REVIEW OF LITERATURE

Pulses are the second important groups of crops after cereals. Pulses have contributed significantly in providing nutritionally balanced food for predominantly vegetarian population in India. Presently, pulse production has remained around 13-15 million tonnes while annual domestic demand has risen to 18-19 million tonnes. This shortfall in pulses is mainly due to near stagnation in production at 13-15 million on account of poor spread of improved varieties and technologies, abrupt climate changes, complex weed pest disease syndrome and declining factor productivity. In order to narrow down the demand supply gap, the country resorts to import of pulses to the tune of 3-4 million tonnes every year. In order to ensure self-sufficiency, a paradigm shift in the research and technology generation is required (Shanmugasundaram and Arros 2009).

India is the largest producer and consumer of pulses in the world contributing around 25-28% of the total global production. The production of total pulses is presently about 15 million tons covering an area of about 22-23 million hectares, majority of which is falling under rain-fed, resource poor and harsh environments frequently prone to drought and other abiotic stress conditions. Due to stagnant production, the net availability of pulses had come down from 60g/day/person in 1951 to 33g/day/person at present (Amarender Reddy 2009).

Mungbean and Urdbean are grown in Kharif (monsoon), winter and spring/summer seasons in different agro-ecological regions. These two crops have strategic positions in South East Asian countries for nutritional security and sustainable crop production. Being rich in quality protein, minerals, and vitamins they are inseparable ingredients of in the diets of the vast majority of Indian population. When supplemented with cereals they provide a perfect mix of essential amino acids with high biological value. These crops have the ability to fix atmospheric nitrogen (58-109 kg/ha in Mungbean and 55-140 kg/ha in Urdbean) in symbiotic association with Rhizobium bacteria, which enables them to meet their own nitrogen requirements. Outside of Asia, Mungbean is grown in Australia, East Africa, the United States, Western South America, and the Caribbean region. The major Mungbean-exporting countries are Thailand and Australia, but Mungbean is frequently exported from Burma, China, India, Kenya and Peru (Handbook of Agriculture 2009).
Mungbean and Urdbean Crops are grown as sole crop or as inter crops with sugar cane, cotton, groundnut, sorghum, maize, pearl millet and pigeonpea during Kharif or sole relay crop in rice fallows during winter and a sole catch crop during spring/summer seasons. The phenology and morphology of these crops are extremely plastic depending on the genotype, growing seasons and ecological regions.

Short duration varieties of Mungbean and Urdbean maturing 60-70 days with the yield potential 8-10q/ha have been developed for different states. Mungbean and Urdbean varieties suitable for Rabi season have been developed. Potential of summer Mungbean/Urdbean has been realized in terms of productivity and economic returns. The agronomy of these crops had been worked out, according to which 25 March for spring season Mungbean/Urdbean and 10 April for summer Mungbean have been found ideal for planting 10 kg N and 30 kg P₂O₅ per hectare when planted after wheat, mustard, sugarcane and no fertilizer application when planted after potato had been recommended (Ali and Kumar 2006).

The Indian Indo-Gangetic plains can also be divided on the basis of crop production pattern:

1. Western IGP, comprising Haryana, Punjab and parts of Uttar Pradesh (northern, central and western) which is largely dominated by rice-wheat cropping system (RWCS).
2. The eastern IGP, comprising eastern Uttar Pradesh, Bihar and West Bengal, which is largely dominated by rice-based cropping systems. About 1 million hectare of pulse crop area has been substituted by other crops (largely rice and wheat) during the past few decades in the Indian IGP. The decline in area is largely attributed to relatively higher profitability of rice and wheat in comparison to pulses (NAAS 2010).

Mungbean is a minor legume in the Indian IGP and occupies only about 8% of the total legume area. About 60% of the Mungbean is grown in Bihar (largely the northern part) and more than 25% in Uttar Pradesh (mostly in western part). The two states of India contribute about 17% of the total Mungbean production in India. Mungbean area in Bihar, Haryana and Punjab has risen in the past few decades while it has fallen in Uttar Pradesh and Bengal. Yield levels are much higher in Punjab in the Indian IGP than in other states. About 80% of the Mungbean is sown in the Kharif (rainy season).
Urdbean crop covers about 0.5 million hectare in Indian IGP. The crop is mainly confined to Uttar Pradesh (0.3 m ha), followed by West Bengal and Bihar. Blackgram is more prevalent in the eastern part of the Indian IGP. Its area has increased in Uttar Pradesh and West Bengal from the year 1985 onwards. This part of the country contributes about 17% of the total blackgram production in India. Yields of blackgram are low, at around 0.5 tonnes/ha but with the gradually increasing trends overtime.

The Indo-Gangetic Plains (IGP) of northern India once been the pulse basket of India, is showing declining trends in area which is quite heavily displaced by rice, wheat and maize due to better irrigation facilities. It is serious concern for sustainability of agro-ecosystem of northern India. In north India, rice-wheat crop rotation is predominant, and there is little scope for replacing wheat with rabi pulse crops; while in south India, there are vast patches of rice fallows, which can be utilized for sowing rabi pulse crops, as there is no strong competitive crop in the rabi season (Ali and Kumar 2006).

Eventhough, a warm, well-drained loam or sandy loam soil is desired for obtaining highest yields in Mungbean and Urdbean, both are grown on a wide range of soils at present. The recommended fertilizer dose is 10-15 kg N, 20 kg P₂O₅, 20 kg K and 20 kg S/ha. Use of Biofertilizer improves the soil and crop performance. Foliar spray of 2% urea at flowering enhances grain yield under rain-fed conditions and also in rice fallows.

Urdbean is cultivated mainly as Kharif crop almost in all states. In northern plains, it is also cultivated during spring as a catch crop. It needs relatively heavier soils than Mungbean. Well-drained, moisture retentive, deep loam soils free from excessive soluble salts and sodocity is ideal. Blackgram is not suitable for summer cultivation due to its long duration (Handbook of Agriculture 2009).

Summer/Spring Mungbean and Urdbean require special N Management. The area under summer Mungbean in the Indo-Gangetic plains is increasing to diversify the rice wheat system and to improve the soil health and sustainability. Mungbean grown during this season is exposed to severe at times as high as 48degress. Under such conditions, the nutrient uptake efficiency of the crop and Rhizobium activity are badly affected which ultimately influence the yield. Hence, Spring/Summer crop suffer low availability on nitrogen. Several studies revealed that 10-20 Kg
N/ha as starter dose is essential for Mungbean and Urdbean at the time of sowing. This is due to the required for nodules to develop on young plants and to the slow growth of Mungbean plant in the first few weeks following the emergence as reported by Kuo et al (1978). Nitrogen application after this need will depress or inhibit Rhizobial activity and nitrogen fixation. Nitrogen fertilization of Mungbean at the pod-initiation or pod-filling stage may be beneficial. Nitrogen applied at 15 kg/ha at pod initiation stage increased seed yield by 18%, whereas nitrogen applied at pre-flowering stage increased vegetative growth only (Sekhon et al, 1987). Mitra et al (1988) reported that maximum seed yield of Mungbean requires a long pod filling period which, in turn, utilizes an abundance of nitrogen. Park (1978) recommended a side-dressing of 15 Kg/ha ammonium sulphate at the flowering stage for higher yields. Imsande and Edwards (1988) reported that Mungbean seeds represent approximately 25 % of the total plant dry weight and contain 45 % of the total plant Nitrogen.

Arya and Kalra (1988) fertilized Mungbean on a sandy soil in Uttar Pradesh over a period of two years, with 20 Kg N/ ha. 40 Kg K2O and four levels of P2O5 (0, 25, 50 and 75 Kg/ha). The highest increase in grain yield was obtained at the 50 Kg P2O5/ha level resulting from optimum in each of the primary yield components- pods per plants, seeds/pod, seed weight, and also nodule number.

Multi location trials conducted in farmers field under AICPIP programme had shown that the mean response to each kg of phosphorus applied at 13 kg P/ha is 1.6 and 3.0 kg grains in Mungbean and Urdbean, respectively (Prasad, 1979). Sarkar and Banik (1991) found significant improvement in seed yield and nodulation of Mungbean with the application of 26 kg P/ha under west Bengal conditions.

Soils of pulse growing regions of India show variable Potassium (K) status. Potassium application is almost negligible in crops like Mungbean and Urdbean (Ali and Srinivasarao, 2001; Yadav et al., 1993; Srinivasarao et al., 2003). Potassium deficiency has not been considered to be a serious problem where Mungbean is most widely grown.

Grain yield increases were obtained in pot experiment with alluvial soil from Uttar Pradesh, when potassium fertilization was combined with small applications of zinc (Singh and Badhoria 1984).
Arora and Luthra (1971) reported a positive correlation between sulphur content of Mungbean leaves at various growth stages and contents of the sulphur containing amino acids-methionine, cysteine in Mungbean seeds. In plant metabolism, sulphur and nitrogen are associated with chlorophyll formation and activation of nitrate reductase. Liming increases soil pH which in turn increases availability of phosphorus and molybdenum and diminishes toxic levels of aluminium, manganese, iron, zinc. Deficiencies in calcium (molybdenum and boron as well) will adversely affect the nitrogen-fixation activity in Mungbean.

In Mungbean, the amount of nitrogen, phosphorus and potassium in the stem and leaves was highest during the vegetative phase of the plant development and decline during flowering and harvest (Thandapani 1985). This reflects a transfer of these elements from vegetative into reproductive structures and eventually storage in the seed. Nitrogen, phosphorus and calcium are higher in the leaves than in the stem in all stages of development, but potassium content of the stems exceed leaves. Calcium in stems increased from vegetative to harvest stage, but calcium in reproductive parts declined sharply from flowering to the harvest stage and averaged only 1.7 mg/g in seeds. Various other mineral element essential in plant growth, generally categorized as microelements, include boron, copper, iron, magnesium, manganese, molybdenum, sulphur and zinc (Poehlman 1991; Singh and Singh 1983).

Seed proteins of Mungbean and Urdbean have low concentrations of sulphur containing amino acids, methionine and cysteine. However, Urdbean is reported to have higher methionine content as compared to Mungbean (Santalla et al., 1998). Urdbean is also known to have digestible sugars such as raffinose and stachyose. The sugars are fermented by certain bacteria that are present in the intestinal tract of digestive system resulting in flatulence. The germinated grains have higher nutritional value compared to asparagus and mushroom (Srivastava and Ali, 2004). With sprouting there is an increase in the concentration of thiamine, niacin and ascorbic acid (Kylen and McCready 1975).

Recently, deficiency of sulphur has emerged a common constraint in several parts of the country. The deficiency of sulphur in pulse crops is more deleterious than cereals. In multi location trials under AICPIP during 1991-94, Urdbean and Mungbean showed significant response up to 20 kg S/ha. From the above studies, it is clear that these crops require 10 kg N, 30 kg P₂O₅ and 20 kg S for optimum yield.
The symptoms of micronutrient deficiencies in Mungbean were described and illustrated by Smith et al. (1983). Micronutrients that have received attention include molybdenum (Paricha et al., 1983, Velu and Savithri, 1983); Sulphur (Mehta and Singh, 1979; Jones et al., 1982) boron (Howeler et al., 1978) and iron (Bassiri et al., 1979). Application of Zn, Bo, Mo, and iron under deficient conditions is beneficial in increasing the yield in different pulse crops but neither all the micronutrients nor their use in Urdbean and Mungbean have been tried for yield increases (Ali and Kumar 2006).

The rhizobial strains that nodulate mungbean and urdbean were identified as the cowpea cross inoculation group and taxonomically classified as _Bradyrhizobium_ sps. (Vigna). Rhizobial strains of _Bradyrhizobium_ that infect _Vigna_, Glycine or Lupinus have not been given species designations, instead they are designated by their genus name followed by the genus of plants that they infect. _Bradyrhizobium_ sps. (Vigna) Mung or _Bradyrhizobium_ sps. (Vigna) Urd may be nodulated by a wide range of strains of “cowpea type” rhizobia presented in sub-tropical soils (Poehlman 1991). Prasad and Ram (1984) also found that inoculation with two combined cultures to be more effective than inoculation with single culture only, as measured by increased weight of Mungbean nodules, dry matter, and crude protein. Singh et al., 1985 reported that nodule number, nodule volume, and nodule dry weight, were controlled by both additive and non additive gene effects.

Sub-tropical environments where Mungbean is mostly grown are generally less favourable for nodulation than temperate environments. High soil temperatures restrict nodulation and nitrogen fixation. Cowpea, which nodulates with same group of strains as Mungbean, nodulates best and fixes the most nitrogen with a day temperature of 24°C. Nodulation decreased as day temperatures were increased or reduced from 27°C. Rhizobial strains differ in their effectiveness at high temperatures. An upper temperature limit of around 36°C was noted for nodulation in beans and soil temperature of 32°C or above to be harmful for nitrogen fixation in beans. In soils, where day temperature frequently exceeds 45°C to 50°C for seven hours daily, rhizobial populations and nodulation could be severely restricted (Date, 1977; Dart 1973; Grahm and Halliday 1977; Hernandez-Armenta et al., 1989).

Soil moisture stress limit root development and vegetative growth and hinders effective nodulation and nitrogen fixation. Water is required for maintaining turgidity of tissues in nodule
and for transport of the product from nitrogen fixation. Water stress reduces nodulation, the activity of existing nodules, nitrogen fixation. Water stress created by withholding irrigation water to Mungbean plants decreased leaf water potential and nodule moisture content and interferes with enzyme activity associated with ureids synthesis and transport (Masefield 1961; Kaur et al., 1985). Excess water reduces the oxygen supply in the soil required for respiration of rhizobial bacteria and reduces the nitrogen supply required for nitrogen fixation. A soil moisture content of 50% of the soil dry weight was optimum for nodule number and nodule dry weight in Mungbean. A pH of 6.5 appears to be optimum for Mungbean rhizobial activity, with a minimum for activity of about 3.5 to 4 (Yadav and Vyas, 1971; Varma and Rao, 1975).

Arhar Mosaic Virus (AMV) of Mungbean reduced nodule number, weight and size in Mungbean (Singh and Mall, 1974). Common Bean Mosaic Virus (CBMV) enhanced content of nitrate nitrogen and total amino acid but decreased nitrogenase activity and leghaemoglobin content (Chowdhury et al., 1987). Seed exudates from Mungbean that were phenolic in character had an inhibiting effect on rhizobial growth (Dadarwal and Sen, 1973; Kandasamy and Prasad, 1979). Root nodulation may be adversely affected by accumulated pesticide residues, or pesticides applied at excessive rates (Gaur and Varshney, 1974; Staphorst and Strijdom, 1976; and Chaudhury et al., 1977). Nematode Meloidogyne icognita infestation reduced the root weight, nodule number, and nitrogen content (Chahal et al., 1985).

Rhizosphere micro-organisms like Azotobacter, Azospirillum, Phosphate Solubilising Bacteria (PSB) and Plant Growth Promoting Rhizobacteria (PGPR) are known to improve BNF by enhancing nodule number, biomass, and nitrogenase activity and suppressing growth of deleterious organisms Combined inoculations showed synergistic effect on nodulation, leghaemoglobin content, nodule occupancy and grain yield as compared to single inoculation of Rhizobium in Mungbean and Urdbean. Development of common inoculants with beneficial rhizobacteria in consortia with Rhizobium is essential for easy delivery in fields. Selection of efficient strains of such microorganisms having synergistic interaction and compatibility in broth and carrier is essential to develop inoculants having consortia of microbes useful to BNF (Tomar et al., 1993; Gupta et al., 1998; Sindhu et al., 2002; Acharya and Biswas, 2002; Prasad et al., 2002; Chandra and Pareek 2002).
Nematicidal potential of various parts and products of neem is well established and reviewed by different scientists. It is traditional practice in some parts of India to use neem products, particularly neem cake as soil amendent for its manorial value as well as for the control of soil borne pathogens including nematodes. The age old practice triggered the idea of using neem products for the management of plant parasitic nematodes and by a systematic neem research in nematology started in 60’s (Alam, 1989; Mojumder & Mishra, 1993).

Singh and Sitaramaiah (1970) and Khan et al., (1979) were first to report bioactivity of neem cake against root knot nematode, *M. icognita* on okra. Water soluble fractions of neem cake were found to be toxic to *M. icognita*, Alam et al., (1982) also reported that water soluble fractions of neem cake and its mixture with soil was toxic to *M. icognita, Rotylenchulus reniformis* and *Tylenchorhynchus brassicae*. Toxicity was increased with decomposition period, the higher being after 15 days of decomposition. Increased toxicity of decomposed oil cakes may be due to the release of more nematotoxic substances from oilcakes itself or from the microbial activity.

Siddiqui & Alam (1985) reported that aqueous extracts of fresh leaf, flower, fruit, root, bark of neem were toxic to *M. icognita* while boiled extracts of fresh leaves were nematicidal to *Pratylenchus penetrans*. Aqueous extracts of dried and powdered seed kernel and seed shell were nematicidal to second stage juveniles of *M. icognita* (Mojumder & Mishra 1991). They reported that with an increase in concentration and exposure time, the mortality percentage was also increased. The penetrability (viability) of treated juveniles which were not killed was also affected as indicated by the reduced penetration. The commercially available liquid formulations, Neemark and Nimbecide were found to be effective against *Heterodera cajanai* when exposed in the aqueous concentrations and made with the help of emulsifier (Triton-X) in laboratory trial (Mojumder and Mishra 1993).

Climate change is the most serious environmental issue in the 21st century. The earth’s climate is frequently changing and leading to degradation of biodiversity, water and soil resources, desertification, coastal erosion, decrease in agricultural productivity etc. Climate change occurs due to natural internal processes, external forces, persistent anthropogenic changes in the composition of the atmosphere or in land use (GOI, 2008).
Kavi Kumar (2007) provides an overview of the available evidence of climate change on Indian agriculture covering impact, vulnerability and adaptation assessments. Eleven of the 12 warmest years were recorded between 1995 and 2006. The IPCC projections on temperature predict an increase of 1.8 to 4.0°C by the end of this century (IPCC 2007).

Scientific studies by Sinha and Swaminathan (1991), two decades ago showed that 1°C increase in temperature will reduce wheat production by 4 to 5 million tons per year. The FAO 2009 (http://en.wikepidia.org/wiki/Climate_change_and_agriculture) also concluded that for each 1°C rise in temperature, wheat yield losses in India are likely to be around 6 million tonnes per year or around$ 1.5 billion at current prices. There will be similar losses in other crops.

It is projected that by the end of 21st century rainfall will increase by 15-31 per cent and the mean annual temperature will increase by 3°C to 6°C. the warming is more pronounced over land areas, with the maximum increase in Northern India. The warming is also projected to be relatively greater in the winter and post-monsoon seasons.

Kumar and Parikh (1998) estimated the relationship between farm level net revenue and climate variables in India using district level data. The study also explores the influence of annual weather and crop prices on the climate response function. Agarwal (1990) analyzes the coping capacity of the rural people, especially women, to the seasonal downturns in the agricultural production cycle and calamities such as drought and famine.

In a country that gets rain for less than 100 hours in a year (a year has 8,760 hours) this would be disastrous. A recent World Bank report (World Bank 2008) studied two drought prone regions in Andhra Pradesh, and Maharashtra and one in Odisha for impact of climate change.

In India, various studies observed an increasing trend in temperature. However, some studies note regional variations in rainfall (Rupa Kumar et al, 1992; Kripalani et al, 1996; Singh et al, 2001). Most of the studies suggest changing pattern in rainfall and an increase in temperature during the different crop seasons or on annual basis. Most of the simulation studies have explained a decrease in duration and production of crops as temperature increased in different parts of India.
Ninan and Satyasiba Bedamatta (2012) gave the details of temperature and precipitation changes across various regions and seasons for the period 2070-2099 with reference to the base period 1960-1990. It was reported that the temperature is likely to increase (4 to 5°C) during January-March across all regions. As far as October – December months are concerned, the temperature also increased (3 to 4°C) across India. It also suggests that there are variations in increase in temperature across the regions. Northeast and Northwest temperature will be higher than the other regions though seasonal variability has been predicted. The projected results suggest that in all four regions of India the temperature is going to increase from more than 2°C to 5°C over the years. The precipitation projection indicates wide variations across the regions over the years. The south-eastern regions of India will have more than 32% decline in precipitation from January to March over the same years (2070-2099). It also suggests that during October-December the precipitation is projected to increase in the North-western regions of India in 2070-2099 (increase of 57% of average). Ninan and Satyasiba Bedamatta (2012) gave the details of climate change impact on different crops by various studies. It can be observed that in general an increase of 2°C in temperature would have a negative impact on crop production. Further, the World Bank (2009) projected that if rainfall is less, the negative impact is much more pronounced.

Kavi Kumar and Parikh (2001) suggested that the loss would be over Rs. 80 to 195 billion. Kumar and Parikh (1998) found that farm level net revenue would decline by 9 to 25%. In India, the projected impact of climate change on agriculture varies across regions because India has immense climatic/geographic diversity. In the arid regions, where the agricultural crops face the heat stress, even small changes in temperature, increase will have a devastating effect (decline) on crop production. In 2009, late arrival of monsoon and erratic rainfall later affected rice cultivation in over 57 lakh hectares and 262 districts were declared as “deficient” rainfall zones. Even if rainfall occurs at later stages many crops do not have the potential to “recover” from the prolonged moisture stress.

Mark New et al., (2012) investigated the climate of the Indo-Gangetic Plain and the implication of climate change on agriculture was assessed in terms of: (a) the recent trends and projected future changes in climate, specifically focused on the IGP, (b) the potential changes in
crop suitability of key crops grown in IGP, and also summarized the key advances that can be expected in climate model information over the next few years.

The prescription for climate resilient management of agriculture in India elaborated by Swaminathan (2010) has the following components: (a) Conservation farming and climate resilient agriculture in the heartland of green revolution viz. Punjab, Haryana and Western U.P., (b) Bridging the gaps between potential and actual yields, (c) Launching a pulses and oilseeds revolution in the rainfed areas, (d) Launching a post-harvest technology and value addition revolution, and (e) Bringing about a management revolution.

Terminal drought and heat stress have become serious problems in pulses, particularly coinciding with reproductive phase. Both stresses combined together are responsible for about 40% yield reduction or more depending upon severity of the stress level. Appropriate management practices are being evolved to mitigate the adverse effect of drought and heat. The major constraints identified are low genetic potential, low and unstable yield, huge post-harvest losses, poor adoption of improved technology and low profitability and returns. By-product utilization will be essential for higher production and profitability. Unpredictable weather condition coupled with temperature extremities (both high and low) adversely affect reproductive physiology and grain filling in almost all pulses and widening scopes of spreading diseases and pest incidence in most disastrous form. Changes in the native flora of Rhizobium and other useful microbes due to ecological imbalances are possible. Terminal drought and heat stress result in forced maturity and may reduce seed yields by 50% in the tropics. Another major problem is the salinity and alkalinity of soils which is high both in semi-arid tropics and in the Indo-Gangetic Plains in irrigated areas. Grain yield is also influenced by temperature extremities. Critical analysis of the north Indian environments revealed that agro-ecosystems of these regions is becoming fragile and posing a potential threat for pulse production. Some of the major underlying reasons for deteriorating conditions are as follows: (1) extensive rice-wheat cropping system replacing pulses (2) farmers choice toward more remunerative crops (3) over-use of groundwater enhancing salinity, and (4) increased incidence of ascochyta blight aggravated with low temperature (Nadarajan 2010; Swaminathan and Kesavan 2012).

In March 2004, temperatures were higher in the Indo-Gangetic Plains by 3-6°C which is equivalent to almost 1°C per day over the whole crop season. As a result wheat crop matured
earlier by 10-20 days and wheat production dropped by more than 4 million tons in the country. Losses were also significant in other crops such as mustard, peas, tomatoes, onion, garlic, and other vegetable and fruit crops. Similarly drought of 2002 led to reduced area coverage of more than 15 million hectares of the rainy season crops and resulted in a loss of more than 10% in food production (Samra et al., 2004). Analysis of sorghum also indicated that the yield loss due to rise in temperature is likely to be offset by projected increase in rainfall. However, complete amelioration of yield loss beyond 2°C rise may not be attained even after doubling of rainfall (Srivastava et al., 2010). Keeping these potential threats in mind, efforts were initiated under INCCA to have an assessment on impact of climate change on ecological sensitive areas in India (INCCA, 2010).

Indian agriculture is facing challenges from several factors such as increased competition for land, water, and labour from non-agricultural sectors, and increasing climatic variability for example, an increase in mean temperature of one degree centigrade during the month of March-April will reduce the duration of the wheat crop in Punjab by one week and thereby the yield by about 400 kg per hectare. Droughts, heavy precipitation events, temperature extremes and heat waves are known to negatively impact agricultural production and farmer’s livelihood. There is a probability of 10-40% loss in crop production in India by 2080-2100 due to global warming (Rosenzweig et al., 1994; Parry et al., 2004).

Mungbean is short day plant that requires 20 to 30°C mean temperature with 600-1000 mm annual rainfall areas, mainly in semi-arid to sub-humid lowland tropics and subtropics. Mungbean is grown both in summer season and in rainy season. The requirement of solar radiation in Mungbean has not received much study. According to Singh et al., (1985), Mungbean cultivars grown in summer with high solar radiation have higher crop-growth-rate, net-assimilation ratio, specific-leaf-weight, and leaf area index than Mungbean grown during the rainy season. Poehlman (1978) suggested that mean temperature of 20-30°C is optimum. Aggarwal and Poehlman (1977) noted that Mungbean plants grown in an 18 °C mean temperature were stunted, developed lesions on leaves and stems or even died. Increasing temperature in an environmental chamber from 18 to 28 °C increase height of Mungbean plants almost threefold. This is due to increased length and a small increase in internodes number (Agarwal, 1976). The appearance of successive leaves in the main stem followed a linear
function of accumulated temperature (degree days) that was modified by day length and relative humidity (Nanda and Saini 1987).