

D I S C U S S I O N

An intimate knowledge of the functional and structural aspects and attributes of the biotic and abiotic components of the ecosystem help in understanding its dynamic behaviour. It is therefore necessary to have a very thorough knowledge about the eco-physiological behaviour and life history of plants. Besides helping in understanding the ecosystem function, the weed status or the indicator status of a plant can best be understood only after having gained an intimate knowledge about its life history. Even workers like Misra and Rao (1948), Bakshi (1952), Salisbury (1942), Pandeya (1953), Mall (1957), Kaul (1959), Ramakrishnan (1959), Varshney (1964) have stressed on the significance of these studies to be of valuable use in understanding the vegetation pattern its development in various habitat system analysis.

The growth performance of a plant primarily depends on germination capacity of seeds and successful establishment of seedlings under a particular set of soil conditions. It is a well known fact that distribution and occurrence of plants are governed by a fairly large number of factors both intrinsic and extrinsic. Exponents of plant Geography have attempted to explain the causes of plant distribution and occurrence for a long time and have often interpreted the same in terms of dispersal (Good, 1925; Gleason, 1925; Wulff, 1943). Lodge (1964) reported that seedling survival of *Cynosurus cristatus* L. would not be expected greater

than 5% whether the species are sown at 1, 5 or 20 lb/ac alone or accompanied by other species, and also the germination and survival in soil of *Cynosurus cristatus* is not directly related to its ^{germination and potential} potential/ability of the species to enter a sword is high. Besides high germinability survival of the species in single species plantings was less than 50% and high production potential is necessary to the continuing presence in grass land of *C. cristatus* in view of its germinability and seedling establishment characteristics.

Ivani (1971) compared the growth of the two species of *Galinsoga* under different densities and observed a marked decrease in fresh weight per plant of both species, although fresh weight per unit area increased there was a decrease in the degree of branching and size of the leaves with increasing density though height of plants remained the same. He further reported that seeds of *G. parviflora* proved to be more responsive to light than *G. quadriradiata*.

Bassett (1973) found only two of *Plantagos*, *Plantago bracteata* (Moench) Hegi. and *Plantago ramosa* Beckl. occurring in Canada. The morphological variation growth and flowering responses in 15 populations of *Plantago major* collected from different climatic regions and habitat types were examined and population differences were assessed, both within and between by using canonical variate analysis.

Warwick and McNeil (1982) in *Plantago major* from southern Ontario observed that *Plantago major* L. is a common weed and has got extensive intraspecific variation resulting in the recognition of many sub species, varieties and forms. Warwick and Sweet (1983) reported that because of rapid developmental rate of plants of *Galinsoga* and the lack of seed dormancy under favourable conditions in Canada one to several generations are possible in a single growing season resulting in a rapid build up of large infestations in a short period of time.

The seed is ejected from the carpel and when seeds are dispersed carpel remains attached to the top of rostellum. The flower colour shows variation from blue to white. From morphological studies it is apparent that maximum seeds are produced from *G. pusillum* .

Yeo (1973) investigated the biology and systematics of six species of *Geranium* . According to him there are no basic characters that will enable us to break the genus into sub genera except an assessment of affinity based on survey of comparatively superficial characters across the entire genus.

Geranium L. (cranes bill) is the largest genus of the family Geraniaceae, with about 400 species distributed throughout the temperate regions of Eurasia and in mountains of high altitudes of tropics.

In India it is represented by about 18 species. Various species of *Geranium* collected from various natural habitats prefer to grow in soils maintaining slightly acidic (6.9) to alkaline pH (8.13) with a carbonate content ranging from 1.2 to 2.4%. These findings are in conformity with those of Rana (1977) who has reported that in many areas of northern India, soil salinity, alkalinity, and water stress are the most important factors limiting plant growth. Ambasht (1964) in *Cyperus rotundus* L. mentioned the importance of studies on the ecology of individual species (Misra, 1962; Pelton, 1951, 1953). The studies of physical and chemical characters of the soil of plots under the cover of *Cyperus* and without cover showed that porosity remained higher in former which may be on account of death and decay of old roots. At the time of excavation many dead roots or minute pores formerly occupied by roots were observed.

The organic carbon concentration in the soils ranges from 0.42% to 0.70% (*G. pratense*) and as high as 0.85% (*G. wallichianum* , *G. nepalense* and *G. pusillum*). The organic matter of the soil plays an important part in the growth of plants, mainly because of the higher available nitrogen content in such soils. Plants depend upon soil in most cases for its nitrogen, sandy desert soils are deficient almost in the organic matter and the addition of mineral fertilizers do not work beneficially (Raza, S.H. 1977).

The nitrogen and organic matter contents of the soil are directly correlated with the growth of plants. Tripathi R.S. (1968) while working on autecological observations on *Asphodelus tenuifolius* Cav. observed that dry weight of the shoot and root, seed output per plant and certain other growth characters show higher values in the fields rich in nitrogen and organic matter as compared with the plants growing in the fields poor in nitrogen and organic matter. Srivastava and Tandon (1951) in *Trapa hispidosa* (Roxburgh) reported that organic matter content ranged from 4.9% to 7.7% and total exchangeable bases in the soil ranged from 28 to 35 millieqts.

Srivastava (1963) in weed *Malvastrum truncupedatum* A. Gray. and *Sida veronicaefolia* Lam. observed that plants grown in different substrata (soil) exhibit best growth in $\frac{1}{2}$ garden soil and $\frac{1}{2}$ manure. They were followed with decreasing performance by those grown in garden soil, clay, manure, sand and garden soil and lime.

On an average moisture content in the soils that support *Geranium* species ranges from 18.3% to 21%. These soils are loose friable with a bulk density in the range of 1.02 gm/cm^{-3} to 1.09 gm/cm^{-3} . These soils are well aerated, maintaining a porosity in the range of 70% to 80%. These plants prefer to grow on ungrazed land which has higher water holding capacity (20% to 27%). These results are confirmed by the findings of Dagar J.C. (1987)

who has reported that in grazed fields the percentage of clay decreased while the proportion of sand increased; thus water holding capacity and moisture equivalent of soil were reduced. The infiltration rate also got decreased by trampling of the grazing animals. These observations are further confirmed by the findings of Misra, K.C. (1979) who has reported that moisture content, infiltration rate, total porosity, total nitrogen, available phosphorus and organic matter content of the soils are higher in the protected sites as compared to the other two sites. Further the moisture retaining capacity of the soil may be higher due to more organic matter content and soil pH.

The species of *Geranium* under observation seems to have wide range of tolerance in relation to soil calcium and is capable of growth both on calcium rich as also on calcium poor soils. The percentage ranges from 0.035% to 2.780% being minimum in Batkoot forests and maximum in Pampore Karewa. However, poor growth of *Geranium pusillum* was recorded in the soils with highest average calcium content. Growth in terms of shoot length and dry matter production was highest in soils with minimum available calcium (*G. wallichianum*). Similar behaviour was observed by Ramakrishnan and Singh (1966) in *Cynodon dactylon*. Clarkson (1967) observed that *Agrostis setacea* showed a better growth performance in calcium poor soils. Correlations between the exchangeable ions in the soil and mineral

composition of plants have been drawn by Mall (1955), Pandeya (1958) Joshi (1959), Ramakrishnan (1959) and Wakhloo (1964). In *Geranium* higher calcium content in the soil invariably resulted in the decrease of dry matter accumulation during preflowering or fruiting period. Under culture conditions when plants were raised in soil with varied levels of lime content confirmed these observations gathered from the field. The plants were stunted with leaves showing distinct signs of chlorosis when grown in soils with highest average calcium content upto 70% (30% soil + 70% lime) and growth parameters could not be recorded as plants did not reach maturity stage. These results are in conformity with those of Srivastava and Tandon (1951) in *Trapa bispinosa*. These authors have reported that CaCO_3 content in the soil is very little about 0.04% to 0.13%. Total exchangeable bases in the soil range from 28 to 35 mgms.

Amhasht (1964) in *Cyperus rotundus* L. found that CaCO_3 (determined by Collins colorimeter as described by Shah and Amin, 1951) was more in base plot whereas pH value was almost the same in all cases. Varshney (1966) in *Bidens biternata* reported that plants had a high degree of tolerance towards the soil calcium and though the plant could thrive in calcareous soil yet it had a lower seed output.

Geraniums showed luxuriant growth in soils with higher nitrogen concentration ranging from 0.115% (city forest) to 0.350% (Dachigam). Misra et al. (1963) also observed the growth and distribution of *Peristrophe bicalyculata* in Banaras to be synchronized with physiological adaptation of nitrogen absorption and assimilation as affected by light. The increase in growth due to high levels of organic matter and nitrogen in the soil has been reported in case of *Lupinus texansis*, *Poa alpina*, *Artemisia* spp., *Festuca ovina* and *Potentilla* spp. by Koch (1967), Scot and Billings (1964), Ellinborg (1964), Johnson (1964) and Nixon (1964) respectively.

Under culture conditions the growth of the plants gradually enhanced in soils treated with different proportions of cow dung (30%, 50% and 70%) and highest growth performance was observed in case of plants treated with 70% cow dung. This is attributed to the availability of more of nitrogen and organic matter content to the plants from such soils. However a higher content of nitrogen alone did not favour the growth of the plants. It can be inferred that in addition to nitrogen, higher levels of potassium and phosphorus are also needed for better growth of the plants as provided by orchard soils, due to the addition of fertilizers to the soils at the time of collection of soil samples from various sites. The percentage of sodium in the soils seemed to have direct impact on the plant growth.

The concentration of iron in the soil samples ranged from as low as 0.00014% (Verinag) to as high as 0.00075% (Bagh-i-Mahtab). The seasonal variation in mineral content appeared to be a property of the soil and is also influenced by the addition of fertilizers to some extent.

Studies on the growth behaviour of *Geranium* populations in natural habitats rendered some characteristic differences in the gross morphology in the samples collected from various habitats. Misra and Misra (1981) while working on association and correlation of plant species in a tropical grassland community reported that all species populations in a natural community are not distributed independently. Plant species may exhibit either positive or negative association among themselves because of interaction between the species or of a similar responses of the species to the same environmental variables (Poole, 1974). Marked variation was observed in the root and shoot extensibility of *Geranium pratense* samples collected from various sites. The root length (primary) was maximum at S4 (16.6 + 3.3 cms.) and minimum at S3 (9.9 + 3.5 cms.). The shoot length also was maximum (50.0 + 4.2 cms.) at S4 and minimum at S3 (18.9 + 1.5 cms.). Significant differences in the leafing pattern were observed which did not have any correlation with the shoot growth pattern observed at various sites. In the samples from S1 and S4 the leaf number per plant was higher (22 leaves/plant)

as compared to plants from S3 having only 14 leaves/plant on an average. The number of seeds on an average ranged between 35 to 45 per plant being maximal in plants from S2 and minimal in plants from S4.

These findings are in conformity with those of Wakhloo J.L. (1964) who while working on Autecology of *Rauwolfia serpentina* Benth. reported that sparse distribution of species is due to (1) comparatively heavy seed and lack of an efficient method of dispersal, (2) poor germination of seed which at best is 60%, (3) a short viability of the seed which is too low for a wild species and (4) the exacting soil moisture and temperature requirements. Hema Joshi (1989) while working on germination behaviour and growth characteristics of two range grasses reported that increasing water stress and temperature reduced percent germination in both the grasses, red light promoted germination while far red light inhibited it. Biomass and total leaf area increased with age; root shoot ratio, specific leaf area and leaf area ratio fluctuated with time while leaf weight ratio generally remained unaffected by the age of plant. Evan and Hughes (1962) data on *Impatiens parviflora* suggested that in some species leaf structure goes through ontogenic progression which are at the same time sensitive to environmental changes leading over all to large changes in SLA (specific leaf area).

According to Bray (1962) in herbaceous species the root ^{or} shoot ratio increases from moist to mesic to xeric species. This observation was later supported by Bray (1963), Struik (1965) and Monk (1966). Similarly in the present case root shoot ratio decreased during favourable conditions of vegetative growth i.e. in summer months. Later with the onset of favourable conditions it increased gradually when shoots began to wither off and roots gained dry weight.

Taylor et al. (1963) showed experimentally that normal enlargement of roots could be arrested by placing lumps of soil around roots. For a wide range of germinating plants and environmental conditions one approximate relationship exists between seedling emergence and soil strength. As the later increases above the optimum range the emergence progressively decreases until none occurs (Taylor and Gardner, 1963). In *Phleum* the seedling emergence was maximum in loose and well watered soils but minimum in compact soils (Kaul, 1976). Black (1955) has also remarked on emergence of seedlings in relation to crusting of soils that changes in soil structure may directly affect plant growth. In this connection we may also cite the work of Arndt (1965).

Black (1968) has also observed restriction of root development occurring in hard surface soils. Vass et al. (1971) in *Verbena bipinnatifida* reported that course

soil is a stronger barrier in root growth than the finer soils.

Morphological variations in the growth performance of various species of *Geranium* growing at various natural habitats were observed. Since very little information is available about mechanisms governing variation in truly wild growing organisms. This is attributed to coherence, because coherence is as much a part of evolution as is variation (Clausen and Hiesey, 1960). The basic mechanism by which coherence is achieved is provided through the chromosomes. The several genes that regulate the phenotypic expression of a character such as petal shape or anthocyanic coloration of stems and leaves are usually located on chromosomes, but each chromosome carries genes that contribute to the control of many other characters as well. It has been shown by Waddington (1957) that there is a close integration between an organism and environment. The environment can modify the channel which the organism can take. A visible triate (i.e. morphological features) is the developmental reaction to a specific genetic environment (Sinnot, 1960).

Environment and organisms both animals and plants is a diphasic system. The dynamic environmental complex works like a sieve selecting plants for growth from a bewildering array of plant forms on account of one or the other factors becoming critical at critical life

cycle of a plant or vegetation (Misra, 1962). Extensive reviews of the ecological effects of human trampling have been provided by Burden and Randerson (1972), Canaway (1975), Liddle (1975a, b) and Crawford and Liddle (1977).

Misra and Misra (1981) while working on association and correlation of plant species in a tropical community have reported that plant or animal species may exhibit either a positive or negative association among themselves because of interaction between the species or of a similar responses of the species to the same environmental variables (Poole, 1974). Since the derivation of "co-efficient of association" (Coole, 1949). Various degrees of association between species in different communities have been reported in the literature (Kershaw, 1958, 1959; Mall, 1961; Smith and Cottam, 1967; Singh, 1969; Risser and Rice, 1971; Mall and Dass, 1973; Billore and Mehta, 1975 ; Dawar and Singh, 1976). Jain (1974) while conducting studies in two ecotypes of *Vernonia patula* (Dryand) Merrill. revealed large number of morphological and physiological characters in which their differences are distinct and consistent. These have been assigned the status of ecotypes because of consistent correlation between the plant characters and the habitat in the either type of *Vernonia patula* both in the field and several experimental conditions.

Since natural selection favours a particular trait of an organism, its effect is transmitted to the progeny through the chromosomes that carry the genes controlling that trait and through these it will also be partially linked with several other distinct characters, regulated by genes carried by the same chromosomes. These findings are further confirmed by the studies in two ecotypes of *Vernonia patula* (Dryand) by Jain (1974) who has revealed large number of morphological and physiological characters in which these differences are distinct and consistent vis-a-vis plant height, leaf production, leaf area, mode and number of inflorescences, including immature, mature and fruiting capitula as is encountered in several species of *Geranium* under observation, both in natural habitats and also under controlled conditions.

MLH Kaul (1967) while working on ecology of *Mecardonica dianthera* (Sw) demonstrated the wide spread occurrence of population differentiation within plant species which was further recognized by the work of Turesson (1922a,b) Gregor (1946), Claussen (1958), Claussen and Hiessey (1958), Misra (1959), Misra and Rao (1948), Misra and Ramakrishnan (1959), Ramakrishnan (1959, 1963) and Kaul (1965a, b). The analysis of the causes of this type of differentiation has directed to the study of environmental factors operating in promoting divergence. Furthermore the ability of a species to enter a community in so far

its reproduction is by seed is a reflection of its germinability and seedling establishment characteristics. According to Lodge (1964) the factors determining the occurrence of a species are its grain weight and viability, but the entrance of a species into the community is more dependant on the ability of the seed to germinate in the soil thereof and the subsequent ability of the seedling to survive as observed by the author (Lodge, 1964) in *Cynosurus cristatus* L.).

The distribution of plants has further been correlated with the various physiological and ecological aspects, involved in the problem, centering around the motile phases of the life cycle, i.e. the seed longevity, type and depth of dormancy, requirement for pretreatments, in addition to the viability under natural storage conditions by Baldwin (1942), Crocker (1948), Stone and Juhren (1951) and Beadle (1952) among many others. Under transplant conditions the plants of *G. pratense* did not attain as much height as was attained by these plants in natural habitats (28.5 ± 2.5 cms.). The basal area was less and stem length taken as a relative measure of growth was only 32 ± 1.0 cms. All these growth parameters seemed to have direct impact on the length of petiole which was only 12.0 cms. Considerably less than what was recorded under natural conditions of growth (18.7 cms.). The number of flowers and fruits produced by these plants under transplant conditions varied. Their size also

did show considerable variation. Such variations were also observed in other species of *Geranium* (*G. wallichianum*, *G. nepalense*, *G. pusillum*) growing under transplant conditions. These variations could be attributed to various environmental factors, operating in promoting divergence.

These results are confirmed by various culture experiments conducted with *G. pusillum* and *G. nepalense* to study the growth performance of these two species under controlled conditions of environment, viz-a-vis irrigation, light edaphic, weed competition and organic manure.

In both the species *G. pusillum* and *G. nepalense* the irrigation at short intervals enhanced the vegetative as well as reproductive growth of the plants. The root length was maximum in those plants which were watered after every two days interval (W1 set) being 6.0 ± 0.9 cms. in the former and 9.0 ± 0.4 cms. in the latter. The shoot length was also maximum in these sets being 20.0 ± 2.0 cms. in case of *G. pusillum* and $32.5 \pm$ cms. in case of *G. nepalense*. These results were further confirmed by finding out the fresh weight and dry weight of both root and shoot portions, which were considerably higher in case of the plants watered after every second day interval as compared to those plants which were watered after 8 days and 12 days interval (W3 and W4 set). In *G. pusillum* the fresh weight of root and shoot in W1 set was 0.510 gms. and 2.500 gms. and in *G. nepalense* the

fresh weight of root and shoot in W1 set was 0.550 gms. and 4.425 gms. respectively. The dry weight calculated in these plants (W1 set) was also maximum as compared to other plants (W5 + W4).

Since various species of this plant were observed growing on soils with varied moisture content, ranging from wet to dry. The growth being more luxuriant on moist soils. The plants growing on such soils showed a better growth performance in terms of fresh and dry weight of shoot and the length of root and the shoot. However the growth declined under increased intervals between two successive irrigation periods (8 days + 12 days interval).

Pearson (1936) while trying to determine the relative effect of light and moisture on the growth of the plant species concluded that increasing soil moisture was effective in controlling the survival in quantity and that at low light intensities all species were weak and would not survive in large numbers.

Observations in field revealed that the *Geranium* species is capable of growth both in open and partially shaded situations were as under culture conditions growth is more profuse when plants are permitted to grow in medium shade attaining as much as 20.5 cms. length (*G. pusillum*) and root penetrating as deep as 4.2 cms.

Same observations were recorded in *G. nepalense* also. The root length was 9.6 + cms. and shoot attained the height of 34.6 + cms. The dry matter accumulation by the plants was highest at partially exposed conditions (med. shade) as compared to those plants which were growing in open sunlight or under deep shade. This differential behaviour of different species of *Geranium* towards light suggests the reason for its presence in both exposed conditions and also in thick forest.

When these plants were grown in competition with other plants (weeds) it was observed that over all growth of plants was more pronounced when growing in competition with one or two weeds and got reduced when the number of competitors was increased. This being a natural phenomenon, more the number of competitors less are the chances of growth and survival for individuals. Since plants of *Geranium* show luxuriant growth in soils rich in calcium, nitrogen and organic matter in nature under culture experiments also plants showed increased growth with increase in the dosage of organic manure. When plants were grown in different types of soils it was observed that garden soil is the best suited soil for the growth of *G. nepalense* and orchard soil is the best suited soil for the growth of *Geranium pusillum* plants.

With regard to chlorophyll estimation positive correlation was observed between the leaf area and total amount

of chlorophyll present in the leaves, in all the four species. The biomass of these plants both in nature and under transplant conditions did show much variation, primarily due to the fact that plants inhabit uniform growth conditions and prefer to grow on soils rich in humus and organic matter content, under natural conditions, which are not made available to the plants when transplanted.

While tracing the phenological events of various species of *Geranium* under observation, it was revealed that the entire life cycle of *Geranium pratense* is complete within a span of 29 weeks which is prolonged to 31 weeks in *G. wallichianum*.

In *G. nepalense* the life cycle is complete within 30 weeks but in *Geranium pusillum* the life cycle from seed germination to senescence of the plant is complete within a span of 17 weeks at some of the sites like Naseem Bagh Botanical Garden, etc. While at the higher elevations the life cycle extends by another 2 or 3 weeks.

Seed Germination Experiments

The importance of seed germination as the initial and critical step in the life cycle of plant has been recognized since long. Pelton (1953) and Clapham (1956) were the first to recognize its importance for autecological studies.

According to Nicholson (1934) Tolstead (1941) and Went (1949, 1957) the germination habits of the seeds of various plant species play an important and significant role in governing their range and distribution.

The germination studies on seeds of various plants and ecotypes have been conducted in India and elsewhere by workers like Misra and Rao (1948), Clapham (1956), Koller (1956), Went and Phillips (1956), Went (1957), Mall (1958), Davey (1961), Ramakrishnan (1960), Roberts (1963), Panje (1964), Kaul (1965), Monk (1967), Varshney (1967), Sen (1967), and Sapru & Kaul (1969).

The comparative study on seed germination of *Geranium* species for varying periods and at different temperatures was made, because temperature has been considered as one of the most crucial factor in germination regulating mechanism of the seed and in certain cases even as a special agent for breaking the dormancy (Chatterji and Mohant, 1967). Workers like Toole et al. (1956), Mayers (1942) and Drake (1947) have found the temperature as playing a significant role in the germination of seeds of desert annuals. According to Barton (1935) the seeds of some annuals like *Dalphinium acutiligea*, *Canadensis* spp and *Lonicora tatarica* did not germinate at high temperatures While Chen and Thimann (1964) observed that *Phacelia tanacetifolia* seeds could germinate at low temperatures only in the presence of light and no germination took

place above 30°C. The use of daily alternations of temperatures i.e. 15°C to 30°C or 20°C to 30°C was reported to bring about the germination of a great number of flowering plants (Harrington, 1954). However in *Tridea procumbens* and *Crypis aculeata* alternating temperatures of 9°C to 30°C did not favour the germination, Mall (1958). Ashby and Hellmers (1955) studied the temperature requirements for germination in various plants and found that some plant seeds germinated at all the temperature ranges while others had a definite low or high temperature requirement. *Rauvolfia serpentina* seeds failed to germinate at constant temperatures of 25°C and 38°C

While maximum germination was observed at an alternating temperatures of 25°C to 35°C (Wakhloo, 1964).

In *Geraniums* it was observed that 14 days interval at lab. temperature (20°C) seemed quite effective for the germination of seeds of *G. pusillum* (100%) and *G. nepalense* (100%) but in *G. pratense* seeds the percentage germination did not enhance beyond 10%, while in *G. wallichianum* the percentage germination recorded was 50% for the same period (14 days). At 10°C the seeds of *G. pratense* and *G. wallichianum* did not germinate even after the lapse of 34 days but in *G. nepalense* percentage germination recorded was 93.3% within this period and in *G. pusillum* all the seeds (100%) germinate within 18 days only.

Singh and Pandeya (1982) while finding out the temperature effects on germinability of five varieties of *Brassica campestris* L. reported that each species or variety has definite reange of minimum and maximum temperature within which germination takes place (Mayer and Poljakoff, Mayber, 1975; Sen, 1977; Pandeya and Sinha, 1978; Thompson et al., 1979). However occasionally periodic alternation of high and low temperatures enhance germinability (Mayer and Poljakoff, 1975). A change in temperature can affect the different constituent germination individually including elongation of the radicle (Tool et al., 1956; Cohen, 1958, Mayer and Poljakoff, Mayber, 1975). These results are in conformity with our findings for germination of *Geranium* spp.

The percentage germination of *Geranium* species enhanced when 1 year old seeds were used indicating that storage often affects the viability and subsequent germination of seeds (Singh and Pandeya, 1982).

Since seed dormancy is regarded as an adaptive mechanism of growth cessation which often confers upon some species a selective advantage in distribution and abundance (Amen, 1967). It is known in most of the plant species a number of causes lead to dormancy in the seeds of wild plants e.g. impermeability of the seed coat (Crocker 1912, Went, 1948) inadequate light (Went, 1957). Presence of the inhibitors within the seeds (Mayer, 1956) unfavourable

temperatures (Bliss, 1956) and the immature embryos. These and many other causes that lead to dormancy have been discussed at length by workers like Toole (1955), Waerings (1957), Billings (1957), Sen (1966) Chatterji (1966) and Amen (1967).

It is known that different species require different treatments like pre-chilling, after ripening, seed coat scarification etc., to break the dormancy. It is observed that seeds of *G. pratense* are quite sensitive to various treatments and these seeds require pretreatments before kept for germination. Mechanical scarification (by giving a prick along micropylar end) increased the percentage germination of *G. pratense* seeds to 50%. While in *G. wallichianum* the 50% germination was the limit at different temperatures without scarification and for varying periods whereas *G. nepalense* seeds and *G. pusillum* seeds thrive best (100%) at all the temperatures (20°C, 10°C and 5°C) for different durations (8 hrs, 6 hrs and 4 hrs).

Wakhloo (1964a) documented a new type of induced dormancy in *Solanum xanthocarpum* seeds. On subjecting them to 8 hrs. direct light at 35°C alternating with 16 hrs. dark at 40°C. Germination started on 32nd day with this treatment while under usual conditions it started with 5-10 days. Singh (1970) found that in *Solanum nigrum* seed, germination of red berried form is depressed by interaction of light and temperature of 15°C while the

germination of black berried form requires longer duration of low temperature.

Poppy (1970) made a study of light factor on seed dormancy/germination of *Capsella pastoris* and *Senecio vulgaris* at different temperatures in response to light. The majority of *Senecio* seeds were found to germinate only with the daily exposures of seeds to diffused lab. tempt. for a few minutes each day at the optimum temperature of 25°C. In *Capsella* on the other hand low temperature pre-treatment in the imbibed state was found to be a pre-requisite for maximum germination of 40% at 25°C in presence of light as the light was found to have no stimulating effect on unchilled seeds.

Sen and Roger (1972) while studying the dormancy mechanisms in *Amhrosia artemissifolia* seeds reported that freshly harvested seeds fail to germinate in either light or dark at 27°C. Young, Kay, George and Evans (1980) working on seed germination of *Atriplex* spp. in response to light conditions recorded the significantly higher germination in presence of light in *A. patula* at constant temperatures from 5°C to 30°C, as compared to germination in absence of light at the same temperature range.

These observations are in conformity with those of Amhasht (1953) who reported that seeds of *Alhagi camelorum* Fisch. have a dormancy of 5-6 months after which 20-25% seeds germinate but seedling mortality is 100%. Furthermore

in various species of *Geraniums* under observations perennation, propagation and reproduction is entirely vegetative through sub-teranean parts as reported by Ambasht (1953) in *Alhagi camelorum* Fisch.

Born, Vanden and William (1958) studied seed dormancy plant developments, and chemical control of *Fagopyrum tartaricum* L. and reported that seed dormancy is not only caused by impermeability of seed coat to water and observed that complete removal of pericarp and seed coat resulted in a small increase in percentage and chemical treatments also were not effective in overcoming dormancy. Same results were observed in *G. pratense* and *G. wallichianum* as well. The alternating temperatures did not seem to have any impact on the seed germination of these two species, while 100% germination was achieved in the seeds of *G. nepalense* and *G. pusillum* In a short span of 12 days and 4 days respectively.

Groves, Hagon and Ramakrishnan (1960) in eight populations of *Themeda australis* reported that seed germination is a critical event in the life history of a species but its relation to various environmental factors was still poorly understood (Mott and Groves, 1981). Authors have concluded that each population of *T. australis* behaves differently and variation in control of dormancy and germination reflect the high level of genetic variability and not due to any environmental factor such as temperature

requires and moisture levels. These results are further confirmed by the findings of Srivastava (1963), while studying the ecology of two perennial malvaceous weeds *Malvastrum tricuspdatum* A. Gray and *Sida veronicaefolia* Lam. reported that species exhibit seasonal variation in the production of dormant and non-dormant seeds. These two species produced seeds more or less throughout the year but the seeds produced were not all fertile. He further reported that seed dispersal was poor in both species as observed in *G. pratense* and *G. wallichianum*. This seems to be an important factor responsible for the non-availability of these two species of *Geraniums* in varied habitats and being restricted only to certain sites preferably at high altitudes.

Baskin and Baskin (1973) studied delayed germination in seeds of *Phacelia dubia* var. *dubia* and reported that seeds germinated in autumn after dispersal in spring and non-dormant seeds that did not germinate in autumn were induced into secondary dormancy by low winter temperatures.

Jerry and Carol (1976) also worked out some eco-physiological aspects of seed dormancy in *Geranium carolinianum* L. from central tennessee. In this species of *Geranium* seed germination occurred in autumn and seed ripening and seed dispersal were completed in May. The freshly matured seeds have hard seed coats and did not imbibe unless scarified, while in *G. pratense* and *G. wallichianum* the percentage germination was nil even after acid scarification

(H_2SO_4 30%). This accounts for some inhibition within the seeds to germinate before their dormancy period (maintained by hard seed coat) is over, and even after dormancy is broken (by giving a prick along micropylar end) the seeds still do not respond to different treatments. It is this phenomenon which primarily seems to be responsible for the scarce growth of *G. pratense* and *G. wallichianum* plants. Culture experiments could not be conducted with these two species, because there should always be a balance between quick water uptake by seeds and its possible partial immobilization coupled with low hydration requirements for germination (cf Chatterji, 1969). Fogg (1950) working with *Sinopia arvensis* found that germination was not affected by moderate water deficiency and that the fluctuations in water content of substratum in a range of 30% to 40% on oven dry basis had little effect on percentage germination. Baxi (1965) reported that seeds of *Indigofera cardifolia* presented a similar picture. These seeds were able to germinate even if a single seed absorbed less than a milligram of water at the time of germination.

The seeds of all the four species of *Geranium* kept in bright sunlight did not germinate at all whereas medium shade seemed quite effective and 36.6% germination was recorded after 8 days in *G. wallichianum* seeds which finally increased to 100% after the lapse of 12 days. In *G. nepalense* and *G. pusillum* seeds also 100% germination was achieved

within the same period. The percentage germination was nil in complete darkness while seeds did germinate when subjected to alternating light and darkness. These results are confirmed by the findings of Baskin and Baskin (1978) in *Rumex crispus*. The author has reported that freshly matured seeds germinated to high percentages in light at 20/10°, 30/15°, 35/20° to low percentages at 15/6°C. Seeds did not germinate in darkness at any temperature tested and concluded that stratification in light or darkness caused a higher percentage of the seeds to germinate in light at 15/c°C.

Chawan (1971) reported that many seeds of *Sida* spp. (desert species) fail to germinate because of an impermeable seed coat. Temperature be considered as one of the most important factors in a germination regulating mechanism (Harrington, 1916).

Sephali De and P.K. Durani conducted preliminary observations on seed germination of *Tridax procumbens* L. Their experiments were based on the present knowledge on the role of various pretreatments in overcoming the dormancy of certain seeds (Evenari, 1952, 1965; Steinbauer and Grigsby, 1957; Cumming and Hay, 1958; Frankland and Wareing, 1960; Friesen and Shebaski, 1961; Taylorson, 1969; Wareing and Saunders, 1971; Harrington, 1972; Stanislaw and Khan, 1977 and others). They reported that hot water treatment proved to be injurious to seed germination. Seeds injured

by pin prick showed 26% germination and also freshly harvested seeds showed 70% germination under natural light conditions but failed to germinate when kept under continuous dark or continuous light.

In all the four species of *Geranium* the burial at different depths (2 cm, 5 cm, 10 cm, 15 cm) did not have any impact on the seed germination, maximum germination in *Calotropis procera* seeds at the burial depth of 2-5 cm. while at lower depths germination was either delayed or did not take place at all. (Sen and Chatterjee, 1965).

Sapru and Kaul (1968) reported 62% germination in fresh *Euphorbia peplus* seeds after their five days storage in mud at a depth of 6-8 cms, while percentage germination decreased in the seeds stored for more than 5 days in mud at the same depth. Ivani (1971) reported that in *G. parviflora* and *G. quadriradiata* the percentage germination decreased from 98% to 56% respectively. When sown on the soil surface to a burial depth of 0.25 cms. while no germination was recorded at a burial depth of 1.0 cm. These observations coincided with those of Sweet (1973) who also reported that *Galinsoga* seeds germinate at the soil surface or at very shallow depths. Misra (1979) reported that maximum percentage germination in *Lioucaena latisliqua* and *Acacia auriculiformis* seeds was recorded in seeds pretreated with boiling water for 2-5 min. and at 1 cm depth. Hawten and Drennan (1980)

did not report any significant variation in seed emergence of *Elensinindica* and *Crotalaria gorensis* at 0-4 cms. depth ranges but at depths greater than 4 cms emergence declined in both the spp.

Misra and Singh (1981) analysed the effect of burial on germination of scarified seeds of three species of *Acacia*, viz. *Acacia arabica*, *A. catechu* and *Albizzia lebbek*. In *A. catechu* the maximum seedling emergence occurred at 1 and 2 cms. depth and in case of *Albizzia lebbek* maximum germination was recorded for seeds at 1 cm. depth, that were either soaked for 24 hrs. in water or acid scarified for 10 min. and sown at 3 cms. depths. The values declined at lower depths. From these observations authors indicated that when depth of sowing is accompanied by scarification seeds should not be sown deeper.