LEVELS OF LITERATURE
Temperature variation in temperature as well as in day length, have a profound effect upon flowering behaviour of many species of plant and demand different optimal combination of these two factors (Falloran, 1975). Many biennial and winter annual plants require prolonged exposure to low temperature before they can flower. It was from Gasser's (1918) experiment on certain cultivated varieties of cereals that the clue to the importance of temperature as a regulator of flowering came first. Gasser's experiments was followed up in the U.S.S.R. by Lysenko (1926) and he devised a technique to induce cold requirement before sowing, which came to be known as vernalization. Low temperature break dormancy in certain seeds and buds.

Most of the cold requiring plants need long photoperiod after vernalization for the induction of flowering, but Chrysanthemum parifolium a day neutral plant hasten to flower by SD treatments preceded by vernalization (since Prue, 1975).

The importance of low temperature for the development of certain plants was known long before it appeared in literature. Earliest available literature in this regard are Anonymous (1837) and Miller (1857). But Lippart (1857) was the first to describe this phenomenon correctly and had carried out some
systematic research and made it clear that winter wheat varieties could be made to behave like spring varieties by exposing the imbibed seeds to low temperature. Later more systematic research work was carried out in different cold countries on the chilling requirement of plants for hastening flowering. Farmers in cold countries started implementing the practice of vernalization since they could raise two crops in a year. In India extensive research work were taken up on vernalization during 1930s. Sen and Chakravarti (1930, 1942, 1944) and Chakravarti (1944) had tried to explore the benefits of vernalization in certain wheat and mustard varieties. They could promote flowering in these crops but the yield was poor. Shanker (1943) could not observe significant earliness in flowering in mustard. Workers at Calcutta, New-Delhi and a number of other places found that Indian wheats are indifferent to pre-sowing low temperature treatments and the yield was poor. Reports on other crops gave the same result. This proved that cold treatment of seeds held little promise in tropical countries. Chakravarti (1955) but the studies by Indian workers have enabled us to gain a clear understanding of certain aspects of the developmental physiology of our crop plants and showed how they differ from the varieties found in temperate region. Chiney with his co-workers (Chiney, 1950, 1951; Chiney et al., 1960; Chiney and Lande, 1951a, 1951b) took up this problem and conducted experiments on effect of vernalization and photoperiods on growth and development and biochemical process that takes
place during vernalization. More recently, Shaker (1983), Sharma (1983) and Dhillon and Singh (1984) were also worked on the same line. Dhillon in (1979) reported improved yield in a short term wheat crop by vernalization treatment. Seres and Faust (1986) showed improved yield by presowing drilling treatment. Dhill and Cartwright (1974) also reported the significance of vernalization and suggested that the sensitivity to vernalization can be used as beneficial tool in the much oscillating yearly scenario.

Devernalization

Devernalization or loss of vernalized condition is common due to certain conditions. The most effective devernalization agent is high temperature i.e. temperature above which required for vernalization (30°C); Wielensiek (1965) reported SE as devernalization factor. When vernalization is suboptimal and followed immediately by high temperature the vernalization treatment causes devernalization. Wild lettuce, (Lactuca serriola L.) can be devernalized only before germination and in the absence of light (Shaker and Prince, 1972). Verma (1969) and Sharma (1983) reported devernalization of oats and plantation respectively by high temperature. Under weak inductive conditions such as temperature 20°C, short days delay bolting compared with long days. Fiers and Kiebe (1994), Huesel (1977) and Galtorniksen (1961) found that short day treatments given during the raising of transplants delayed bolting.
the nature of vernalization

Site of perception of low temperature:

Gregory and Purvis (1940) working with rye (Petricus rye) showed that vernalization treatment causes changes in embryo itself and not in the endosperm. They removed embryo from endosperm and cultivated them in sterile medium containing sugars; such embryos were given a period of chilling treatment and showed typical hastened flowering responses when planted.

Hollingsworth (1964) experiment proved that all dividing meristems cells, including those in leaves are potential sites of vernalization. Excised shoot tips and fragments of embryo consisting essentially of shoot tips are sensitive to a chilling treatment (Purvis, 1940). In most of the biennial and perennial plants vernalization occurs at the shoot tip. Localized cooling treatments applied to biennial and perennial plants causes flowering when the stem apex alone is chilled e.g. celery (Curtis and Chang, 1932).

Metabolic changes during vernalization:

Metabolic changes during vernalization have been studied extensively by a number of workers but yet to get a clear idea (Devay, 1967; Istrinova et al., 1973; Bhasker, 1983; Sharma, 1983). Excised embryos needs an external supply of sugar for vernalization during the early part of the low temperature treatment (Purvis, 1940). The first 2-3 weeks cold had no effect
in excised embryos. This can be reduced by leaving embryo
attached during the first 1-2 days of cold treatment (Pervis,
143). This undoubtedly proved that endosperm or other storage
tissues are necessary for effective vernalization. Fuglesby
(1971) and Purvis (1939) studied the genetics of vernalization
in winter cereals and concluded that vernalization response is
heritable and it causes a shift in genetic expression of these
plants. More recently Calahan and Law (1979), Law and Turgeon
(1985a, 1996), Flood (1984), Flood and Ballesteros (1986), Merry
et al. (1986) and Livitrameno and Mozlov (1986) also studied the
genetics of vernalization. Denson and Sanzala (1974) suggested
that such a shift causes quantitative change in some metabolic
products. Since light may interfere with vernalization by
changing the level of metabolism they advocate vernalization in
dark in order to find out the effect of vernalization alone
during the juvenile stage.

Chilling treatment given to wheat plant causes a change in
the level of total endospermic. Crone (1964), Jones and
Reimerger (1970) and Francher (1983) observed a gradual decline
in amino acid content with the advancement of chilling treatment.
Jones and Reimerger (1970) reported a marked increase in total
alcohol soluble amino acid and amide fractions in Wodean wheat
during vernalization. Several workers reported the change in the
level of total free amino acid during or after chilling treatment
(Pauli and Mitchell (1960), Ishikawa and Osumi (1975), Trivastowo-
and Forster (1972), Zeec and Haull (1962), Sarkowski et al. (1972) could not find any qualitative or quantitative change in total free amino acids and aminonitrages compound in spring and winter wheat before or after vernalization. Kirillova (1955) analysed the qualitative changes in amino acids in cold grown wheat plants and found that some amino acids increased while others decreased. Yaskov and Rozova (1962) reported an increase in proline level in winter variety of barley during chilling treatment. Kocser and Saliik (1974) found an initial increase of proline, alanine and glutamic for 3 to 4 weeks and then declined in the seedling etrpy during vernalization. Jones and Heinbeger (1970) stated that changing pattern of alcohol soluble amino acids and amines with inhibition, grain variety and vernalization serve to indicate that a drastic charge takes place in the content of amino acid and protein at distinct phases as a direct result of vernalization. However, they could found only little effect of vernalization on the total concentration of wheat protein. Spermann (1961) reported decrease in soluble protein fraction in barley during the early period of vernalization and increased at later periods. Sharma (1973) and Tjasker (1973) found increase in protein content in plantago and mustard seedlings during vernalization. Chakravarti and Reddav (1974) could decrease the vernalization responses by blocking the protein and nucleic acid synthesis with chemical inhibitors. Electrophoretic analysis of protein from wheat plasule which
received chilling treatment revealed the appearance of new protein (Terone, 1972). Higher protein levels during vernalization were reported by Pavlov and Sukova (1964). Low level of protein during vernalization were found by Isikawa et al. (1975).

Many workers observed the importance of nucleic acid metabolism in plants during vernalization. Pavlov and Sukova (1964) reported that protein levels during vernalization were higher than in the controls. Isikawa et al. (1973) observed increased RNA content during vernalization. Dewey (1965, 1967) has shown with winter wheat that biochemical mechanism of vernalization is partly bound to nucleic acid metabolism. He concluded that during vernalization specific RNA synthesis takes place at the beginning of cold induction. But Finch and Carr (1950) working with vernalized rye embryo could not find any increase in RNA content.

Vernalization is known to affect carbohydrate metabolism in cereal plants. Winter and spring wheat varieties grown at 12°C had at 9°C highly significant differences in the level of sucrose, oligosaccharides and starch (Tripe, 1966). Several workers reported an increase in reducing sugars in winter varieties during cold treatment (Aksenova, 1960; Knoddllir, 1963; Valte, 1960; Vech, 1960; Thurin, 1960).

An increase in invertase activity during cold growth was reported by Freese (1969) and Rutherford (1971). Enzymatic analysis of carbohydrate by osylase was high due to vernaliza-
floral treatment (Chiroy et al., 1973; and Ishikawa et al., 1977).
Floral activity in the embryos of winter wheat and spring wheat during vernalization was at a higher level (Argo and Noria, 1979).
Ishita (1973) reported process-like enzymes as a cause of vernalization in winter wheat. Pavlov and Uskova (1964) reported that catalase activity was higher in non-vernalized seeds of winter wheat. Stanislavsky (1966) found stimulation of peroxidase activity by vernalization treatment in winter wheat.

Flowering stimulus

On the basis of results obtained from the grafting experiment Galusha and Lang (1941) suggested that a transmissible flowering stimulus vernalin is formed as a result of chilling in bean-like plants. Working with tobacco and tobacco plants they proved that vernalin and florigen are independent, and vernalin must be present if florigen is to be formed. Lang (1965) proposed a model for the events which is taking place in the cold requiring plant is as follows:

(Low temperature Vernalized state Vernalin Florigen)

Vernalin → Florigen → Flower
(cold requiring plants only in inductive photoperiods independent of daylength)

Many workers reported the production of a transmissible flower promoting substance as a result of vernalization.
(1965) in *Fraxinus excelsior*, trubinlin and Schvedalaya (1960) in *Lacuna carota* and Kellensalek (1961) in *Lunaria murin*

Vernalization requirements for certain winter plant species can be replaced by chemical, ethylene acid and its derivatives proved to be one of the most effective compounds (Lang, 1956; Fankar, 1958; Tanam et al., 1965). Adenosine diphosphate (ADP) treatment can also replace the cold treatments in winter wheat seedlings (Louda, 1963, 1964, 1965, 1966). Vernalization causes an increase in endogenous GA level (Hartley, 1969; Totino and et al., 1978 and Ijag, 1969, 1970). According to Chellahkher (1969), GA is one of the essential factors in the flowering process of the plant. It proved vernalin effectively to account for vernalization (Fig.1).

Farie and Geneppe (1971) proved the effectiveness of cytokinins to replace the vernalization requirement in winter wheat. Several workers reported its flower initiation effect in various plants. de Kiewics and A sensa (1944/1962) found that cytokinin is effective to initiate flowering in unchilled cory. L. verna (1963) and Kellensalek (1966) found that temperature above 30°C are very important inductive factor under SD condition.

L. loorar (1971) and Kellensalek (1972) reported flower formation by high temperature treatment (40-50°C) under non-inductive conditions in *Filtrum amniculum* and in *Poa pratensis* respectively. High temperature action on flower induction is paradox only when given in the middle of the dark
Fig. 1: Induction of flowering by vernalization treatment.

A model proposed by Deb (1969).
period. Flowering is induced to flower at vernalization temperature around 5°C, well below (17,9). Like high temperature, the low temperature treatment is effective only during darkness. He suggested that both low and high temperature influence the same process and the flower formation depend on this. Light removes a blocking, darkness has a reblocking effect, but low and high temperature prevent this reblocking.

**Photoperiodism**

Tennyson in 1856 suggested the possibility that daylength might influence plant distribution and development. Later in (1913) Julian graphically realised the importance of daylength as a controlling factor of flowering in hops and hemp (Cannabis and Humulus). Hans Lowes (1913) in Germany at about the same time could induce flowering in *Vicia faba* by giving a few days of continuous illumination from incandescent lamps. However, it was CAMERA and AFANC (1920) who first clearly demonstrated the fact that seasonal changes in daylength could profoundly affect the life cycle of many plants. They concluded from their experiments that flowering could be accelerated either by long days or by short days depending on the plant and classified plants into three groups: long day (LD) plants, short day (SD) plants and day neutral (DN) plants. Plants which remain permanently vegetative when kept under unfavourable day length conditions are known as obligate photoperiodic plants. Whereas plants which ultimately flower even under unfavourable conditions are
called quantitative photoperiodic plants. Obligate photoperiodic plants show a well-defined critical daylength, below or above which flowering will not occur in LDP and SDP respectively. Whereas facultative photoperiodic species show only a graded response to daylength with no sharp cut-off point. Fillman (1969) defined photoperidom as a response to the timing of light and darkness.

Experiments conducted with soybeans proved that flowering responses increase with duration of photoperiods and with increasing light intensity, whereas morning needs only very low intensity light to produce flowering response (Salisbury, 1965). Light as an important promotory effect on flowering because of its influence on the rate of photosynthesis in the main light period. Light irradiances in this period provide additional energy and substrates for growth and the more rapid initiation and development of flowers (Cocksall, 1974). Vince Prue (1973) found that immediate product of the light reaction during photoperiodic cycles are more important than stored photosynthetic products for induction in *Phaseolus*

However in *Helianthus* very brief daily exposure to high intensity light causes induction although it is photosynthetically insignificant (Schwebe, 1959). Long day plants like *Sinapis* (Gertsch and Gustafson, 1940); *Triticum* (Sagro, 1971); *Lactuca vulgaris* (Fite and Price, 1953) and *Lupinus* (Inovye and Kvo, 1984) flower when grown on culture media with sucrose without light.
Interaction between an endogenous timekeeper and a light sensor (photoreceptor) regulate floral induction. William R. Hillman (1964) provided some best evidence for the involvement of circadian rhythms in photoperiodism. Recently, Hall (1984) also conducted experiments in the same line. In his stated that "For photoperiodic timing to run to completion only a light-off signal is essential. The first evidence for the involvement of phytochrome with photoperiodism came from the essential night break reversibility experiments carried out by Borthwick et al. (1952). Forhakos (1968) put forward a hypothesis in which phytochrome served as both timer and photoreceptor. The pigment (phytochrome) exist in 2 forms (FR and IFR) and is known to regulate an array of physiological responses in plants, besides flowering. Light has at least two functions in photoperiodism: the photoperiod set the timer in some way, while a night break interact with the timer to induce (LRP) or prevent (SFP) flowering at certain times (Lüdke, 1922). SD plants require phytochrome or FR during the inductive dark period. While LD plants require the presence of IFR (Phytochrome) throughout the most diurnal cycle (Mans, 1975). FR for the induction of flowering in SD FR is required at certain times in the daily cycle (Mans, 1975; Thomas and Lüdke, 1984).

Mickel (1974) made it clear that it is difficult to explain the difference between SD and LD on the basis of phytochrome action alone. However, Uriti et al. (1965) could not find any red/or red photoreversibility in the spring weevil Lerna pascificostata
Impatiens walleriana cv. Ceres which involved in flowering one
is phytochrome and the other an unknown pigment with far-red,
green photoreversible properties.

Induction-reversal reactions and high irradiance reaction
are the two possible types of reaction distinguished in photo-
corticogenesis on the basis of different irradiation. The action
spectra of high-irradiance reactions are found to have resem-
blance to photosynthesis eg. Hudson et al. (1977) found that
high intensity light which induced flowering in Impatiens alta
are very much close to the level required for photosynthesis.
In Impatiens alta Evans (1975) and in Impatiens walleriana
Friend (1969) found that blue light was very efficient than
red and far-red for the induction of flowering.

Knitt (1934) was the first to demonstrate that perception
of the photoperiod takes place in leaves. Photoperiodic
induction acts over a certain distance which implies the movement
of a signal, the floral stimulus, from the site of production
to the site of action. Site of production is leaf and site of
action is shoot apex in case of flowering. Sachs (1979) and
Berger et al. (1961 a, b) reviewed recently the importance of
photosynthetic assimilation for the floral transition. Lang
(1965) distinguish four or six steps in the floral transition in
photoperiodically sensitive plants.

1. The induction of the leaf leading to the synthesis of the
floral stimulus.
2. The migration of the floral stimulus from the induced lead to the short apex.

3. The evocation of the apex.

4. The initiation and differentiation of floral primordia by the meristem.

The term photoperiodic induction is used for the process occurring at the short apex in response to the arrival of the floral stimulus and committing it irreversibly to the formation of flower primordia (Evans, 1969).

Events occurring at root apex:

Events occurring after the beginning of induction may be considered as part of evocation. The end of evocation is taken as the time at which the first morphologically distinct signs of flowering occur (Vince-Prue, 1975). The inception of flowering is a process of differentiation which involves a redistribution of sites of activity at the apex (Gufford, et al., 1971).

Plants apices are too minute and light and it is extremely difficult to study the sequence of development by biochemical estimations hence histological techniques are employed to study the sequence of development in short apex in response to the arrival of flowering stimulus.

Apical dome increases in size i.e in diameter/length just before flowering in most plants (Evans, 1969; Ferridge and Cockshull, 1972). But in few plants such as Perilla norkinensis (Coughenour, et al., 1964) and Lupinus lupulus (Thomas and
Schwabe, 1970) the apical zone clearly becomes smaller just before flowering.

Berrier (1971) discussed the significance of the shortening of the cell cycle and the increased complexity of meristems in apices during transition. The cytoblastological zonation pattern is usually lost on flowering (Cougarade, 1967). The distinction between the central and peripheral zones of apical meristems tends to disappear as IAA and ribosomes density increases throughout the apex (Cougarade and Bronner, 1965; Lin and Gifford, 1970). Modern plant shows zonation pattern i.e., juvenile corpus, central mother zone, peripheral zone etc. in short apices both in vegetative and reproductive conditions (Berrier, 1964; Urr, 1970 and Braker, 1973). Size and number of starch grains changes in the apical meristems during the transition to flowering (Berrier, 1971).

Increase in mitotic activity in *Sinapis alba* has been described as one of the initial steps of the sequential events in floral evocation (Berrier et al., 1974). Gifford and Groom (1971) observed an increase in total protein, IAA and IBA content during transition of apex from vegetative to reproductive condition. Berrier (1971) documented the sequence of events during evocation in *Sinapis alba*. There is a first peak in mitotic index at 24 h, when IAA synthesis is at a minima, and a second peak of mitotic index at 62 h when first flower bud begins to become visible. Nucleolus volume, citochromes and dicotylosome number were maximum at the time of second mitotic peak (Berrier et al., 1967).
Lavelange and Lembier (1974); Lavelange et al. (1974); Pryke and Lembier (1973a,b); Inoue and Inoue (1978); Inoue et al. (1972). *Lycopersicon esculentum* showed the first peak in mitotic index between 12 and 24 hours and a second peak between 42-44 hours (Carr, 1971). Height and width of meristems progressively increased after 24 hours. Banerjee and Ghose (1964) reported ultrastructural changes in tunica and corpus cells of shoot apex of *Nicotiana tabacum* during transition to flowering. Lembier (1982) studied the morphological changes in the apical bud of *Sinapis alba* in transition to flowering. Initial morphological changes at shoot apex right require early changes in the regulation of the expression of a few genes (Merker, 1965; Salisbury, 1963; Steele, 1968 and Stewart, 1962). Francis and Lynder (1976a) and Francis (1976b) suggest a possible significance of the initial cell cycle events in *Alnus* in transition to flowering from vegetative stage. Protein composition in the induced shoot apex differs from that of leaves and stems (Kahle, 1970, 1975; Pierard, 1975). Pierard et al. (1980) and Lynder et al. (1983) found new proteins in photoperiodically induced shoot apex which is abort in vegetative apex. Lynder et al. (1983) studied the changes in protein composition of (35) methionine labelled meristems of vegetative and evolved apex of *Sinapis* by using the techniques of isoelectric focussing and polyacrylamide gel electrophoresis and found that most of the differences were quantitative but few possible qualitative differences were also observed. RA contents were also found to increase after 1D
treatment (Lance, 1957), Gifford and Tepper (1962), Gifford (1963), Price and Evans (1963), Perrier (1970), Miller and Lydon (1977). Tressel et al. (1978) observed increased incorporation of $^{13}$ C into RNA immediately at the end of the critical dark period of 11.5 h, to twice that of in the vegetative plants kept in LD e.g. Pharbitis nil. A positive relationship between increases in the carbohydrate level of the shoot tip and flower initiation was established in photoperiodically induced and cold requires plants (Hidulph, 1935; Rodrigues Perera, 1962; Struveskaya and Krushelina, 1964; Sadik and Elsun, 1969). Increase in carbohydrate at the shoot apex is assumed to be the critical requirement for the transition from leaf to flower initiation (Izeh and Jockett, 1969; Labazko and Kukhla, 1970; Porto and Elsun, 1972).

**Process occurring in leaf:**

Flowering is a complex response to a variety of stimuli and interactions between environmental factors such as temperature and light as well as between light dependent processes such as photoperiodism and photosynthesis (Vince Prue, 1974). The leaf is the main site of the photoresponse for the control of flowering (Levart, 1984). Plants growing in different photoperiod shows variation in biochemical constituents of leaves (Vince Prue, 1975). Such physiological evidence has emphasized the importance of photosynthetic assimilation for the floral transition (Sadik, 1979; Isknder et al., 1981 a,b). But there is good evidence that some plants including Pharbitis (Friend,
1975; King et al., 1970). *Erasea* (Friend et al., 1964) and
Harley (Wältner and Keitzer, 1974) do not require the input of
energy from immediate photosynthesis for floral induction. The
role of photosynthesis in photoperiodic induction is therefore
mainly to provide an energy source for the synthesis or control
of promotors and inhibitors and their translocation from the leaf
or to provide some more immediate products of the intermediary
steps in photosynthesis that are essential for these processes
(Friend, 1974).

Electrophoretic analysis of proteins synthesized in the
leaves of *Xanthium* during a single inductive night showed no
consistent difference from those synthesized in non-inductive
leaves (Sherwood et al., 1971). Additional proteins component
was detected in the cotyledons of *Pharbitis nil* during induction
(Ota et al., 1970). Application of cyclohexamide on leaves at
the beginning or at the end of a 16 hour inductive night
inhibit flowering in *Xanthium* at a greater extent than at the
intermediate time (Loss, 1974). However other inhibitors of
protein synthesis does not inhibited flowering when applied to
leaf. Chloramphenicol and azinomycin analogues (Vince Prue,
1975).

Arase et al. (1970) reported the suppression of flowering
in *Pharbitis* when actinomycin D was applied to cotyledons.
5-Fluorouracil also inhibited flowering in *Pharbitis* and
*Xanthium* when applied to leaves (Leuert, 1962; lommer and
Leuert, 1962). However application of 2-M(2-thiouracil) to
leaves induced flowering in FD (Nichols and Far, 1969). Under inductive photoperiod, levels of IAA increased in stem and leaves of *Impatiens balsamina* while no change was observed in plants grown under non-inductive photoperiods (Kumar and Panda, 1961). Mumber of workers reported an upsurge in IAA content during induction (Heskser, 1993; Semler, 1970; Stiles and Davies, 1976).

Hidwell (1974) stated that higher level of chlorophyll, number and orientation of chloroplast and longer and thicker leaves with higher photosynthetic capacity are the plants adaptation to shorter light periods. Jordal (1958) observed reduction in chlorophyll content i.e., about 20-30 percent in *Lolium, Lupinus* and *Salvia* when it transferred to long day from short day. In *Lolium* (Jordal, 1958) found a variation in the ratio of chlorophyll a and b with photoperiod. But in *Lolium multiflorum* the ratio increased under short day (Heyss and Bourd, 1971).

*Floral stimulus:*

In 1931, Thallpyan postulated the concept of florogen the flowering hormone which is assumed to originate in leaf under inductive condition and move to the shoot apex where it manifest into flowers. Transmission of floral stimulus was demonstrated with various photoperiodic response type, interspecific and inter generic (Long, 1965; Beavart, 1976) certain plants like *Lolium, Silene, Bryophyllum* and greer *Petunia (Petunia eonoploides)* are capable of indirect induction which means that receptor shoots brought into flowering under non-inductive
conditions by grafting can themselves function as donors in the next grafting experiment (Zeewart, 1976). The floral stimulus in these species appears to have self-perpetuating properties whereas in red perilla (P. origanum) an induced leaf continues to produce floral stimuli indefinitely under non-inductive condition but the receptor shoot does not function as donor (Zeewart, 1976). But still the floral stimulus is only a physiological concept.

Chailakhyan (1957) modified his earlier theory under the impression of gibberellin as flowering hormone, and he believed that flowering is due to the combination of two complementary stimuli gibberellin and enthein. Gibberellin is a limiting factor in SD plants under long day and enthein is a limiting factor in LD plants under short days. Later on (Chailakhyan, 1977) suggested that GA is only a component of florigen and cannot induce flowering directly. But Lemmier (1976) and Hellensiek (1978b) disagreed with him that GA is one of the components of florigen, instead they suggested that cytokinin may be a part of florigen.

Deblocking of a specific flower forming GA resulted in floral induction in Silene aristata L. (Hellensiek, 1966, 1969). Appropriate photoperiodic treatment will deblock the gene which initiating the synthesis of floral hormone. Deblocking genes were considered to be responsible for inhibitors. Hellensiek's model of flower induction (Hellensiek, 1974) was reproduced in Fig. 2.
Fig. 2

A model for the process of flowering as proposed by bellens in 1976.

Note 'Cytokinin' as floral hormone.
Tentative general scheme of the mechanism of flower formation

(Starting at the top, from vegetative adult plants)
Relationship between photoperiodism and vernalization

Cold requiring plants show a large spectrum of interactions with photoperiodism (Chouard, 1960; Lapp-Enn, 1961, 1973; Parvis, 1961; and Lang, 1965). Interko et al. (1974); Surtet and Reid, 1973; Pressman and Legh (1965), found vernalization or photoperiodic requirement for the induction of flowering can replace or modify each other in a number of plants (Vince, 1914, 1976).

Parvis and Gregory (1973) found no vernalization in flaxus m. o. cernalis (1964) and laubnate and winter (1977) also observed no vernalization in some winter wheat varieties and in Bromy, winter barley respectively. Kellerenick (1953) found the similar phenomenon in laurusitis and at plant LD/LD treatment or cold treatment followed by LD can induce flowering. However a careful analysis lead Kellerenick to conclude that the two processes were different alternative mechanism leading to the same result.

In several plants LD (continuous light) and vernalization may substitute for each other: e.g. Conidiococcus columbiae, Campanula longifolia and St. cecopitana (after, 1960 a, b) and Pyrillia funaria (Kellerenick, 1966). Late flowering Pilgr matumen containing the late in shows similar type of responses (Larier, 1976; Kellerenick, 1969; Surtet and Reid, 1974; Reid and Surtet, 1975, 1977; Surtet, 1977; Terry and Linder, 1979; Reid, 1961). Kellerenick (1984) by means of 8D and light break interruptions showed that replacement of vernalization by LD was
a photoperiodic effect at least in _Fila e arvense_. Flood (1974) found that the process of vernalization and photoperiodism are physiologically interactive in controlling ear emergence in wheat.

**Photoperiodism after vernalization**

It has long been known that the manifestation of vernalization effects under various photoperiods depends upon the specific daylength requirements for flower initiation in the plants concerned. Most are LIP (Heller, 1970). Some are PP or DP. Hein et al. (1973) found that in certain cases vernalization and photoperiodic requirements are governed by different genes.

Photoperiodic treatment preceded by cold is the most common combination for the induction of flowering. Sugar-beet cv. Klein-wanziele (argava, 1963) and some winter wheat varieties (Taljova, 1973) required an absolute LP treatment after a specific period of vernalization whereas some plants show a quantitative LP requirement and are also able to flower under SD after longer vernalization although later (Taljova, 1973; Pierik, 1967a; Kühn and Stegler, 1969; Heller, 1973; Junger, 1973; Freeman and King, 1968). Certain LP plants require SD treatment in between vernalization and LP exposure for better performance e.g._Adonis pulicaria_ (Reutele, 1961).

**Lunaria pulicaria** (Reuter et al., 1974), the Argentine winter pelargonium (Rivera and Torres, 1963) and _Lunaria obtusifolia_ (Holtzowski, 1964, 1968). Whereas in some LIP critical daylength decreases when it is subjected to prolonged cold treatment
Cuthbertson, 1966; et al., 1962). *Cardamine pratensis* (Bierk, 1967b), *Apium graveolens* cv. Prasaky obrovsky (Tachesova and Brekule, 1975) and certain *Trifolium* varieties (Tanisova, 1967) behave as any neutral plants after vernalization while some other *Trifolium* varieties behave as FDR after vernalization (Kasor, 1957).

**Growth:**

Daylength modifies many aspects of vegetative growth of a plant besides flowering. Vegetative responses to daylength include dormancy and the phenomenon associated with it, and the formation of tubers and bulbs, leaf growth, stem elongation, rooting capacity, branching habit etc. Increased photosynthesis under increased daylength influences the degree and pattern of branching (Vince Prue, 1975). Friend (1966, 1969) found that increase in light duration and light intensity influence the rate of both photosynthesis and inflorescence development. Butls (1966) showed that photoperiodic influence on vegetative growth is independent of its influence on light energy available for photosynthesis. Lodson et al. (1977), Furian and Winter (1976) and Evans (1975) are of the opinion that photosynthesis and assimilation of photosynthates are important in growth and development of plant. For (1968) observed accelerated development and intensified growth with reduction in dry weight and seed production in Peas under continuous light. Any treatment which hastens flowering reduces the growth components (Chiray et al.,
1958 and Haslop Harrison, 1963). High temperature inhibits biosynthetic processes to a larger extent than the low temperature (Benchenko, 1974).

Light is necessary for photosynthesis, and hence for the growth of all green plants. Since photosynthesis account for the production of organic compounds and thereby increase the dry matter content, formation of new vegetative organs, the measurement of photosynthetic rate and the quantity of chlorophyll pigment give an idea of growth. Calculations of growth parameters like relative growth rate (RGR), leaf weight ratio (LWR), net assimilation rate (NAR) and leaf area index (LAI) are important tools to study growth and development of a plant under varied environments (Blackman, 1955; Gregory, 1926; Purvis, 1944 and Benchenko, 1974).

The concept of growth analysis has proved highly effective in studying a plant's relation to many environmental conditions. Growth of a single plant can be analysed more effectively in terms of dry matter increment per unit time and as a function of leaf area that is less than of crop growth due to factor beyond. LAI help to determine total dry matter production (Leopold and Friedmann, 1975). However, Ras and Pottersvik (1960) observed that LAI, LWR and NAR are more important in crop growth which influence yield. Leaf area is a more important determinant of plant growth than the photosynthetic capacity of individual leaves (Bisco, 1952). LAI like photosynthesis decline with leaf age (Grene, 1965). Grove and Evans (1964) and Hegg (1964)
Interpretation of increased LAS as the result of increased net photosynthesis. LAS express a plant’s capacity to increase dry weight in terms of the area of its assimilation surface. Fall in the total daily light period causes increase in leaf area ratio in most plants (Auger, 1965). Seeding vernalization accelerated the production of dry matter (Grom et al., 1959). Lehmann et al. (1959) observed that stem elongation, tillering and leaf production were more affected by differential vernalization and photoperiodic treatment of different varieties of wheat. Presowing chilling treatments to seeds induce enhancement in growth and yield especially branching and tillering in several crops (Anjum Singh, 1963, 1964). Reduction in light intensity causes modification in leaf morphology of *Citrus* and *Mung* bean so that growth can sustain but LAS was reduced in these plants. Leopold and Wiedemann (1975) observed that certain grasses could adopt short photoperiod by increased photosynthesis. LAS treatment causes increase in leaf area and greater stem elongation. In grasses the rate of tillering is more in SD than in LD (Starr et al., 1963). Branching habit is also influenced by daylength. *Cyperus longus* plants grow under SD lose apical dominance and the basal shoot gives a bushy appearance. Cameron andillard (1920) showed that plants grown under SD promote auxiliary shoot development. Long and Austin (1971).

Long photoperiod reduce the leaf number before flowering and increase the rate of leaf emergence (Driessen, 1965; Kirby and...
Plants growing in LD are usually taller with larger internodes and larger leaves (Vince Prue, 1975). Under LD, plants attain maximum height little earlier than DD and SD conditions (Vera, 1969; Blacker, 1973). Veriization and photoperiodic response together exert strong influence on leaf number (Rogers, 1958) and pod set number per ear (Pogats, 1960; Fiske and Lein, 1970).

Formation of storage organ depends on it is accelerated by exposure of leaves to particular photoperiods (Vince Prue, 1975). Experiments conducted by the h. during 1960-1 with graftings of tobacco varieties differing with respect to the nature of their photoperiodic response on South American species of potato (Solanum tuberosum, S. aurantiun, and S. polyadenium) shows that the photoperiodic conditions favourable for flowering of different species of potato are simultaneously the conditions favourable for emergence of the tuber formation stimulus in their leaves. Tuberization in potato appears to be hastened by DD treatment. Vince Prue (1975) stated that development of storage organ is also an inductive process like flowering. bulb formation in ability to withstand influence of day length and temperature, and is a qualitative LD plant.

wheat and their influence on yield. Several workers showed that long-day treatment hastened growth and development in oats
to presowing chilling treatment to seeds. Besides vernalization
and photoperiodic response a third factor, basic development
rate appears to exert an important influence on wheat development
(Flood, 1973, 1984). Khanna and Sinha (1975) reported the role
of pods in photosynthetic system in mustard and pea. Inamenga
et al. (1979a, 1979b) showed that in rape at the time of
flowering the main photosynthetic system is leaves, but at the
middle stage pods take over it, thus the pods supply the dry matter
required for the growth after it takes over the photosynthesis.
Sarg and Cliney (1964) stated that vegetative and reproductive
differentiation as well as growth and development are governed
by a common regulatory mechanism.