2. REVIEW OF LITERATURE

The review of literature pertaining to history of research on plant and moisture relationship, water requirement, and consumptive use, effect of different levels of soil moisture and fertilizers on growth, yield and quality, and the modifying influences of varying environmental factors upon growth and mineral nutrition is presented below:

2.1 History of research on plant and moisture relationship:

Research on plant response to soil-water in relation to nutrient availability is of recent origin despite the antiquity, importance, and almost world-wide occurrence of irrigation. The first experimental demonstration of the role that soil water plays in plant growth is generally attributed to Van Helmont (Russell, 1961). Later, Wood Ward (1699) published the results of his investigation on quantitative relationship between the increase in plant weight and the amount of water transpired. In India, Leather (1910) commenced his classical work at Pusa and considerable work has been since then done on irrigation requirements of various crops. Lawes (1850) carried out experiment at Rothamsted on "estimating water lose" by crop plants. Veihmeyer and Hendrickson (1950) viewed that soil water is equally available for crop growth and transpiration over the
entire range of available water between field capacity and permanent wilting point. An analysis of eighty experiments by Stanhill (1957) showed that majority of results did not favour Veihmeyer's view.

In the beginning of the century Briggs and Shantz (1912) defined water requirement as "transpiration ratio" i.e. water transpired per unit weight of dry matter produced. The classical works of Penman (1948) and Thornthwaite (1948) were the landmarks in the history of irrigation research. Their concepts of potential transpiration or potential evapotranspiration brought out the paramount role of climatic parameters in plant-water relationship. Since then the concepts in water use by plants have changed considerably with the time. The recent concept of estimating optimum range of available soil moisture consists of conducting soil moisture regime experiments and correlating the consumptive use of water with the reading of evaporimeter.

2.2 **Definition of some of important terms used in soil plant water relationships:**

The definition of some of the terms used in this text for describing soilwater-plant-climatic relationships are given below (Dastane, 1967).

Field capacity (F.C.):

It is the moisture content in percentage of a soil on oven-dry basis when soil has been completely saturated and
downward movement of water has practically ceased. This is the upper limit of available moisture range in the soil moisture and plant relations.

Permanent wilting point (P.W.P.):

It is the moisture content in percentage of a soil at which nearly all plants wilt and do not recover in a humid dark chamber unless water is added from an outside source. This is the lower limit of available moisture range for plant growth.

Available moisture:

It is the moisture which lies between field capacity and wilting point of a soil and is utilised by plants for their growth.

Bulk density - Volume weight:

It is the ratio of weight of oven dry soil to its bulk maximum volume.

Deficit soil moisture:

It is the difference between the soil moisture content and the field capacity. This is equal to:

\[
\text{Deficit soil moisture} = \frac{\% \times \text{B.D.} \times \text{Depth of soil}}{100}
\]
Potential evaporation (P.E.):

It is the evaporation from a large body of free water surface which is not normally affected by advective energy which depends primarily on the evaporative demand of the climate.

Evapotranspiration (E.T.):

It is the total water lost from a crop land due to evaporation from the soil and transpiration from the crop for a particular area during a specified time.

Potential evapotranspiration (P.E.T.):

It represents the amount of water evaporated in unit time from a crop which is green and active. This crop should cover the ground completely with a non-limiting supply of moisture (Thornthwaite, 1948). According to Penman (1948) this term is called "Potential transpiration".

Consumptive use (C.U.):

It is the water lost in evaporation, transpiration, and that used by the plant in metabolic activities. This is expressed in depth in inches or mm.

Often the term evapotranspiration has been used synonymously with consumptive use, although in strict sense, the latter includes water required for building of plant besides transpiration and evaporation losses. Quantitatively, there is a little difference and hence these can be applied
interchangeably for the loss of soil moisture from growing crops. Numerically, consumptive use is equal to net irrigation requirement plus effective rainfall plus storage changes in the soil moisture.

Water requirement (W.R.):

It is defined as water needed for raising a crop in a given period. It includes consumptive use and other economically unavoidable losses. It is also expressed in depth for a given time.

Effective rainfall:

It is the total or part of precipitation received when the soil moisture up to the rooting zone of crop is below the storage capacity of soil.

Delta:

It is the total depth of water required by a crop.

Water use efficiency:

It is the rate of increase in crop yield per unit of water applied. This is equal to \( \frac{\text{Yield}}{\text{E.T.}} \).

Crop response:

It is the increase or decrease in yield of crop per unit of fertilizer or water applied.
Harvest index:

It is the economic yield divided by biological yield \( \times 100 \).

This is equal to \( \frac{\text{Economic yield}}{\text{Biological yield}} \times 100 \)

2.3 Water requirement and consumptive use:

Narsinga Rao (1936) reported that 1011 to 1133 gram of water were required to produce a gram of dry matter in bunch variety of groundnut.

H'Ina (1958) determined the periods at which groundnut was very sensitive to soil moisture and found that moisture requirement was lowest from germination to flower formation and utilisation of moisture was greatest during flowering. The crop which received adequate supply of water at these stages yielded well.

Grimes et al. (1962) and Musick and Grimes (1961) showed that the flowering and pollination stages of plant development were associated with increased water use.

Mantell and Golden (1964) investigated the influence of irrigation frequency and intensity on the yield of peanut in fine sandy clay and clay loam soils in Israel, and got optimum pod yield with five irrigations at a frequency of 30 days. The consumptive water use was 670 mm from 0-150 cm soil layer. There were indications that replenishing the deficit to the field capacity in 0-60 cm layer only might be sufficient,
provided the entire root zone was at field capacity, at the beginning of the growing season.

Chen et al. (1964) studied water absorption and economic irrigation to peanut in China and showed that relatively small quantity of water compared with total was consumed during 1-30 days after sowing, but absorption increased rapidly from then to the peak of flowering (30-60 days) and was maintained during pod development. Goldberg et al. (1967) reported similar findings on consumptive use of water by groundnut grown in sandy soil and observed that the peanuts were sensitive to soil moisture. When the available moisture in the root zone fell below 40 per cent, both yield and quality suffered.

Bhavanishankar Rao and Srinivasalu (1955) studied the effect of irrigation frequency on yield of groundnut, and found that a maximum of 3250 pounds of pod yield per acre was obtained when irrigations were given every ten days, and reported that this frequency of irrigation could be varied depending upon the stage of development of crop.

Radder et al. (1968) determined the effect of intensity of irrigation on flowering and yield of groundnut in red loamy soils. Irrigation during summer at 7 days interval increased flower production by 9 and 12 per cent and yield by 46 and 50
per cent over an interval of 10 days in case of Spanish Improved and Asiriya Mwitunde groundnut varieties, respectively. In case of Spanish Improved, maximum number of flowers were produced during 5th and 6th week after sowing (40 to 50 per cent of the total) while in Asiriya Mwitunde the maximum number of flowers were produced during 8th week period (30 per cent of the total).

Chandra Mohan (1970) investigating the efficient water management for TMV-2 groundnut variety at Bhavanisagar, showed that a maximum yield of 3221 kg per hectare could be obtained consistently for five years, when the crop was irrigated at 60 per cent moisture availability or at 1.05 atmosphere tension measured upto 30 cm depth and further reported that giving irrigation at higher moisture regimes than 60 per cent moisture availability had not registered extra yield of pods but there was considerable reduction in yield when irrigated at 80 per cent moisture availability. He also reported that wetting of the soil need be done only upto a depth of 30 cm where more than 80 per cent of the effective roots are found and scheduling of irrigation and water requirement depend on water holding capacity of soils, rooting depth of crop, and seasonal conditions.

Dastane and Singh (1966) reviewing the work done on water requirement of crops in India stated that in Madras,
the number of irrigations required for groundnut varied from 6 to 9. Irrigating at 60 per cent available moisture gave maximum yields.

Rao (1966) raised groundnut crop on red soils from January to April under irrigation and found six to seven irrigations were required during the growth.

At Sirguppa (Anon., 1943) studies on groundnut with three depths of irrigation 1.50, 1.85 and 2.0 acre inches were conducted and found that the lowest depth of 1.50 acre inch per turn gave maximum yield of 719 lb per acre and the duty for groundnut was 62 hectares on black soils in kharif season.

2.4 **Crop factors affecting consumptive use:**

Fritschén and Shaw (1961) reported that the ratio of evapotranspiration to pan evaporation in corn increased till the plant attained the height of 50 inches. There was no change in the ratio there after and it decreased at maturity. From this they concluded that the water use by corn is dependent on the development of corn.

England (1963) maintained that loss during the first part of April, under seedling oats, consisted primarily of evaporation. By the first of the following month, rapid growth and higher temperature resulted in higher moisture withdrawal.
rates. This progressive increase up to peak rate may be due to combined effect of development of oats as well as increase in the evaporative demand.

Lemon et al. (1957) found a drop in evapotranspiration in cotton due to maturity, after attaining maximum growth in August. They concluded that continuous rise in transpiration rate to the August peak was due to the increased leaf area.

Hearn and Wood (1964) carried out experiments on wheat, beans, maize, and onion at Nyasaland during 1958 to 1961. They determined water use by crops by soil moisture studies and also computed by meteorological data. They concluded that in maize at planting, water use consisted of only evaporation from bare soil to which a value of 0.3 evapotranspiration may be assigned. The maximum water use i.e., 1.4 evapotranspiration occurred when leaf area reached the maximum at tasseling.

Fritz (1959) obtained reduced water requirements of orchards by spraying with white ash. He also found smaller irrigation needs of fruit trees with a ground cover of straw mulch. He attributed a part of the effect due to difference in the reflection coefficient of soil and vegetation. The albedo of vegetal cover (when it is green) is approximately 0.25 while the same for soil varied considerably depending upon soil moisture content. The value was 0.20 when the soil
was wet but was as high as 0.50 when the soil was dry.

Wolf (1964) during his study of soil moisture extraction trends of several legumes and grass mixture as affected by cutting frequency, at Wisconsin under unirrigated conditions observed greater moisture extraction up to twelve inches depth in case of mixture cut five times than the mixture cut three times during the crop season regardless of nitrogen level or species in the mixture. This differential behaviour was attributed to large portion of roots within twelve inches of depth in case of former treatment.

Monteith (1959) showed the effect of colour of the leaf on evapotranspiration. He stated that radiant energy is reflected back depending upon the reflection coefficient of surface. It is a few per cent for clean water, very nearly constant at about 25 per cent for many agricultural crops irrespective of shade of green and 15 per cent for forests.

Colour of the crop especially at yellowing stage affects consumptive use because of the difference in the reflection coefficient values.

2.5 Effect of moisture stress on plant growth and yield:

Billaz and Ochs (1961) studied the effect of moisture stress at different stages of growth, in pot culture experiments
and reported that susceptibility to drought in groundnut was greater at the period of maturation, than at those of active growth and start of flowering and full bloom. They further reported that drought decreased vegetative growth, flowering, and gynophore formation.

Portanier (1957) who studied the effect of various factors including soil moisture on flowering in groundnut, observed that decreasing soil moisture arrested flower development before arresting stem elongation and further noticed that when water was applied, stem elongation started immediately but flower development started three days later.

Reddi and Rao (1968) concluded that flowering was the most critical period during the growth, and moisture stress at this period affected yield of groundnut.

Su and Lu (1963) studied the effect of time of irrigation on peanut yield in sandy soil in China and observed that the critical periods sensitive to water deficiency were peak flowering and early fruiting. They obtained 10 per cent higher yield with 60 per cent available moisture content over 40 per cent available moisture and 47 per cent higher yield than that of no irrigation. They further stated that irrigation of 40 to 50 mm each time gave better results than that of 20 to 30 mm irrigation. Pods produced under irrigations were smaller than those produced without irrigation.
2.6 Yield and quality in relation to available moisture:

Chandra Mohan (1966) at Bhavanisagar found that maximum yields were obtained when the groundnut crop was irrigated at 60 per cent of moisture availability in the effective root zone. The water requirement varied from 556 to 634 mm. The number of irrigations required varied from six to nine depending on rainfall.

Rao and Srinivasalu (1955) conducted a trial with TMV-4 spreading type of groundnut for two summers (February to June) in deep red sandy soils, varying the intervals between two irrigations. Irrigation at an interval of 10 days gave the highest yield of dry pods of 1735 lb per acre as compared to irrigations with 15, 20, and 25 days interval.

Mehrotra et al. (1967) found that pod yields of groundnut increased with irrigation over control and also there was an increase of 1.6 per cent in the oil content.

Singh et al. (1968) studied the effect of three levels of irrigation on yield and quality of kharif groundnut and found that the irrigation did not influence oil percentage, but increased significantly the yield of pods when irrigation was given at flowering.

2.7 Water use efficiency and its relation to canopy, stomatal resistance, and root distribution:

Kramer (1969) working on plant and soil water relationship concluded that water use efficiency is related
closely to radiation which provides energy for growth and transpiration of green terrestrial plants and the most promising way to increase efficiency of water use is to encourage production of dry matter rather than to decrease water use, as water use efficiency is related to crop canopy and internal regulation by the stomata. Further, he explained that the differences observed in water use efficiency between various crops were due to parameters (evaporation, precipitation, irrigation, leaf area index, canopy, resistance, and root distribution) and photosynthesis (net assimilation rate, LAI and canopy resistance) of crop canopies.

Teare et al. (1973) conducting experiments on water use efficiency in sorghum and soyabean reported that water use efficiency for sorghum yields was 1.75 g DM per kg water and for soyabean yield 0.60 g DM per kg water and the period of greatest water use for both was from full bloom to pod filling for soyabean and from boot leaf to anthesis for sorghum.

Paul (1971) studying water use by dry land wheat as affected by nitrogen fertilization stated that nitrogen rates not only increased the grain yield but also increased the evapotranspiration by raising the water use efficiency by an average of 56 per cent.
Staple (1964) who worked on dry land agriculture and water conservation and on research in water use pointed out that a better understanding of soil, plant, and meteorological factors as they influence crop production under field conditions is needed before further gains in water use efficiency can be expected.

2.8 The methods and devices for scheduling irrigation through soil conditions:

2.8.1 Periodic soil moisture determination:

In this method, moisture is determined periodically by thermogravimetric method. Soil samples are taken in the entire profile and these values are correlated with crop growth and yield. Optimum moisture regimes in the effective root zones have been worked for different crops. Since soil sampling is a laborious process, various devices have been invented for measuring moisture in situ. Special mention can be made of a tensiometer (Richard and Gardner, 1936), gypsum blocks (Bouyoucos and Mick, 1940) and Bouyoucos, (1961) neutron scattering device.

2.8.2 Water evaporimeters:

Joshi (1969) conducted field experiments on hybrid bajara on sandy loam soil at Anand (Gujarat) during two summer seasons and correlated the values of evapo-transpiration with those from various types of evaporimeters.
fitted with different mesh screen covers. The sunken screen pan evaporimeter with 4 x 20 mesh lid gave a ratio of unity with consumptive use of water by the crop. Hence he concluded that the sunken screen pan evaporimeter can be used directly to estimate the water use by this crop.

Robinson et al. (1963) scheduled irrigations to sugarcane on the basis of evaporation from the U.S.W.B. class A pan. They obtained maximum sugar yields when 2.5 inches of irrigation water were applied after 2.9 inches had evaporated from the pan.

Joshi (1963) working at I.A.R.I., New-Delhi, reported that the ratio of actual water use by bulb onions to U.S.W.B. class A pan for the entire period from December to March was 0.65, while Sharma et al. (1967) working with maize at Sabour found this ratio to be 0.85.

Recently some workers have used different types of evaporimeters for studying evaporation and evapotranspiration. These studies throw some light on the possibility of using an evaporimeter in irrigation practice. Bathkal and Dastane (1966) reported that there was a significant correlation between consumptive use of water by cowpea, sorghum, and wheat and evaporation from U.S.W.B. pan.

Singh (1968) working at Udaipur conducted experiments to study relationship of consumptive use of water by wheat
and reported that the water use by wheat was correlated with the values of evaporation from U.S.W.B. class A pan.

Srivastava (1964) reported a significant correlation between the water use by berseem and evaporation from the U.S.W.B. class A pan. He further observed that the computed values from the Penman's formula over estimated the consumptive use of water while that from the Thornthwaite's formula under-estimated it. Narang (1965) working at I.A.R.I., New-Delhi, on bulb onion corroborated these findings.

Dastane and Singh (1966) scheduled irrigations for number of varieties of crops on the basis of evaporation from U.S.W.B. pan at I.A.R.I., New-Delhi. They fixed the value on the basis of water holding capacity of soil, effective root zone, critical stages of growth and U.S.W.B. pan evaporation. Crop required in all five irrigations including that given at presowing.

Fritschen and Shaw (1961) found that the ratio of evapotranspiration in maize to evaporation from U.S.W.B. class A pan was found to vary with stages of crop growth and that ratio (ET/EO) was 0.80 when there was good canopy. They concluded that pan evaporation might be used to estimate evapotranspiration and irrigation requirements, provided that the relationship between the crop to be irrigated and the evaporation has been established for the
Sharma and Dastane (1966) used sunken screen open pan evaporimeter with a screen cover of mesh size 6 x 20 and 4 x 20 and found the ratios of E/ET varied from 0.97 to 1.05 depending upon the crop and periods of growth. There was high correlation of more than 0.9 between the values from the evapotranspiration by crops of barseem, wheat and onions and the values from pan. They concluded that the sunken pan evaporimeter fitted with 6 x 20 or 4 x 20 mesh size screen cover is a reliable device for predicting consumptive use of water by crops.

2.9 **Effect of nitrogen on growth, yield, quality and its uptake in relation to moisture availability:**

Knowledge of total nutrient absorption by plants and its pattern through the season is basic to an understanding of the nutrient requirement of a crop. On an average about 60 per cent of the applied nitrogen is absorbed by plants. Under favourable conditions a much higher proportion of nitrogenous fertilizer may become a part of plant but cases of heavy losses also occur. Most of nitrogen loss is due to leaching, but part of the nitrogen loss is due to denitrification. Both leaching and denitrification are favoured by an excess of water.

Mohammad et al. (1932) studied the effect of nitrogen on germination and growth and showed that large amount of
nitrogen usually caused peanut plants to become dark green in colour and grow rapidly producing succulent vegetation which did not flower and fruit well.

Satyanarayan and Krishna Rao (1962) worked on nutrition requirements of Spanish Improved groundnut variety under dry conditions. Higher levels of nutrition in groundnut resulted in higher yield. The critical level of nitrogen in the leaves may be taken at 3.23 per cent at the stage of commencement of flowering for higher yield. The nitrogen content of leaf decreased with the advance in age of groundnut crop. Further, they stated that the application of 20 pounds of nitrogen increased the number of flowers and the number of two seeded pods per plant and also shelling percentage.

Nijhawan (1962), studying the effect of application of manures on composition of groundnut, noticed that applying 25 pounds nitrogen per acre increased the yield, but had no effect on oil percentage of the kernel. While organic manure did not affect yield, it increased the oil content and decreased the protein content.

Prevot (1949) emphasized the importance of maintaining peanut at a high level of nitrogen metabolism prior to the fruiting period, as a large quantity of nitrogen was translocated from the leaves to the developing fruit.
Sturkie et al. (1943) reported that a marked response was obtained from added nitrogen to Spanish peanuts. The yield of groundnut was doubled by the addition of 120 pounds nitrogen per acre in the form of nitrate of soda in Norfolk. The yields of peanuts were increased with each successive increment of nitrogen. The high level of nitrogen did not affect the percentage of sound or mature kernels.

Lachover (1963), investigating the effect of split application of ammonium sulphate on the yield and quality of edible groundnut grown in pots, observed that high application of 1000 kg per hectare of ammonium sulphate at planting, depressed the yield and stimulated the top growth. Best results were obtained by applying 200 kg per hectare of ammonium sulphate before sowing followed by 4 applications of 200 kg per hectare each at 20 days interval. Splitting the normal dose of 500 kg did not produce any higher yields than application of the entire dose before sowing.

Negi and Dalai (1957), reviewing the work done on manuring of groundnut have found that the groundnut responded very well to an application of 25 pound of nitrogen per acre in the form of ammonium sulphate at sowing, under Punjab conditions.

Thornton and Broadbent (1948), working on influence of nitrogenous fertilization on peanut showed that nitrogen and
phosphorus are absorbed in small quantities by developing fruit and translocated to other parts of plant. But the uptake through gynophore was negligible when there was ample nitrogen in root zone. Similar results have been reported by Bledsoe and Harris (1950).

Mc Clelland (1944) obtained an increased yield of 1188 pounds of nuts and 1.38 tons of hay by the addition of 18 pounds of nitrogen per acre to white Spanish improved.

2.10 **Effect of phosphorus on growth, yield and quality and its uptake in relation to moisture availability:**

The requirement for phosphorus is comparatively 3 to 4 times less than nitrogen. A crop of groundnut giving 1500 kg per hectare of pods removes 15 kg phosphorus per hectare.

The efficiency with which fertilized phosphorus is absorbed by plants has been studied intensively. It has been found that only 15-25 per cent of the added phosphorus is used by the plant in a year.

Gopalkrishna and Nagarajan (1958) reported that phosphorus was found to be a limiting factor in yield. Its deficiency reduced flower production and affected the size and filling of pods.

Wahhab and Muhammad (1958) studied the effect of phosphorus fertilization on sandy loam soils, with 375-450 mm
rainfall during growing season. They obtained an average increase of 257 pounds per acre in pod yield by application of 37.5 pounds of phosphorus as superphosphate and the maximum increase was 520 pounds per acre in a favourable year. Application of 30 pounds nitrogen per acre as ammonium sulphate stimulated vegetative growth and tended to decrease the beneficial effect of phosphorus.

Huber (1957) reported that positive correlations were found between pod and hay yield and significant interaction was found between phosphorus and nitrogen. Further, he observed that the effect of nitrogen on yield was negative when applied alone but was positive when combined with phosphorus.

Lachover and Ebercon (1966) studied the response of groundnut to superphosphate in soils low in available phosphorus, and obtained increase in flower number, yield and phosphorus uptake with the application of superphosphate up to 600 kg per hectare. Higher rates gave no response.

Satyanarayan and Krishna Rao (1962) studying the nutrition of Spanish Improved groundnut under dry conditions in Andhra Pradesh indicated that an application of 40 pounds phosphorus per acre at sowing increased the number of flowers, and pods and shelling percentage and also influenced
favourably the oil content. The critical level of phosphorus in leaves for getting maximum yield was 0.49 per cent at the stage of commencement of flowering.

Gilleir and Prevot (1960) while studying the effect of various phosphatic fertilizers on groundnut, obtained more consistent results with diacalcium phosphate and recommended its application when rainfall exceeded 800 mm. Yield responses to ammonium sulphate were often due to sulphur contained in it. In South Senegal, a fertilizer dose of 40 kg ammonium sulphate + 60 kg dicalcium phosphate + 20 kg potassium chloride per acre increased the peanut yield upto 50 per cent.

Katarki and Banahatti (1965) reviewing the work done on NPK fertilization to groundnut in black soils of Karnataka State, under dry conditions, reported that in one year out of 3 years nitrogen application at 10-20 pounds per acre increased the yield of groundnut while phosphorus application at 50-100 pounds per acre increased the yield in two years but the effect of potash was deleterious.

Harper (1920) and Pate (1931) indicated that phosphorus stimulated the setting of fruits and decreased the number of unfilled pods.
Miller and Duley (1925) showed that, with low soil moisture supply there was low content of phosphorus within the plant. Neller and Comar (1947) stated that moisture depletion was conducive to the fixation of phosphorus. Trumble (1947) concluded that the relatively low phosphorus content of plant was due to inadequate soil moisture supply under dry conditions.

Hallock et al. (1971) studied the distribution of nutrients in peanut lines near maturity and reported that the fruit was highest in phosphorus and zinc contents and lowest in potash, calcium, manganese, boron and magnesium. The phosphorus content in fruit varied from 0.27 to 0.38 per cent, and in the leaf from 0.18 to 0.25 per cent.

2.11 Canopy, dry matter accumulation and the factors affecting:

Knowledge of the different factors influence the time and rate of dry matter accumulation in different parts of any plant is basic to the development of plant and to increased crop yield through cultural and fertilizer application practices.

In most of the crops, growth and development proceed unimpaired and yield maximised only when water status is maintained (Slatyer, 1969).
Kramer (1963) and Hagan and Laborde (1964) who worked on water stress and plant growth, reported that plant growth was controlled by plant water stress and only indirectly by soil water stress and plant water stress depended on the relative rates of water absorption and water loss, rather than soil water supply alone. They further stated that vegetative growth is particularly sensitive to water deficits, because growth is closely related to turgor and loss of turgidity stops cell enlargement and results in smaller plants and they emphasised the need for irrigation scheduling to be based on physiological measurement.

Miller and Gardner (1972) found that stomatal closure due to water stress in plants resulted in a greater reduction of growth rate than in transpiration.

Burström (1965) working on the effect of water deficits in plants reported that water deficits in plants not only reduced the total amounts of growth but also changed the pattern of growth; root-shoot ratio was increased by the water stress and leaf area was reduced. He further explained that the reduction in growth was due to the reduced photosynthesis on account of partial closure of stomata which interfered with entrance of carbon dioxide.

Troughton (1969) who worked on plant water stress and carbon dioxide exchange of cotton leaves noticed that the
initial or immediate effect of lowering of the leaf water potential of the plant was of closing of stomata and reduction in carbon dioxide uptake.

Kanemasu et al. (1969) who studied the effect of reduction in soil water potential in plants reported that for any given set of conditions with respect of light, temperature, nutrition etc., a reduction in soil water potential resulted in a reduction in leaf turgor potential and a concomitant increase in stomatal diffusion resistance.

Hayden et al. (1972) who studied effect of leaf colour, chlorophyll concentration and temperature on photosynthesis rates in barley lines observed that leaf colour and chlorophyll content affected canopy temperature and indirectly plant metabolism and dry matter production. Highest photosynthesis of field grown plants occurred at 25°C. Green plants had significantly higher photosynthesis than pale green or golden plants.

Miller and Gardner (1972) who studied the effect of the soil and plant water potentials on dry matter production of snap beans observed that during the period of soil water shortage the increase in stomatal resistance caused a reduction in CO₂ uptake and hence photosynthesis. The dry matter production rate was sharply reduced on soil depleted
of water.

Florell and Faulker (1934) concluded that maximum leaf development of spring wheat occurred during the flowering stage and maximum stem development took place during filling stage of growth and further stated that when wheat was stressed during vegetative and flowering stages, shorter plants were obtained as a result of lower soil moisture absorption, lower soil nutrient uptake and reduced photosynthesis. Stressing wheat at jointing, flowering, and dough stages of growth significantly reduced grain yield compared with optimum irrigation.

Dastur (1924) found that since there was a close relationship between water content per unit of leaf area and the rate of photosynthesis, a low photosynthetic rate usually occurred during dry season.

Dastur and Desai (1933) working on relation between water content, chlorophyll content, and the rate of photosynthesis in some tropical plants at different temperatures reported that the water content in the plant was more important in determining the rate of photosynthesis than the chlorophyll content.

Robins and Domingo (1962) who worked on moisture and nitrogen effects on irrigated spring wheat stated that
severe moisture stress must be avoided from boot stage to maturity for maximum wheat yields.

Boyer (1968) reported that decreased water supply decreased leaf water potential, increased stomatal resistance, reduced photosynthesis and thus decreased growth in corn, soyabean, and safflower.

Baheja and Krantz (1958) reported that the whole sorghum plant accumulated dry matter continuously and almost linearly until maturity. The pattern of dry matter accumulation by the whole plant and its component parts were generally the same in all plots which received fertilizer, although the magnitude of increase differed markedly among treatments. The dry matter accumulation in the fertilized plants was high early in the season especially during 35 to 42 days and proceeded nearly until maturity.

2.12 Modifying influences of various environmental factors upon growth, mineral nutrition, root development and distribution:

2.12.1 Growth and mineral nutrition:

Cheliadinora (1941) studying the influence of temperature on the response of groundnut to day length, found that longer day increased the green weight and flower production.

Moore (1937) working with nutrition levels in peanut plants found that Spanish peanuts bloomed abundantly when
exposed to illumination continuously for several weeks.

Shibuya (1935) making morphological studies on fruitification of peanuts indicated that oxygen in the pegging area is necessary for fruitification, but the amount required was not determined.

Burd (1919) and Wittwer (1943) have reported that the decline of anabolic activity is associated with blossoming, and gives way gradually to final resurgence of absorption of mineral nutrition and acceleration of organic synthesis in vegetative tissues.

Raheja (1966) studying the requirements of secondary essential elements in crops stated that the uptake of sulphur by legumes ranged from 10-14 pounds per acre and estimated that on deficient soil, cropped with cereals and legumes in rotation, an annual dose of 10 pounds per acre of sulphur is required.

Hagan (1952) from the literature reviewed, concluded that the net synthesis of organic materials depended upon the rate of carbon assimilation and rate of respiration which increased with increase in temperature.

Blackman and Mathaei (1905) observed that if temperature and carbon dioxide are not limiting, the rate of carbon assimilation was proportional to light intensity and further
indicated that the general level of growth of plant depended upon carbon assimilation and protein synthesis.

Page and Bodman (1953) reviewing the ecology of plants stated that aeration is as important as water supply and optimum soil temperature.

Bledsoe and Harris (1950) and Harris (1949) studying the effect of the nutrient supply on effective flowers producing fruits reported that the nutrient supply of the plant influenced the effectiveness of flowers and peg in production of fruits. Calcium, particularly when deficient in the pegging zone, gave a low percentage of fruits.

Colwell and Brady (1945) and Bledsoe and Harris (1950) studying the effect of calcium on yield and quality of large seeded type groundnut concluded that deficiency of calcium produced a few fruit and affected the fill and quality of groundnut.

Cheliadinora (1941) working on the influence of illumination intensity and day length and temperature on growth of peanut found that the longer day increased the green weight and flower production of plant and further noticed that the photoperiodic treatment was effective only when temperature was favourable during flowering period and increase in temperature also increased the yield of fruit.
The final size of the plant is the result of many growth factors acting on it during its development. It is a summation of its growth component facets. Went (1957) illustrated that the ceiling in growth in sugar beet could be attained due to improvement in methods of growing, nutrition, control of climate by adjusting sowing dates, and improved varieties.

Harris (1949) working on the growth of peanuts with nutrient deficiencies in the root, and pegging zone reported that the yields were increased when sulphate ion was used in fruiting medium.

Bledsoe et al. (1949) studying the absorption of calcium by peanut observed that the radioactive calcium was actually absorbed by the shells and seeds of developing fruit with some movement to other parts of the plant when labelled calcium was applied to the roots of the plant.

2.12.2 Root development and distribution:

Miller (1938) studying the role of sulphur in plants observed that the sulphur increased the root system of plants and developed dark green colour of leaves of legumes. Reviewing the effect of supply of oxygen on root growth he concluded that supply of oxygen was very essential for root respiration and further stated that when soil air
was deficient in oxygen, it adversely affected the rate of respiration and in consequence the rate of uptake of solutes and absorption of water by plants. He also noticed the decreased microbial activity in poorly aerated soils.

Albert and Armstrong (1931) studying the root growth of crops under varied conditions of soil aeration reported that under aerated conditions of soil, root growth was vigorous, and much branched and fibrous. These workers further noticed that by virtue of fibrous character, the plants were able to tap a wide area for nutrients.

Burström (1953) reviewing the physiology of root growth found that growth of roots was dependent upon supply of metabolic product and availability of minerals from the soil.

Bruner (1932) studying the root development of peanut grown in a sandy soil in Oklahoma observed that during early stages of plant growth the absorbing rootlets developed prominently in the first foot of soil but later, the subsoil became progressively more and more filled with them.

2.13 Harvest index:

Donald (1962), Wallace and Munger (1966) and Singh and Stoskopf (1971) presented evidence that improvement in economic yield of several crops derived in part from higher percentages of biological yield being partitioned to the
plant organs which constituted economic yield.

Vogel et al. (1963) working on plant performance characteristics of semi dwarf winter wheat obtained a significant negative correlation between height and harvest index and suggested that the harvest index can be improved by reducing the plant height.

Singh and Stoskopf (1971) studying the harvest index values in cereals observed that cereals developed too large a leaf and stem structure in relation to grain yield and that there was an imbalance of time for vegetative growth and grain filling. Further they noticed that reduction in plant height which reduced the sink size of stem improved the harvest index and the harvest index was positively correlated with grain yield but negatively correlated with vegetative growth.

Thus it can be seen from the review of literature that not much work has been done on consumptive use of water and mineral nutrition of groundnut and scheduling irrigation to groundnut. Since these aspects are important in evolving suitable fertilizer application and irrigation practices, the present investigations were carried out with
the following main objectives.

1. To find out an optimum soil moisture regime and the critical nutrient status of the plant at flowering, pod development and maturity for getting maximum yield.

2. To study the moisture extraction pattern from soil under varying soil fertility and moisture conditions.

3. To find out the consumptive use of water at optimum moisture regime during different stages of crop and to relate it with the loss of water from sunken screen pan evaporimeter and tensiometer for scheduling irrigation.

4. To study the effect of N and P in relation to soil moisture, on growth, yield, and quality.