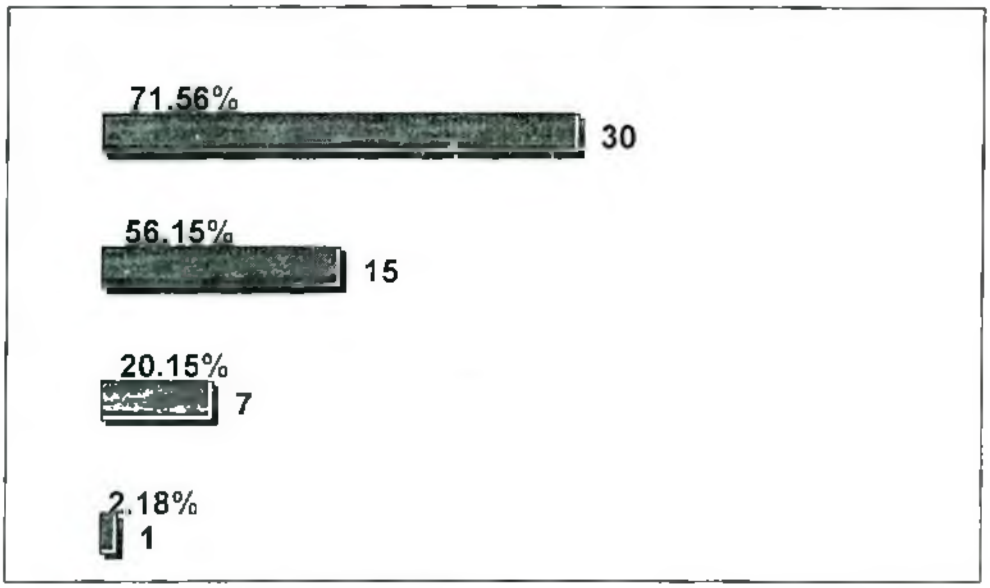
Seeds of *Cassia tora* do not germinate immediately after dispersal and they germinate in spring and summer when light and soil moisture are not limiting. Since seeds exhumed in April of each year germinated from 56% to 71% in light but from only 8% in darkness at the simulated and only 2 or 3 germinated seeds were found in each petridishe, it is concluded that light stimulates the germination.

The time of rainfall is important for the germination of seeds of *Cassia tora*. Temperature during the summer-rainy season is high to permit germination of this summer annual.

Two and four months age seeds break their dormancy. Seeds of *Cassia tora* showed high percentage of germination with the increase of age and temperature; 4 to 7 months old seeds showed more percentage of germination than freshly harvested seeds. The low germination percentage was noted in freshly harvested seeds (October to February) and was higher in April to June and July.

Germination in darkness remained noticeably lower than that of the light.





Germination percentages (%) of seeds of *Cassia tora* after 1 day, 7 days , 15 days and 30 days.

CHAPTER -3

SEEDLING GROWTH

3.1 INTRODUCTION

Germination naturally is a major factor in the establishment of plant community. Germination of the seed of the higher plant may be regarded as that consecutive number of steps which causes a quiescent seed, with a low water content to show a rise in its general metabolic activity and to initiate the formation of a seedling from the embryo. Generally germination is identified by the protrusion of some part of the embryo from the seed coat, which in itself is already a result of growth. In many seeds this is the radical and therefore germination is frequently equated with root protrusion. However in some seeds it is the shoot, which protrudes first, for example in *Salsola*. (Mayer and Poljakoff-Mayber, 1963).

Seeds can germinate when placed under suitable conditions of temperature, light, moisture and substrate. But many seeds do not germinate when placed under favorable condition and such seeds are said to be dormant.

Baskin and Baskin (1971) worked on germination of winter annuals in July and survival of the seedlings in the Central Tennessee Cedar Glades. Some winter annuals (e.g. *Arenaria patula, Arabidopsis thaliana*) produce seeds that are non-dormant at the time of dispersal (Caudle and Baskin 1968), in late spring or early summer, acquire the ability to germinate at higher temperature and by autumn they are capable of germinating at September and October temperatures. Other species of winter annuals (e.g. *Draba verna, Stellaria media*), produce seeds which usually are dormant at the time of maturity and dispersal (Baskin and Baskin, 1971) have after-ripened for 1-2 months, many of them have lost their dormancy and will germinate if placed under suitable temperature condition.

Newman (1963) studied the factors controlling the germination of *Aira praecox* and *Tcesalia nudiculis*. In these two winter annuals he found that the seeds responded to increase temperature with aging, but that some germination could take place during the summer if the substrate was continuously moist for several weeks.

Ratcliffe (1961) studied factors influencing germination in seeds of *Erophila verna* (L) Mey. (*Draba verna* L.) from the Derbyshire limestone in Great Britain.Two of his experiments, one concerned with after-ripening of seeds and the other with effects of different temperatures on dark germination of after-ripened seeds. There was very little germination in any of these experiments; the best was about 20% in 12 weeks old seeds in the light (photoperiod= 16 hours).

Light is a very important factor for the growth, development and distribution of plants. Light affects photosynthesis, growth, reproduction, flowering, germination and other physiological activities of plants. Percentage of full daylight, which the species requires in the field just to keep itself live, is known as compensation point (Misra *et al*. 1969). It is the light intensity at which the plants energy income can just balance its expenditure through respiration. Shade plant has not only a lower compensation point than a sun plant, but also it cannot make such good use of higher light intensities (Misra *et al.* 1969; Mahmood *et al.* 1975).

In nature, *Cassia tora* occurs as a weed in both open (sun) and shade habits, which indicate their differential tolerance of light intensity. Every species has a certain range of light requirement under which it shows the best performance, when no other factor limits its growth. On principle, some species are designated as " Heliophobous" (shade tolerant or shade loving) when they grow under forest canopy or do well under shady conditions. Others have been observed to grow only in open place; with no shade to interfere are regarded as " Heliophilous" (sun loving) plants.

There is a need to investigate the effect of light intensity on the distribution of various herbaceous plants growing in fallow, derelict land. It is really difficult to evaluate the intensity of light and also to know the precise amount of light that plant actually uses. Therefore, the present investigation designed for the purpose of studying the effect of environmental factor (light and soil moisture) in controlling germination (in the field) and growth of *Cassia tora.*

3.2 MATERIALS AND METHODS

3.2.1 Materials

Seeds of *Cassia tora* of the year 2006, were used in the present investigation. Mature fruits were collected from the above plant growing in the natural habitat of Dhaka University Campus, Mirpur and Uttara. Seeds were separated from the fruits, dried in the sun and stored in plastic containers in the laboratory at room temperature until used.

3.2.2 Methods

In the Botanical garden of Curzon Hall Campus an experiment was done. There were four plots , the length and breadth of each plot 48"×36"; No. of rows were four and No. of seeds were sown 40 (per row). Soil of those plots was broken by hands and made it free from large particles of stones and bricks and thus the soil was prepared for sowing (soil PH is 6.0 and organic matter is 2.4%). Seeds were considered to be germinated when the radical emerged out from the seed coat. The plants were harvested from the garden grown in sun habitat. After 15 days from the sowing date the seedlings were harvested. Two uniform size plants were harvested from each of the four rows. In each harvest, plants were carefully washed with tap water and the length of the shoots of seedlings were measured. The seedlings were dried in the oven at 80°C for 48 hours. The dry weights were then recorded.

The following observations were made during the vegetative and reproductive phase of growth and development of plants.

The vegetative growing period of the plants was recorded from the date of emergence of seedlings to the date on which the first flower appeared. The time taken for the opening of the buds was recorded. Fruiting phenologies were recorded for each species. The date of first fruit appearance was also recorded. The number of fruits per plant was counted.

3.3 RESULTS AND DISCUSSION

The various measurements of growth for the *Cassia tora* are presented in Table-4.1, 4.2 and 4.3.

Table 4.1 showed the mean values for the length of shoot (cm) at different harvests.

The length of shoot was measured in cm every 2 weeks interval from initial to 1st harvest and 1 week interval of 1st to 6th harvest and continued upto 9 weeks of growth, grown in the Botanical garden of Carzon Hall campus (D.U.).

The plant appears to be healthy in summer season. The length of the shoot increased with the increase of time. After initial and 1st harvest the mean length of shoot was 7.28±1.58 and 10.02± 1.32. After 2nd, 3rd, 4th, 5th, and 6th harvests the mean lengths of shoot were 13.51±1.86, 20.50±3.41, 31.10±5.02, 39.07±6.60 and 47.89±8.49 respectively. After 6th harvest the maximum mean length of the shoot was 47.89±8.49.

Table 4.2 showed the mean values of shoot and root dry weight at different harvests.

Mean total dry weight was 12.33g/week /plant which was higher in 6th harvest than other harvests.

The shoot and root dry weights were higher in 6th harvest 10.33g and 2.00g respectively than other harvests.

Flower initiation began after 9 weeks of sowingand fruiting began after 11weeks. In an experiment, Misra *et al* (1969) showed that direct light promotes the production of leaves and flowers. In *Cassia tora* mean No. of fruits/plant were 60 to 80. The fruit production per plant indicates that plant grown in more light, have the tendency to produce more fruits than those growing in less light condition.

Table 3.1 : The mean values for length of shoot of *Cassia tora* at different harvests.

Collection of seeds	Sowing date	Harvest no.	Length of shoot(cm) (Mean of eight plants)	Mean length of shoot (cm)
12-10-06	25-03-08	Initial (10-04-08)		
		Plot-1	7.43	
		Plot-2	7.09	7.28± 1.58
		Plot-3	7.16	
		Plot-4	7.45	
		1st(27-04-08)		
		Plot-1	7.45	
		Plot-2	9.81	10.02± 1.32
		Plot-3	12.83	
		Plot-4	10.01	
		2nd(05-05-08)		
		Plot-1	10.77	
		Plot-2	15.77	13.51± 1.86
		Plot-3	15.60	
		Plot-4	11.90	
		3rd(13-05-08)		
		Plot-1	16.60	
		Plot-2	26.22	20.50± 3.41
		Plot-3	17.06	
		Plot-4	22.12	
		4th(22-05-08)		
		Plot-1	29.42	
		Plot-2	36.07	31.10± 5.02
		Plot-3	25.50	
		Plot-4	33.43	
		5th(01-06-08)		
		Plot-1	36.25	
		Plot-2	42.31	39.07± 6.60
		Plot-3	29.00	
		Plot-4	48.75	
		6th(09-06-08)		
		Plot-1	36.75	
		Plot-2	58.87	47.89± 8.49
		Plot-3	39.31	
		Plot-4	57.00	

Table 3.2: The mean values of shoot and root dry wet at different harvests.

Harvest no.	Mean total dry weight (g/week/plant) (Mean of eight plants)	Mean dry weight (g)	
		Shoot	Root
Initial	0.19	0.16	0.03
1st	0.62	0.56	0.06
2nd	1.12	0.95	0.16
3rd	2.11	2.29	0.34
4th	7.61	6.25	1.35
5th	10.11	8.51	1.60
6th	12.33	10.33	2.00

Table 3.3: Physiological process of *Cassia tora.*

Collection of seed	Sowing date	1st germination date	Flowering	Fruiting	No. of fruit/plant	Fruit ripening
12-10-06	25-03-08	27-03-08	02-06-08	18-06-08	60-80	11-09-08

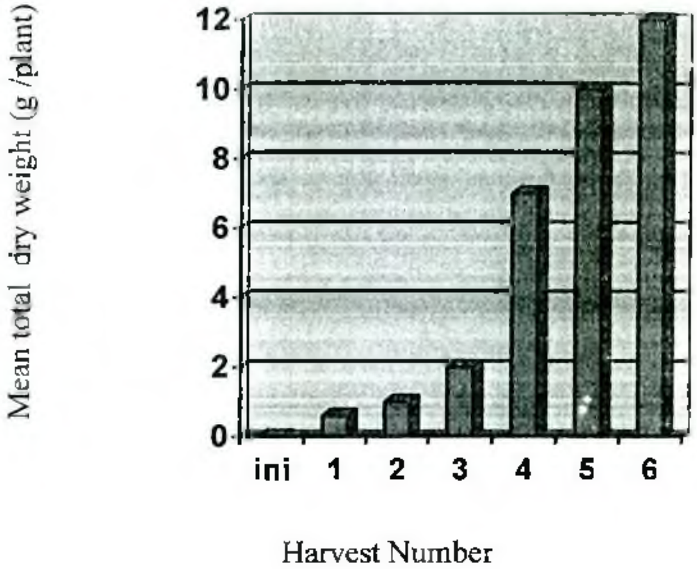


Fig : Mean total dry weight (g /plant) at different harvest

Seedling growth and fruiting of *Cassia tora*

plate 1 and 2

Plate 1 : Growth of plants after 06 (six) weeks.

Plate 2 : Plants showing fruits after 12 (twelve) weeks.

CHAPTER- 4

GROWTH ANALYSIS FROM SUCCESSIVE HARVESTS OF PLANTS GROWN IN THE FIELD

On the broadest scale plant growth analysis involves an assessment of the primary production of vegetation in the field, considered at the ecosystem and community levels of organization.

An outline of the techniques involved here has been given for the herbaceous communities by Milner and Hughes (1968) and Singh (1974). The role of primary production in the energetic of the whole ecosystem has been summarized by Phillipson (1966).

In the comparison with studies at this level, the growth analysis of communities focuses attention on much less extensive processes, both in time and in space.

Besides light and temperature , soil moisture and nutrient stress caused by natural drought spell particularly in rain fed crops and inter and intra specific competition often become the controlling factors of the net production in cropland ecosystem (Singh, 1974).

Variation in the dry matter production due to varietal differences and environmental conditions is better understood by studying the structure and efficiency of assimilatory surface. Such study is popularly known as growth analysis and provides a physiological insight into the differential behaviors of the plant.

Growth analysis chiefly involves determination of assimilation rate per unit leaf area (net assimilation rate), rate of dry matter production per unit body weight (relative growth rate) and leaf area per unit land area (LAI).

plate 1

plate 2

The classical approach in which the course of events is followed through a series of relatively infrequent large harvests (with much replication of measurements).

The functional approach in which harvest supplying data for curve fitting are smaller (less replication of measurements) but more frequent.

In any field of scientific study a consistent notation is a great advantage, especially where equations and mathematical expressions abound. Plant growth analysis had such a fragmentary evolution that more before attempted a comprehensive and coherent system of notation.

Cassia tora is a summer annual. The plant which germinates in the spring passes the summer in the vegetative phase, flower and sets seeds and dies in the following autumn and winter. *Cassia tora* is a widespread weed .The seeds are brownish, yellow, smooth, shiny and about 2mm. in diameter. On getting the necessary conditions for germination it takes 3 to 4 days for the seed coat to open.

4.2 MATERIALS AND METHODS

4.2.1 Materials

Seeds of *Cassia tora* collected in the year 2006, were used in the present investigation. Mature fruits were collected from the above plant growing in the natural habitat of Dhaka University Campus, Mirpur and Uttara. Seeds were separated from the fruits, dried in the sun and stored in plastic containers in the laboratory at room temperature until used.

4.2.2 Methods

In the Botanical garden of Curzon Hall Campus an experiment was done. There were four plots, the length and breadth of each plot was 48"×36", No. of rows were four and No. of seeds were sown 40 (per row). The plants were harvested from the garden grown in sun habitat. Two uniform size plants were harvested from each of the four rows. In each harvest, plants were carefully washed with tap water. Growth analysis was counted from 1^{st} harvest to 5^{th} harvest. 1^{st} harvest interval time was 15 days and others harvest interval time were 7 days. After 15 days from the sowing date the seedlings were harvested. The seedlings were dried in the oven at 80°C. The dry weight was then taken.

Relative growth rate was calculated from the following formula.

$$RGR = \log_e W2 - \log_e W1 / (T2-T1)$$

The principles to be followed are as follows:

RGR: Relative Growth Rate

W2: Final weight

W1: Initial weight

T2-T1: Harvest Interval Time.

4.3 RESULTS AND DISCUSSION

In any field of scientific study a consistent notation is of great advantage, especially where equations and mathematical expressions abound. Plant growth analysis had such a fragmentary evolution that more before attempted a comprehensive and coherent system of notation.

The results of the relative growth rate are presented in Table 3.1and Fig 3.1. At the outset the value of RGR began to show an increase upto the 4^{th} harvest and then declined. In the 5^{th} harvest it was noted that plants are forming fruits and leaves are also falling. Hence the value of RGR declined.

Table: 4.1 Relative growth rate in *Cassia tora* at different harvest.

No. of Plot	Harvest No.	Harvest Interval Time.	Relative growth rate (g/week/plant)	Mean relative growth rate (g/plot)	Mean relative growth rate (g/Harvest)
1	1st	15 days	.006		
			0.01		
			0.004		
			0.006	0.0032	
2			0.08		
			0.115		
			0.13		
			0.14	0.058	
3			0.098		0.033
			0.11		
			0.095		
			0.096	0.049	
4			0.09		
			0.05		
			0.04	0.025	
			0.02		
1	2nd	7 days	0.005		
			0.05		
			0.07		
			0.09	0.02	
2			0.11		
			0.05		
			0.05	0.03	
			0.03		
3			-0.16		
			0.05		
			0.07	0.003	
			0.07		
4			0.03		
			0.02		
			0.13	0.022	
			0.1		
1	3rd	7 days	0.18		
			0.25	0.067	
			0.08		
			0.03		
2			0.04		
			0.01	0.027	
			0.11		
			0.06		
3			0.01		
			0.05	0.021	
			0.06		
			0.05		
4			0.17		
			0.14	0.097	0.053
			0.16		
			0.31		
1	4th	7days	0.26		
			0.17	0.117	
			0.27		
			0.24		
2			0.17		
			0.26	0.102	
			0.10		
			0.29		

No. of Plot	Harvest No.	Harvest Interval Time.	Relative growth rate (g/week/plant)	Mean relative growth rate (g/plot)	Mean relative growth rate (g/Harvest)
3			0.15		
			0.16	0.075	
			0.15		
			0.14		
4			0.12		
			0.23	0.075	0.092
			0.13		
			0.12		
1	5th	7 days	0.001		
			0.008	0.011	
			0.02		
			0.06		
2			0.07		
			0.04	0.04	
			0.2		
			0.01		
3			0.04		
			0.01	0.017	
			0.07		
			0.02		
4			0.06		
			0.08	0.022	0.022
			0.02		
			0.02		

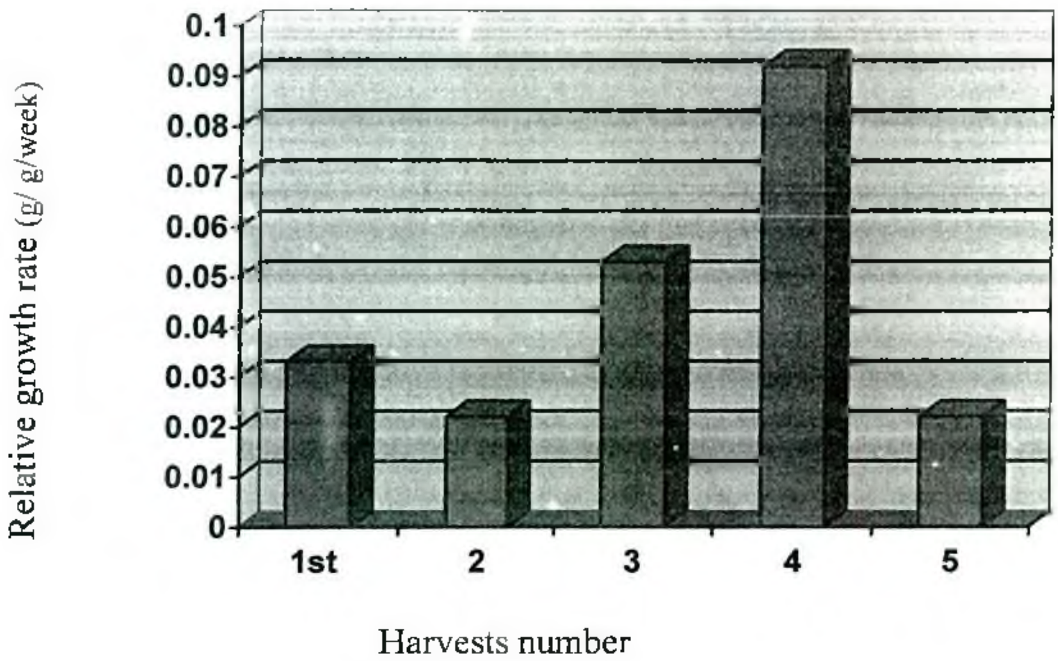


Fig 4.1: Relative growth rate (g /g/week) at different harvests

4.4 DISCUSSION

After 6 weeks the growth of plot 1 and 3 were comparatively lower than plot 2 and 4. Because the site of plot 1 and 3 were sunny and the site of plot 2 and 4 were shady. For that reason the soil of plot 1 and 3 were more drought than plot 2 and 4. The drought condition was not suitable for the growth of plants.

In the month of April the relative growth rate was found 0.033g in the 1st harvest within 15 days and in 2nd to 3 rd harvest the relative growth rate were found 0.022g and 0.53g respectively within 7 days in the middle of the May. In 4th to 5th harvest the relative growth were found 0.092g and 0.022g respectively in the last of the May.

The highest growth rate was found in 4th harvest than others harvest. In the month of April to May the relative growth rate was highest because rainfall was continued during that time and light, temperature and soil moisture became suitable for germination and seedling growth.

Growth of *Cassia tora* in the field experiment

Plate 1 and 2

Plate 1 : Growth of *Cassia tora* showing the plants rows.

Plate 2 : Same in plot 2 showing dense growth.

Plate 1

Plate 2

CHAPTER -5

GENERAL DISCUSSION

GENERAL DISCUSSION

In recent years experimental ecology has developed rapidly and its main object is to explain the occurrence of particular species or population in a particular environment.

Number of topics have been discussed in relation to its own implications in the previous chapters. In this section, the salient features will be brought together.

An assessment of the extent to which the results presented explain the way in which the distribution of particular plant species is limited by environmental factors can now be done. The following three factors were considered to explain the nature of distribution of the selected species.

1. Seed germination under laboratory and in the field condition.
2. Growth analysis from successive harvests of plant growth in the field.
3. The field experiment of seedling growth in the summer season.

1. Seed germination under laboratory and in the field condition.

Seeds of *Cassia tora* collected in the year 2006 and 2007, were subjected to study the germination behaviour.

The germination behaviour of the summer annual weed *Cassia tora* can be affected by the season and age of seeds.

In the laboratory, the freshly harvested seeds were very little germination.

Seeds of *Cassia tora* do not germinate immediately after dispersal and they germinate in the spring and summer when light and soil moisture are not limiting.

In the month of February (2007) the percentage of seed germination was very low (11%).

In month of July (2007) the highest percentage (41%) of seed germination recorded with the nine months old seed.

In the field experiment, the month March (2008) germination occurred with the 15 months old seed of *Cassia tora*. Germination percentage was recorded after 1 day (2.18%), 7 days (20.15%), 15 days (56.25%) and 30 days (71.56%).

2. Seedling growth

Cassia tora were grown in the Botanical garden and growth measurements were taken *Cassia tora* showed significant ($p = 0.05$) increase of shoot height (47.89±8.49) in the summer season.The species exhibited significant ($p = 0.05$) shoot and root dry weight (10.33g and 2.00g).

Flower and fruit formation were also appeared in proper time.

3. Growth analysis from successive harvests of plant growth in the field.

In the Botanical garden of Curzon Hall Campus an experiment was done. Growth analysis was counted from 1st harvest to 5th harvest.

The highest growth rate was found in the 4th harvest, which was 0.092g.

Progress curve showed the relative growth rate was increased in the 4th harvest and then decline.

CHAPTER -6

REFERENCES

REFERANCES

Adams, A.W. (1952). Biological Flora of the British Isles: *Succisa protensis*. Moencha. *Journal of Ecology*. **43:** 709-718.

Baker, H. G. (1947). Biological Flora of the British Isles: *Melandrium dioicum* (L. emend) Coss and Germ *Journal of Ecology* .**35:** 283-292.

Bakshi , T. S.(1952). The autecology *of Anisochillus criocephales* Benth. *J. Ind. Bot. Soc.* **31**: 269-280.

Bakshi , T. S. (1954). The vegetation of *Pilani* and its neighborhood. *J. Bombay. Nat. Hist. Soc.* **52:** 484-514.

Bakshi , T. S. and Kapil, R. H. (1952). The autecology of *Mollugo nudicaulis Bull. Bot. Soc.* Bengal. **6:** 45-48.

Bannister, P. (1965). Biological Flora of the British Isles: *Erica cinerea* L. *Journal of Ecology*. **53:** 527-542

Bannister, P. (1976). *Introduction to Physiological Plant Ecology*. Blackwell Scientific Publications.

Baskin, J. M. and Baskin, C. C. (1971). Germination ecology and adaptation to habitat in *Leavenworthia* spp.(Cruciferae). *American Midland Naturalist*. **85**: 22-35.

Baskin, J. M. and Baskin, C. C. (1972). Physiological ecology of germination of *Viola rafinesquii*. *American Journal of Botany*. **59:** 981-988.

Baskin, J. M. and Baskin, C. C. (1973). Delayed germination in seeds of. *Phacelia dubia* var. *dubia*. *Canadian Journal of Botany*. **51:** 2481-2486.

Baskin, J. M. and Baskin, C. C. (1981). Seasonal changes in the germination responses of buried *Lamium amplexicaule* seeds. *Weed Research*. **21:** 299-306.

Baskin, J. M. and Baskin, C. C. (1983a). The germination ecology of *Veronica arvensis*. *Journal of Ecology*. **71:** 57-68.

Baskin, J. M. and Baskin, C. C. (1983b). Seasonal changes in the germination responses of buried seeds of *Arabidopsis thaliana* and ecological interpretation. *Botanical Gazette*. **144:** 540-543.

Baskin, J. M. and Baskin, C. C. (1984a). Effect of temperature during burial on dormant and non dormant seeds of *Lamium amplexicaule* and ecological implications. *Weed Research*. **24:** 333-339.

Baskin, J. M. and Baskin, C. C. (1984b). Role of temperature in regulating timing of germination in soil seeds reserves of *Lamium purpueum* . *Weed Research*. **24:** 341-349.

Baskin, J. M. and Baskin, C.C. (1988). Environmentally induced changes in the dormancy states of buried weed seeds. Proc. 1987 British Crop Protection Conf. Weeds **7C- 2:** 695-706.

Beddows, A. R. (1959). Biological Flora of the British Isles : *Dactylis glomerata* L. *Journal of Ecology*. **47**:223-239.

Beddows, A. R. (1961). Biological Flora of the British Isles: *Holcus lanatus* L. *Journal of Ecology*. **49**:421-430.

Beddows, A. R. (1967). Biological Flora of the British Isles: *Lolium perenne* L. *Journal of Ecology*. **55:** 567-587.

Beddows, A. R. (1973). Biological Flora of the British Isles: *Lolium multiflorum* Lam. *Journal of Ecology*. **61:** 587-600.

Bell, J. N. B. and Tallis, J. H. (1973).). Biological Flora of the British Isles: *Inipatrum nigrum* L. *Journal of Ecology*. **61**: 289-305.

Burkill, J. H. (1935). A Dictionary of Economic Products of *Malya peninsula.* (Crown agents for the colonies, London).**1**: 482.

Caudle, C. and Baskin, J.M.(1968). The germination pattern of three winter annuals. *Bull. Torr. Bot. Club*. **95**. 331-335.

Chester, E. W. (1982). Some new distributional record for *Lesquerella lescurii (*Gray) Watson (Brassicaceae), including the first report for Kentucky. *Sida* 9**:** 235-237.

Chester, E. W. (1992). The vascular flora of Lake Barkley (Lower Cumberland River) seasonally dewatered flats. In : D.H. Snyder (Editor), Proceedings of the Fourth Annual Symposium, on the Natural History of the Lower Tennessee and Cumberland River Valleys. Center for Field Biology, Austin Peay State University, Clarksville,TN, pp 67-79.

Clapham, A. R. (1956). Autecological studies and the Biological Flora of the British Isles. *Journal of Ecology*. **44**: 1-11.

Delouche, J. C. (1976). Seed dormancy: A mimeograph prepared for seed physiology course (AGN 8203), Missippi State University, Mississippi, U.S.A.

Duncan, D. P. (1952). Autecological studies of important forest trees. *Ecology.* **33:** 285-286.

Galinato, M. I. and Van der Valk, A. G. (1986). Seed germination traits of annuals and emergents recruited during drawdowns in the Delta Marsh, Manitoba, Canada. *Aquat. Bot.*, **26:** 89-102.

Gaudet, J. J. (1977). Natural drawdown on Lake Naivasha, Kenya and the formation of papyrus swamps. *Aquat. Bot.,* **3:** 1-4.

Grime, J, P. (1966). The role of seed dormancy in vegetation dynamics. *Ann. Appl. Biol.* **98:** 555-558.

Krebs, C. J. (1999). *Ecological Methodology.* Addison Wesley Longman, Menlo Park. Calif.

Larcher, W. (1975). *Physiological Plant Ecology*. Springerverlang Berlin. New York.

Mahmood, A; Grime, J. P. and Furness, S. B. (1975). Polymorphism in *Arrhenatherum elatius* L. Beaur. Ex. J. and C. Presl. *New Phytol.* **75:** 269-276.

Mayer, A. M. and Poljakoff-Mayber, A. (1963). The germination of seeds. Pergamon Press. Vol 3, page. 14

Mikkelsen, D. S. and M.N. Sinha. (1961). Germination inhibition in *Oryza sativa* L. and control by preplanting soaking treatments. *Crop. Science* **1**: 332-335.

Milner, C. and Hughes, R. E. (1968). *Method for the Measurement of the Primary Production of Grassland.* IBP Handbook No. 6. Blackwell Scientific Publications, Oxford.

Misra, K. C.; Rao, D. N.; Ambasht, R. S.; Dwivedi, R. S.; Mukherjee, K. L. and Ananthakrishnan, P. V. (1969): Ecology: Study of Ecosystems. A. H. Wheeler and CO. (P) Ltd. Allahabad.

Misra, R. (1957). Plant ecological studies in Madhya Pradesh Presidential Address. Nat. Acad. Sci. India 27th session.

Montasir, A. H. (1950). Studies on the autecology of *Zilla spinosa.* Bull Faculty Sci. Fonad. I. Univ. **29:** 1-52.

Muller- Dumbois, D. and Ellenberg, H. (1974). *Aims methods in vegetation ecology*. John Willey and Sons. New York.

Navasero, E. P., L. C. Baun and B. O. Julliano (1976). Grain dormancy, peroxide activity and oxygen uptake in *Oryza sativa* L. *Phytochemistry.* 14/B (9): 1899-1902.

Newman, E.I. (1963). Factors controlling the germination date of winter annuals. *Journal of Ecology.* **51:** 625-638.

Olmsted, C. H. (1941). Growth and development of range grass. Early development of *Boutelona curtipeudula* in relation to water supply. *Botanical Gazette.***102:** 499-519.

Phillipson, J. (1966). *Ecological Energetics.* Studies in Biology No. 1. Edward Arnold, London.

Ratcliffe, D. (1961). Adaptation to habitat in a group of annual plants. *Ecology,* **49:** 187-203.

Roberts, H. A. and Neilson, J. E. (1982a). Role of temperature in the seasonal dormancy of seeds of *Veronica* sp. L. *New Phytologist,* **90:** 745-749.

Roberts, H. A. and Neilson, J. E. (1982b). Seasonal change in the temperature requirements for germination of seeds of *Aphanes arvensis* L. *New Phytologist* ,**91:** 150-166.

Salisbury, E. J. (1921). Vegetation of drying mud and retarded germination. *Naturalist, pp.* 329-332, 365-366.

Salisbury, E. J. (1928). On the causes and ecological significance of stomatal frequency with special reference to the woodland flora. *Philosophical Transactions of the Royal Society* B, **216**: 1-65.

Salisbury, E.J. (1970). The pioneer vegetation of exposed muds and its biological features. Philos. Trans. R. Soc. London, Series B, Biol. Sci., **259:** 207-255.

Singh, M. K. (1974). Eco-physiology of six rice varieties under dry land farming. Ph.D. Thesis. Banaras Hindu University. India.

Smith, L. M. and Kadlec, J. A. (19؛3). Seed banks and their role during drawdown of a North American marsh. *Journal Applied Ecology.* **20:** 673-684.

Takahashi, N. (1967). Dormancy and germination of rice seeds with respect to germination inhibitors. *Bull. Instt. Agric. Res. Tohokee. Univ.* **18(2):** 195-213.

Tansley, A. G. (1939). *The British Islands and their vegetation.* London. Cambridge University Press.

Tansley, A. G. (1939). *Introduction to Plant Ecology*, G. Allen and Unwin. London.

Van der Valk, A. G. (1981). Succession in wetlands: a Gleasonian approach. *Ecology.* **62:** 688-696.

Van der Valk, A. G. and Davis, C. B. (1978). The role of seed banks in the vegetation dynamics of prairie glacial marshes. *Ecology.* **59 :** 322-335.

Van der Valk, A. G. and Davis, C. B. (1979). A reconstruction of the recent vegetational history of a prairie marsh, Eagle Lake, Iowa, from its seed bank. *Aquat. Bot.* **6:** 29-51.

Webb, D. H., Dennis, W. M. and Bates, A. L. (1988). An analysis of the plant community of mud flats of TVA mainstream reservoirs. In: D. H. Snyder (Editor), Proceedings of the First Annual Symposium on the Natural History of Lower Cumberland and Tennessee River Valleys. The Center for Field Biology of Land Between The Lakes, Austin Peay State University, Clarksville, TN, pp. 177-198.

Went, F.W.(1948). Ecology of desert plants. I. Observations on germination in the Joshua Tree National Monument, California. *Ecology*. **29**: 242-253.

Went, F.W.(1949). Ecology of desert plants. II. The effect of rain and temperature on germination and growth. *Ecology*. **30**: 1-13.

Went F. W. and M. Westergaard (1949). Ecology of desert plants. III. Development of plants in the Death Valley National Monument, California. *Ecology*. **30**: 26-38.

Went F. W. (1954). Germination as a major factor in the establishment of communities. 8th International Botanical Congress. Sect.**7**: 228-229.

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