Introduction
Electromagnetic spectrum which are of bio-physical importance can be conveniently classified under four main titles, the ionising region, the ultra violet region, the visible region and the infrared region (Cassey, 1962). Wave lengths below about 10Å° are referred to as ionising radiation which include alpha, beta, gamma and x-rays, wave lengths from 200 nms to 400 nms are referred to as ultra violet radiation, and the visible region extends from approximately 400 nms to 740nms and is sub divided into various bands such as blue (470nm-500nm), green (500nm-560nm), yellow (560nm-600nm), orange (600nm-650nm) and red (650nm-760nm). The infra red region has wave lengths longer than those of the red end of the visible spectrum (Nobel, 1972). All photobiological behaviour of plants and animals such as photo synthesis, phototropism, phototaxis, photoperiodism, vision etc depend upon the visible part of the electromagnetic spectrum for excitation and regulation. An important example is photo regulation of seed germination, otherwise called photo blastism. Studies on photo regulation of seed germination began in the late nineteenth century and gathered momentum by the turn of the century. The effect of light on plant growth, differentiation and morphological development is termed photo morphogenesis. Light inhibits internode elongation, promotes leaf expansion (dicotyledons) or leaf up rolling (monocotyledons), promotes chlorophyll synthesis and chloroplast development and stimulates the synthesis of secondary products such as anthocyanin pigments. Light acts in morphogenesis as a specific environmental stimulus rather than as an energy source. The pioneers of the investigations showing the importance of light as a factor of germination at the end of the 19th and beginning of the 20th century are Cieslar (1983), Gassner (1915) and by Lehman (1913).
The quantum of light requirement for germination vary from plant to plant. Seeds of most cultivated plants germinate in the dark as well as in the light, while seeds of wild plants show greater sensitivity to light. In some species light requirement is needed only immediately after harvesting, eg Salvia pratensis, while in certain other species the effect of light is needed at least for an year, eg Epilobium parviflorum (Niethammer, 1927). Induction of light requirements was demonstrated by Toole (1959) for lettuce seeds of the variety Great Lakes. The seeds of Spergula arvensis and Stellararia media require light for germination only in the buried stage (Wesson and Wareing, 1969)

White light can affect germination in one of the two ways- it can stimulate germination, or it can inhibit germination. When germination is stimulated by light, the seeds are commonly said to be positively photosensitive. The type and amount of light energy required for germination varies from plant to plant. The most sensitive plants need only very small amount of light energy (eg:- Lactuca sativa and Lythrum salicaria), while other seeds require up to 24 to 48 hours continuous illumination Eg:- Epilobium (Shimogawara, 1954). In most light sensitive seeds, whether positive or negative in their light responses, the effect of a specific light treatment varies considerably with time of imbibition in darkness before application of light treatment. Photosensitivity of lettuce Var, Grand Rapids seeds in relation to imbibition was observed by Evanari and Newmann (1953). A clear peak of photosensitivity occurs after approximately 8 hours imbibition, followed by a steady decline in sensitivity. The relationship between the times of imbibition and photosensitivity are different for different seeds. Using the same variety of lettuce seeds Ikumma and Thimman (1954) have observed different results when they used red light. These different results may be due to differences in the conditions under
which the two batches of seeds matured on the mother plant or to differences in storage conditions. Another possibility is that white and red light act slightly differently.

The germination of photosensitive seeds in darkness and under light treatments, can be modified by temperature. Eg: Lettuce Var. “Grand Rapids” is a light requiring seed but its photosensitivity varies according to temperature. The seeds germinate in total darkness at normal experimental temperatures of 20° to 25°C (Al-Baghadi and Smith, 1975). At higher temperature dark germination falls off, and the seeds become light requiring. At even higher temperatures germination is prevented completely both in the dark and light. In 1950, Toole showed the interaction of light response of seeds with temperature for seeds of Lepidium virginicum. The main photoreceptor pigment for photo morphogenic reactions is Phytochrome. Two types of photomorphogenic responses are recognised, the low energy reactions and the high energy reactions (Hendricks and Borthwick, 1950). The existence of pigment called phytochrome was first deduced from studies of a typical low energy reaction (or induction reversion response). The seeds of certain varieties of lettuce, which need light for germination are induced to germinate by exposure for a few minutes to red light (peak activity at 660 nm) of low irradiance level. A similar dose of far red light (peak activity at 730 nm) is inhibitory to germination, and the effect of a red light exposure is negated by an exposure to far red light. Alternating exposures of red and far red light can be given for many cycles and whichever wave length is given last determines the response. These observations led Hendricks and Borthwick in 1950's to postulate the existence of a photoreceptor named Phytochrome in 1959, existing in two photo reversible forms. One form, Pr, absorbs red light at 660 nm, and is thereby converted to the second form, Pfr,
active in promoting germination in lettuce seeds. Pfr, shows peak absorption in the far red, and under far red illumination it is converted to Pr again:

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\text{Pr} \xrightarrow{660 \text{ nm}} \frac{730 \text{ nm}}{\text{Pfr}}
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Phytochrome, which is a blue green chromoprotein, in solution shows photoreversibility between the Pr and Pfr forms, with absorption maxima at 660 and 730 nm respectively. It is universal in green plants. The presence of phytochrome in seeds and properties of phytochrome at the molecular level, are now well known (Pratt, 1982; Quail et al. 1983). With specially designed spectro photometers, absorption by phytochrome is directly observable in etiolated tissues where it is not masked by chlorophyll. The active form Pfr may be unstable in plant tissues. The only other spectral region known to have an effect on germination is the blue region (400 nms – 500 nms) (Small et al., 1979). Blue light has been reported to inhibit germination in the normally light stimulated lettuce var. Grand Rapids and in the normally light inhibited Nemophila insignis (Small et al., 1979). Later they found that blue light can be either stimulatory or inhibitory to the germination of lettuce seeds, depending on the duration of imbibition prior to light treatment. Evidence that blue light may operate through phytochrome was obtained by Black and Wareing in 1958.

Photo inhibition of germination was shown by many seeds which germinate in the dark and are inhibited by irradiation with white light, eg.: Amaranthus caudatus, Nemophila insignis and Phacelia tanacetifolia (Rollin and Maignon, 1967; Rollin, 1968).

This inhibition by white light is usually due to the FR irradiation and due to the inter conversion between the two pigment forms (Bartley and Frankland, 1984). The way in
which the active form of phytochrome brings about its effect on germination is still unclear. But the evidence for phytochrome being on or near a membrane is clear and molecular models have been constructed to explain how it could change ionic channels in a membrane (Mayer, 1986). The response of seeds to light is modified by various internal and external factors. Osmotic stress, the presence of growth promoters or growth inhibitors, the oxygen tension and other factors, all can change the duration and intensities of light required to evoke a certain response (Mayer, 1986).

Whether photoblastic or non photoblastic, the metabolism of germinating seeds is amphibolic, i.e., it is both catabolic in the sense of degrading reserve compounds to provide energy and raw materials for the early growth of the seedling and anabolic in the sense of producing machinery for protein synthesis and biogenesis of various organelles needed for the catabolic activity as well as the true anabolic synthesis of new cells and tissues. Germination incorporates those events that commence with the uptake of water by the quiescent dry seed and terminate with the elongation of the embryonic axis (Bewley and Black, 1994). The visible sign that germination is complete is usually the penetration of the structures surrounding the embryo by the radicle; subsequent events, including the mobilisation of the major storage reserves, are associated with growth of the seedling. Uptake of water by a mature dry seed is triphasic, with a rapid initial uptake (phase I), followed by a plateau phase (phase II) and further increase in water uptake occurs only after germination is completed. The influx of water into the cells of dry seeds during phase I results in temporary structural perturbations, particularly to membranes, which lead to an immediate leakage of solutes and low molecular weight metabolites into the surrounding imbibition solution. This is due to the transition of the membrane
phospholipid components from the gel phase achieved during maturation drying to the normal, hydrated liquid crystalline states (Crowe and Crowe, 1992). Within a short time of rehydration, the membranes return to their more stable configuration, at which time solute leakage is curtailed.

On imbibition, the quiescent dry seed rapidly resumes metabolic activity. The structures and enzymes necessary for this initial resumption of metabolic activity are generally assumed to be present within the dry seed. Reintroduction of water during imbibition is sufficient for metabolic activities to resume. One of the first changes upon imbibition is the resumption of respiratory activity which can be detected within minutes. After a steep initial increase in O₂ consumption, the rate declines until the radicle penetrates the surrounding structures. At this time, another burst of respiratory activity occurs (Botha et al., 1992; Bewley and Black, 1994). The glycolytic and oxidative pentose phosphate pathways both resume during phase I, and the Kerb’s cycle enzymes become activated (Nicolas and Aldasoro, 1979; Salon et al., 1988). Tissues of the mature dry seed contain mitochondria, and although these organelles are poorly differentiated as a consequence of maturation drying, they contain sufficient Kerb’s cycle enzymes and terminal oxidases to provide adequate amount of ATP to support metabolism for several hours after imbibition (Ehrenshaft and Brambil, 1990; Attucci et al., 1991).

During germination of seeds, there appear to be two distinct patterns of mitochondrial development, which are obvious in cotyledons, depending on the nature of the stored reserves. In starch storing seeds, repair and activation of pre existing organelles predominate, whereas oil-storing seeds typically produce new mitochondria (Morohashi and Bewley, 1980; Morohashi, 1986). For example, the biogenesis of mitochondria in
germinating maize embryos (which store oil in the Scutellum, although starch is the major endosperm reserve) involves the synthesis of cytochrome C oxidase subunits encoded by the organellar genome, which is followed within hours by the synthesis of nuclear-encoded subunits (Ehrenshaft and Brambl, 1990). This implies the coordinated regulation of mitochondria and nuclear genomes in plants begins during the early stages of germination. The metabolic changes occurring in the early stages of germination are the result of the activity of various enzymes, which are either present in the dry seed or very rapidly become active as the seed imbibes water. Enzymes breaking down starch, proteins, hemicellulose, polyphosphates, lipids and other storage materials, rise in activity as germination proceeds.

The main storage carbohydrates are starch, oligo- and poly saccharides of the cell wall and soluble sugars. Seeds usually contain both amylase and amyllopectin organised in the starch grains. Starch is broken down by alpha and beta amylases, but only some of the alpha amylases are capable of attacking the native starch grains of cereals (Halmer, 1985). Dry seeds contain mainly β amylase, as in dry Zea mays seeds. The rise in amylase activity in the seed during germination is primarily in alpha amylase which, when amylolytic activity is at its peak, accounts for 90% of total amylolytic activity of the endosperm (Marshall 1972). Attack of starch by alpha amylase results in a mixture of sugars, maltose and glucose. The enzymes involved in breakdown and synthesis of starch in cereals have been reviewed by Marshall (1972) and Halmer (1985). Breakdown of starch in peas was shown by Swain and Dekker (1966) which follow the path way:
The changes in the enzymes involved in starch breakdown during the germination of peas showed that low activity of beta amylase was present in the dry seed, but no alpha amylase activity could be detected. The activity of both these enzymes began to increase only two days after the onset of imbibition (Shain and Mayer, 1968; and Swain and Dekker, 1966). Two distinct phosphorylases, I and II were shown to be present in a number of seeds including peas. Their level did not change at the same rate, phosphorylase I apparently increasing more rapidly. Both phosphorylases were able to catalyse glucan formation from suitable primers, as well as the phosphorolytic breakdown of starch (Matheson and Richardson, 1976).

Gibberellin is the growth substance controlling the initiation of synthesis of hydrolytic enzymes. In some seeds including peas, cytokinins are also involved. Gibberellic acids (GA) are known to obviate the requirement of seeds for various environmental cues, promote germination, and counteract the inhibitory effects of abscissic acid (ABA), frequently in combination with cytokinins (Bewley and Black, 1982; 1984). In seeds of a very few species, there is an increase in GA content in response to an external stimulus (Hilhorst et al., 1986; Karseen et al., 1989). In Phaseolus vulgaris seeds alpha galactosidase activity is high in the embryo and low in the cotyledons of the dry seeds. During germination its activity falls in the embryonic axis and rises in the cotyledons (Lechvallier, 1969). The cell walls of the endosperm of lettuce are
impregnated with galacto-mannans and mannans which are broken down by the enzymes beta-mannanase and beta-mannosidase (Bewley and Halmer, 1980). The presence of invertase has been demonstrated in a number of germinating seeds, for example barley (Prentice, 1972) and lettuce (Eldan and Mayer, 1974) which is responsible for sucrose breakdown. It is probable that part of the sucrose is metabolised by glycosyl transfer reactions (Pridham et al., 1969). In Phaseolus seeds malonic acid is formed during germination, which after five days of germination are found in the embryonic axis (Duperon, 1960). Most of the enzymes involved in the breakdown and the interconversion of carbohydrates become active during germination, most by de novo synthesis, some by activation or release.

The lipids are generally present in special organelles referred to as lipid bodies or spherosomes. Lipid bodies contain part or all of the enzymes required for the breakdown of lipids to fatty acids and glycerol, which is the first step in lipid breakdown and is carried out in a step wise manner by lipases. Fatty acids undergo beta oxidation, while the glycerol becomes part of the general carbohydrate pool present in the seed and as such becomes available for various processes including respiration. In Arachis cotyledons enzyme systems have been shown which convert glycerol to glycerol phosphate which is then converted to triose phosphates. This can then be either converted to pyruvic acid or to sugars (Stumpf and Bradbeer, 1959). The bulk of fatty acids formed following lipase action are broken down by the process of beta oxidation, resulting in the cleavage of two carbon units in the form of acetyl co A and ATP. Beta oxidation was showed to occur in extracts of various seeds (Rebeiz et al., 1965).
In many seeds disappearance of lipids is accompanied by the appearance of carbohydrates. But lipids are not always converted to carbohydrates during germination. Boatman and Crombie (1958) and Crombie and Comber (1959) followed lipid breakdown in two different seeds, Citrullus vulgaris and the oil palm Elaeis guineensis. In Citrullus lipids are rapidly broken down both in the cotyledons and the rest of the seed and the breakdown products utilized in respiration. There does not appear to be conversion to carbohydrates.

The lipid bodies are surrounded by a membrane. Initial breakdown of lipids is by the action of lipases, and some lipase activity may be assumed to be associated with this membrane (Huang and Moreau, 1978). There are several lipases present in seeds, which differ in the pH optimum for their activity. Lin et al., (1982) showed that in homogenates of soybean cotyledons three different activities of lipase can be demonstrated – an acid lipase with a pH optimum of 4.9, a neutral lipase with an optimum between pH 6.0 and pH 7.5 and an alkaline lipase with an optimum at pH 9.0.

Lipase activity changes during germination and the course of the change differs in different parts of the seed (Yamada, 1957). In castor beans (Ricinus communis) lipase activity in the embryos reaches a peak after 24 hour germination, while in the endosperm it only begins to increase after about 50 hour. The sub cellular location of lipase varies in different seeds. In rape and mustard cotyledons it is associated with lipid bodies (Lin and Huang, 1973; Lin et al., 1983). In soybean cotyledons the alkaline lipase is apparently associated with glyoxysomes and the neutral one with the lipid bodies (Lin et al., 1982).

There is a great amount of diversity in lipase activity from the point of view of pH optimum, substrate specificity and tissue and sub cellular location. The presence of a
lipase inhibitor, which is a protein have been demonstrated in sunflower seeds (Chapman, 1987).

The storage proteins of most seeds are found in well defined organelles, the protein bodies, which are small membrane bound particles between ½ to 10 nm in diameter which, in addition to proteins, also contain phytin. The protein bodies are vesicles derived from the endoplasmic reticulum in which proteins are deposited during seed formation and maturation. During germination the storage proteins are broken down and the protein bodies empty, their membranes remaining intact, eventually give rise to vacuoles (Ashton, 1976; Pernollet, 1978). The sequence of breakdown of protein bodies in some of the cereals differs from that in seeds of dicotyledonous plants (Pernollet, 1982). Breakdown of storage proteins in the cotyledons is accompanied by the appearance of new proteins in other parts of the seedling. Seeds contain a variety of proteolytic enzymes some of which are present in the dry seeds while others appear during germination. The proteolytic enzymes can be divided into proteinases and peptidases depending on the size of the molecule which is attacked. Peptidases are usually divided into the endo peptidases and the exopeptidases (carboxy peptidases and amino peptidases), depending on the site of the bond in the protein molecule which is attacked. In most cases the enzymes having proteolytic activity are soluble and are present or develop in the storage organs, i.e., in the cotyledons or the endosperm.

The proteolytic enzymes and peptidases of germinating seeds show great diversity with regard to their specificity for peptide linkages, their pH optima and their response to inhibitors (Mayer and Marbach, 1981; Muntz et al., 1985). The enzymes, responsible for proteolytic breakdown, initially present in the protein bodies may be synthesised, or
activated in the protein bodies themselves. The protein bodies of the seeds of Vigna radiata contain a number of hydrolytic enzymes. However during germination the storage protein vicilin is not broken down until an additional endopeptidase (Vicilin peptidohydrolase) is synthesized de novo in the cytoplasm and transported to the protein bodies (Baumgartner et al., 1978). In Phaseolus vulgaris two alkaline peptidases which are present in the cotyledons of the dry seed, do not become active during germination, while the activity of three acid peptidases and proteinases which are also present in the dry seeds rises during germination (Mikkonen, 1986).

Although many questions are still open with regard to the detailed mechanism of protein metabolism during germination, there is some information about the fate of breakdown products. During germination, proteins are broken down to amino acids, part of these amino acids are oxidatively deaminated and the carbon skeleton enters into various respiratory and carbon cycles. The ammonia formed by deamination is detoxicated by the process of amide formation. The chief amides formed are glutamine and asparagine depending on the plants (Chibnall, 1931; Lea and Joy, 1983). Germinating seeds usually contain enzymes causing hydrolysis of the amide bond, glutaminase and asparaginase. Asparaginase has been shown to be present in many developing seeds and its activity is dependent on potassium ions (Sodek et al., 1980). Liberation of ammonium from asparagine by asparaginase led to the formation of amino acids.

Dry seeds contain very little free amino acids. The growth of the embryo in the germinating seed is dependent on a supply of amino acid for its protein synthesis. The amino acid pool increases during germination in lettuce seeds (Klein, 1955). The main source for these amino acids is the storage protein, but its amino acid ratio need not
necessarily be the same as that of the newly synthesized seedling protein and inter conversion of amino acids occurs. For eg:- transamination and deamination reactions.

Glutamine has a special role in this. Virtanen et al., (1953) have shown that in germinating pea seeds, homoserine, which is absent in the dry seeds is synthesised during the first 24 hour of germination. Arginine is also synthesised de novo in germinating peas (Shargoal and Cossins, 1968). The synthesis and inter conversion of amino acids are apparently the same as in other plant tissues and proceed the same pathways (Forest and Wightman, 1971, 1972, Miflin and Lea, 1982, Lea and Joy 1983).

Higher plants contain two predominant types of chlorophylls – chlorophyll _a_ and chlorophyll _b_. Chlorophylls absorb light near both ends of the visible spectrum-the blue and the red light and transmit green light. All photosynthetic organisms have other pigments that absorb light between the red and blue region of the spectrum. In higher plants, these are mainly carotenoids. The yellowish to orange pigments absorb primarily in the violet to blue region of the spectrum and transfer it to chlorophyll for use in photosynthesis. Chlorophyll synthesis can not proceed in the absence of light.

The present work is an attempt to study the positive effects and actions of the visible spectrum on germinating seeds of green gram ( _Vigna radiata_) and horse gram ( _Dolichos biflorus_) belonging to the pulses family. Experiments were conducted in the germination phase of these two seeds under different wave lengths of light namely blue (470nm-500nm), green(500nm-560nm), yellow (560nm-600nm), orange (600nm-650nm) and red (650nm-760nm). White light was used in the above experiments as the control.
Experiments were conducted in the four different sets of exposures on the above two seeds and the germination behaviour noted.

I Set: This set constitutes the duration of 6 hours exposure of chosen wavelengths only and 18 hours darkness.

II Set: This set constitutes the duration of 12 hours exposure of chosen wavelengths only and 12 hours darkness.

III Set: This set constitutes 18 hours exposure of chosen wavelengths only and 6 hours darkness.

IV Set: This set constitutes continuous exposure to chosen wavelengths without any interruption.

In all the four sets, experiments were carried out in two lots.

In the first lot of the experiments the morphological effects during germination process such as percentage of germination, average weight of the seedlings on each day with the above time intervals and chlorophyll content were studied. In the second lot of experiments, the biochemical responses of the germinating seedlings such as total protein content, asparaginase activity, amylase activity and lipase activity were studied.

What is the rational in choosing these parameters? What objectives, precisely, do you intend to achieve by this random selection?