CHAPTER II

REVIEW OF LITERATURE

The review of literature embracing the relevant references in relation to the present investigation has been presented as under.

Effect of Mineral nutrition on yield of soybean

Mineral nutrition of soybean is very complex and is less well understood than that of many other field crops. Nelson (1971) in a review of the experience in U.S.A. concluded that the key to obtaining responses of soybean to fertilizer was to employ good production practices, especially with regard to variety, soil $p^H$, spacing. In general it was summarised that soybean responded to $P$ and $K$ but not to $N$. Khurana (1983) observed that soybean plant utilize $8.3$ kg nitrogen/10.0 kg of seed. Phosphorus uptake is four times lower than nitrogen consumption ($2.2$ kg of $P_2O_5$/kg of seed). Therefore, the balanced rise of fertilizers for a good crop growth is very important.

Chandel and Saxena (1986) revealed that a good soybean crop demands about $240$ kg nitrogen per hectare. For the development of nodules $P$ and $K$ are also required. Soybean is also to fix $80-150$ kg/ha atmospheric Nitrogen. Since soybean is able to meet most of its $N$ requirement from the atmosphere, nitrogenous fertilizers are generally not applied. However differences in
requirement and capacity of fixation of N by soybean sometimes necessitates supplementation of N at 15-20 kg/ha as basal in low organic carbon soils. This also preferred to boost the initial vegetative growth when soybean behaves like a cereal plant.

Howkey (1957) found that soybean were unable to accumulate enough nitrogen during the pre-bloom stage to produce high seed yields. Singh and Singh (1968) reported that application of 10 kg N/ha increased significantly grain yield but not straw yield. In another experiment N was found to significantly reduce yield in a moderately acid soil where response to N was not affected by increasing P and K level, Maples et al. (1969).

The application of herbicides alone or along with fertilizers slightly degraded the cells of nodule bacteria, thus decreasing the N accumulation by soybean nodules. (Blanco et al. 1973)

Application of phosphorus and potash should be done as per soil test. However, in those soils which are poor in P and K an application of 60-80 kg P\textsubscript{2}O\textsubscript{5}/ha; 40-60 kg K\textsubscript{2}O/ha as basal may be recommended. Jones et al. (1977) reported that either P or K applied above increased the number of nodules/plant and per unit volume of soil. Applied K increased the number and weight of nodules and the number of pods per plant more than P; but increase were largest when both P and K were applied.
Miller and Pesele (1961) made a detailed study of the yield of soybean grown in a sandy loam soil under various levels of added phosphates and potash and found that seed yield was more closely related to the potash content than to the phosphorus content. Over 50 per cent variation of yield was associated with the phosphate and potash content of the upper leaves of plants sampled at post flowering stage. Chevalier (1978) reported that during active growth period of soybean DM decreased with increasing K rate and the reverse was true of seed formation. At maturity seed and stem DM increased with increasing K rate, showing a favourable effect of K on ripening. N, P, K. contents were low in the stem and high in the seed. N content decreased with increasing K rate and protein yield was considerably increased.

Venugopal (1985) revealed that a 3.3 tonnes per hectare crop of soybean contains in seed about 67 kg of potassium, 27 kg of phosphorus and 200 kg of Nitrogen. Voss (1967) indicated that a 50 bushel per acre soybean crop 3368 kg/ha removes 314 kg N, 34 kg P and 101 kg K/ha. He has further reported that during the years of application under favourable conditions, the recovery generally ranges from 5-20 per cent for phosphorus and 50-60 per cent for K.

Hammond et al. (1951) reported that soybean plants absorbed 56 kg potassium per hectare over the entire growth period, the
maximum daily uptake of 1.7 kg/ha at between 87-94 days after sowing. From the 80th days after sowing upto maturity at 135 days, the plant absorbed 24 kg/ha of potassium. At maturity 72 per cent of the total potassium was present in the seed.

De Mooy and Pesels (1966) reported that maximum yield of soybean can be obtained when the level of potash equilibrium in the field is 600-800 kg/ha. Mascarenhas et al. (1969) observed in a trial in 1965 and 1966 of soil pH 5.5, soybean yield was increased by 18 per cent. On the other hand Mascarenhas et al. (1968) reported that in the soil of pH 4.8 the response to potash was small. Hymowitz et al. (1971) working at Jabalpur indicated that application of K alone decreased seed yield.

Reiss and Shewwood (1965) found that application of potassium alone reduced seed yield, but increased seed weight. According to Pumphy et al. (1966), the highest response was generally shown by high yielding varieties and the lowest response by low yielding ones. Potassium did not respond in soybean variety, Harnon-273, phosphorus with potassium delayed flowering but potassium alone hastened with a high level of Nitrogen. Tewari (1965).

Bobrecha et al. (1986) conducted a trial on good wheat complex soil in the Corpathian Submontane region in 1981-83.
Soybean were given no fertilizer or combinations of 20-80 kg/N/ha and 20 kg P_2O_5/ha + 30 kg K_2O/ha or 2.5 times these rates. High N rates slightly prolonged the growth period. Seed yield increased linearly with N rate but was not related to PK rate. The optimum mic fertilizer rate of 60 kg N+40 kg P_2O_5+60 kg K_2O/ha gave an average yield of 2.84 ton/ha.

Tewari (1965) conducted a NPK factorial experiment during two successive cropping seasons to study direct and residual affects of various treatments on the flower initiation and the yield of soybean. He found that all the treatments gave maximum yield in the first season, suggesting that fertilizers should be applied during every cropping season. N and P at 20 lbs of N_2 and P_2O_5/acre gave the highest yield, but K failed to show any response. The residual responses to potassium and phosphorus during second year were significant but not to N.

**Effect of Phosphorus**

Phosphorus is required by all living organisms and every living cell. As early as in 1769, Guha, a Swedish chemist found phosphorus to be an essential constituent of bones of men and animals. In 1804 Theodore de saussure reported that phosphorus is an ingredient of the ash of plants and it is removed from the soil by growing plants. Von Liebig (1855), reported that Rock
phosphate as well as bones, could be dissolved in Sulphuric acid and thus rendered more soluble and efficient for use of growing plants.

Thomas Green Elemson wrote, there can be no civilisation without population, no population without food and no food without phosphoric acid. (After nitrogen, no other element except phosphorus is critically important for plant growth. Availability of phosphorus is greatly influenced by the pH of the soil.)

Effect of different phosphatic fertilizer on soybean has been studied since long time in India as well as in abroad. Cooke (1936) and Bray (1937) studied the value of rock phosphate with organic matter like straw and found that there was marked effect of phosphorus on crops. Ghani and Alcon (1943) indicated that certain fractions of phosphorus which are acetic acid soluble (Non Apatite calcium phosphate) were extremely low in the acid soils of Assam, Bengal, Bihar and Madras. Roger et al. (1953) while studying the comparative efficiency of various fertilizers found that the response of Rock phosphate in crop production depend on many factors related to the rock, soil and plant.

Cottage (1955) reported that rock phosphate as a source of phosphorus to crops in acid soil is beneficial, even in soils of high acidity and containing high amount of iron and alumina,
where as the phosphorus added through Superphosphate was fixed, the same supplied through rock phosphate was found to be a good source of P supply to crops.

Bonemeal as a source of phosphatic fertilizer in India was recorded in the publication, "the rice revolution in India". Deshmukh (1953) indicated a drive for collection of bones and found out that any of the Bombay manufactured bone digester could be utilised in selected places for the manufacture of Bonemeal. Bonnet et al. (1954) after comparing the efficiency of eighteen sources of phosphatic fertilizer found that the rate of dissolution and release of P from the rock phosphate in the soil was not rapid enough to ensure optimum P supply to fast growing maize plants in the early growth period. Seat et al. (1959) reported that the addition of organic matter along with rock phosphate caused active solvent action and thereby increased the availability of phosphorus. Similar result have also been reported by Ghosh (1963) in case of bonemeal.

Mascarenhas et al. (1970) under two years experiments observed that response to P in the range of 0 to 100 kg $P_2O_5$ per hectare was linear and significant in both years in the soil of pH 5.5. Result obtained at Jabalpur indicated that the rate of 80 kg $P_2O_5$/ha in adequate. Singh and Sexana (1968) conducted an
experiment of phosphate fertilization and did not indicate differences for 0, 80 and 160 kg \( P_2O_5 \)/ha.

Howell (1954) indicated that an increase in the level of P from 2 to 10 ppm resulted in taller and heavier plants, greater yield and a higher oil content in the seed of all the varieties used. He observed a marked differences in varietal response when a wider range of P level was provided. One variety 'chief' continued to respond favourably to P level as high as 112 ppm, whereas two other varieties 'Lincoln' and 'Ellin' were adversely affected by levels of 50 and 112 ppm. There was little or no effect of the P level on the number of days to flower. Since varieties tolerate high levels of phosphorus, whereas other not (Howell and Benard 1961).

Matsara and Dutta (1971) using phosphatic fertilizers as sources of phosphorus to paddy, wheat, soybean, pea, maize and potato crop grown in acid soils of Palampur (pH 4.5) and Baster (pH 5.9) found that the application of 80 kg/ha of \( P_2O_5 \) through superphosphate and rock phosphate gave similar yield of paddy, wheat and maize but was benefitted more with rock phosphate than superphosphate.

Mandal and Khan (1972) while studying the release of phosphorus from insoluble phosphatic materials in acidic low land
rice soils to explore the possibility of utilizing the comparatively cheap source of phosphorus for such soils found that 86 per cent of phosphorus added as superphosphate converted to available form. Both basic and Rock phosphate helped to maintain in the soil a higher amount of available phosphorus than other sources. Bone meal, however, was slightly inferior to superphosphate in the matter of supplying phosphorus in soil. Singh et al. (1976) reported that in the acid soils of Kangra district (pH 5.0 to 6.8) rock phosphate was as efficient as or slightly more efficient than superphosphate.

Singh and Dutta (1976) found that availability of P from Rock phosphate was found increasing with the advancement of time of contact of the phosphate materials in acid soils. Mixing F.Y.M. with the phosphatic fertilizers enhanced phosphorus availability from these sources. In order to efficiency of various sources of phosphates, it was found to be in the order of Mussorie Rock phosphate, Superphosphate, Udaipur Rock phosphate and Laccadive Rock phosphate in the acid soils of Kangra (pH 5.0). In Coorg soil (pH 5.5), the efficiency order was as follows; superphosphate, Mussorie Rock phosphate, Udaipur Rock phosphate and Laccadive Rock phosphate.
Borthakur and Sharma (1979) made a comparative study on direct effect of Mussorie rock phosphate and single superphosphate on wheat in 1975-76 and their residual effect on subsequent rice crop in 1976-77. These workers showed that Rock phosphate was superior to single superphosphate.

Senapoti et al. (1984) undertook a study to evaluate Mussorie Rock phosphate, Super phosphate, mixture of Rock phosphate and super phosphate and Ratna Phosphate (Polophus) as sources of P for rice which was grown in pots with a lateritic loamy acid soil (pH 5.2). It was found that dry matter yield and uptake of phosphorus in any form was beneficial, the highest yield being obtained with 50 per cent rock phosphate treatment. It was also observed that the difference in dry matter yield due to 20 per cent S.S.P. + 80 per cent R.P. and super phosphate alone was not significant.

Robertson (1967) obtained yield response to the highest level of annually applied phosphorus when soil contained 62 lbs of available \( \text{P}_2\text{O}_5 \) per acre. In growth chamber studies with soybean Borkert (1984) observed that the highest rate of added P increase root length and decreased root radius, while higher rates reduced root growth. In pot trials in which the same amount of P was added to different vol. of soil, reduced soil vol. increased root
growth and decreased root radius. In a split root nutrient solution experiment decreasing the amount of in a P containing solution increased P influx but this was not sufficient to prevent a decline in total P uptake and reduced shoot weight.

Smith and Sanchez (1982) reported that the extent to which local low reactivity patos de Minor phosphate rock (PR) and banded super phosphate (OSP) application can replaced high cost broadcast OSP application. Highest soybean (Glycine max) yields were obtained in two consecutive crops with a single broadcast (OSP) application of 352 kg p/ha or by broadcasting 172 kg p/ha + banding 44 kg p/ha per crop, all as OSP. Combination of a broadcast (PR) application of 88 kg p/ha + 44 kg p/ha as banded (OSP) per crop resulted 81 per cent of the maximum yield at 31 per cent of the cost of applying 352 kg p/ha as (OSP). Increasing the broadcast (PR) rate to 352 kg p/ha while maintaining the same banded OSP rate produced 89 per cent of the maximum yield at 50 per cent of the fertilizer cost. Other OSP combinations (44 broadcast + 44) annual band; 88 broadcast + 22 annual band; 88 broadcast + 44 annual band and 178 broadcast without annual band also produced over 80 per cent of maximum yield/38 to 50 per cent of the fertilizer cost.

Mistra (1983) from numerous experiments have shown that direct application of rock phosphate can give good soybean yield only in moderate to strong acid soils (pH less than 6.0).
In neutral and alkaline soils ($p^H$ above 6.5) it is of little use. In general, the greater the acidity, the higher the effectiveness.

**Effect of lime:**

Soybean yield improved with the application of lime to the acidic red soils of Ranchi, Bihar, Mandal et al. (1966). Experiment conducted as early as 1912 at Jorhat revealed that liming could boost up the yield of soybean by 500 per cent (ISSS, New Delhi, 1961).

Chatterjee et al. (1972) conducting experiments reported that application of lime at the rate of 2 ton/ha to a leached sandy loam alluvial soil of $p^H$ 5.4 increased seed yield and dry matter yields, nodulation and calcium contents of plants of improved pelican soybean.

Chandel and Sexana (1986) reported that the ideal $p^H$ range is 6.6 to 7.5. This $p^H$ is also ideal for nodulation. In acid soils, lime and in alkaline soils, gypsum should appropriately be used to improve nodulation and growth of soybean. Several investigators, Nelson and Hartwig, (1947) Welch and Nelson, (1950); Nelson and Colwell, (1945) and Gray and Sturgis, (1961) have indicated response of soybean to lime in the acid soils of Southern U.S.A.
Soybean at low yield levels usually tolerate soil acidity but respond markedly to lime application. There are many other positive effects of liming in addition to making calcium available (Ohlrogge, 1960). Chandel and Sexana (1986) again reported that in Zinc deficiency soil, one spray of solution of Zn \( \frac{704}{2} \) and \( H_2O \) at 5 kg + 2.5 lime in 1,000 liters water per hectare should be sprayed. Venugopal (1986) revealed that the soils for soybean should be sandy loam to loamy in texture, acidic in reaction and with high organic matter content (1 to 2.5 per cent). The pH should be 5.0 to 6.5.

Calland (1960) and Nelson (1960) noted that the soil should be limed to a pH of 6.5 for optimum seed yield. However, increasing the pH to 7.0 slightly reduced seed yield (Fellers 1918). According to Mascarenhas et al. (1969) in acid red latozol (pH 5.5) lime increased seed yield in two consecutive years of trials.

Barthakur (1980) observed that application of lime resulted in better nodulation and increased seed yield of soybean mainly bragg variety at Jorhat soils. Similarly, Borthakur and Sarmah (1984) observed that increased percentage of lime with an increase in the level of lime, and application of 150 per cent of lime could significantly increase the yield of soybean. They also reported that application of lime and potash is essential for boosting up soybean production in highly leached acid sandy loam soils in Assam as lime stimulates nodulation and potash helps in the formation of bold grains in soybean.
EFFECT OF MOLYBDENUM

The significance of molybdenum on growth of legumes was long established (Bortels 1937). This element is required in symbiotic nitrogen fixation as well as other physiological processes of higher plants (Evans 1956).

Alfonso and Jimenez (1987) reported that Molybdenum inoculation gave the highest rate of nitrogen fixation particularly in the presence of molybdenum. Increasing molybdenum concentration reduced nitrogen uptake and in the presence of 0.5 ppm the leaves became chlorotic and growth and development were inhibited. Plant height, flower and pod numbers were greatest in plants grown in complete nutrient solution in the absence of molybdenum.

Hurduc and Savules (1985) indicated that the effect of inoculation with bacteria and application of urea and molybdenum in nutritive solution was investigated on soybean cv. Flora grown in quartz sand. They noticed that the treatment resulted in increased pigment concentration of the foliage; increased photosynthetic productivity and increased pod and grain production.

Barshad (1951) and Evan et al. (1951) revealed that the acidic condition of soil favours low solubility and consequently low uptake of molybdenum by plants. In certain cases, some of the beneficial effects of liming can be attributed to increased
availability of native soil molybdenum (Anderson 1956; Evans et al. 1951; Haris, 1952; Robinson et al. 1951; Stout et al. 1956 and Giddens and Parkins 1960). De Mooy, (1970) obtained seed yield increased upto 356 kg/ha at 2 sites with soil pH values in the range of 5.8-6.7. Lee et al. (1967) also got the similar result.

Lyashko (1986) reported that the application of molybdenum to soil increased the nitrogen content in plant, and protein content in seed of soybean; application of nitrogen to the plants decreased nitrogen and protein content in seed. Applied molybdenum increased the molybdenum content in seeds, but uptake of soil molybdenum was highest with seed inoculation combined with molybdenum application.

Experiment conducted by Jones et al. (1971) showed that yield increased of 9 bushels/acre by seed treatment with and foliar application of only 35 gm sodium molybdate per hectare. In trial in an acid soil pH 4.9 seed treatment with molybdenum increased seed yield by 32.6 percent, pod number per plot by 33 per cent, seed number/plant by 18 per cent, 100 seed weight by 12 per cent, and seed protein content by 8.7 per cent, but increased seed oil content by 5 per cent.

Burton and Curley (1966) conducted an experiment with 'Chippewa' soybean planted in a soil virgin to soybean confirmed
that the inoculant molybdenum combinations contained too few rhizobia to bring about effective nodulation even when used as early as 3 weeks following preparation. Poor nodulation was reflected in low yields. When sodium molybdate was mixed with the inoculant immediately before application to the seed at planting time excellent nodulation and increased yields were obtained.

Parker and Harris (1962) reported that increased in seed yield, leaf nitrogen, seed protein and seed weight by application of sodium molybdate. Seed yields were increased by 10 per cent in 1960 and 55 per cent in 1961. The increased yield obtained from 0.2 lb/acre (225 gm/ha) of molybdenum alone was equivalent to the increase obtained from 2 tons/acre (5 tons/ha) of lime. They further reported that seed treatment was superior to foliar application.

Buzetti and Vargas (1985) conducted a field trial in Mato Grosso do Sul in 1979-80, soybean cv. VFU-1 were given 90 kg P and 60 kg K per hectare and 0.5 or 6 of the trace elements Zn, Mo, B, Cu, and Fe. Omission of Zn and Mo reduced seed yield most significantly to 1.93 and 1.95 t/ha respectively composed with 2.19 ton when all trace elements were applied and 0.71 ton in the absence of trace elements. Jethalmalani et al. (1969) did not obtain any response of soybean to molybdenum.
EFFECT OF BORON

Plant need relatively a very small amount of boron and mature properly. Boron content of different plant species have been reported to vary in amount indicating specific boron requirements for different crops (Wallace 1945; Hass 1945). Besides this, the comparison of different plant parts reveals a differential uptake (Bobko and Zerling, 1958; Gandhi and Mehta 1960) most of which is immobilised in cell wall or intracellular substances and afterwards do not take part in the plant throughout its growing period.

Different functions have been attributed to the boron in the plant body. Boron does not replace any of the essential elements but a definite association of this with absorption of utilization of calcium, (Brenchley and Warington, 1927) of Potash (Reeve and Shive 1944). Efficient utilization of nitrogen and mineral matter and assimilation of iron is strongly suggested by Bobko et al. (1955). Brenchley and Thorton (1925) have pointed out the role of boron in growth and functioning of nodules of vicia fava.

Boswell (1972) conducting field trials on soybean indicated that with the application of boron and Mn washed leaves increased Zn, Cu and Mo, content of leaf decreased those of N and Ni,
and did not effect those of P, K, Ca, Mg, B, Mn, Fe, Al, Sr and Bd of leaves.

Gitteir et al. (1986) reported that foliar Mn approximately increased soybean seed yield from 10 to 39 bu/ac. Copper, Fe and Zn concentrations were higher in blades than in petioles. Sampled from upper most fully expanded trifoliate soybean leaves at the R1 growth stage. Boron concentrations were not consistently higher in blades than in petioles from the trifoliate leaves. Blade and petiole Cu concentrations data indicated that like Mn the critical Cu level would be higher for soybean when based on blades from trifoliate leaves than were based on the trifoliate leaves. Decreased Zn concentration occurred in blades, petioles and seeds where correction of Mn deficiency did not increase Zn uptake. The decreases in Zn concentration in the plant tissues were attributed to dilution from increased plant growth due to foliar Mn application. It was pointed out that correction of Mn deficiency would decreased. Boron as well as Cu, Fe and Zn in soybean tissue on soils where root systems extract insufficient amount of these micronutrient to attain pre-treatment concentration.

Effect of Rhizobial inoculation:

Soybean being a leguminous crop can utilize atmospheric nitrogen by rhizobium legume symbiosis. To increase this symbiosis, soybean seed must be treated with an efficient Rhizobium japonicum
culture. For soils rich in organic carbon, 500 gm. peat-based culture will be sufficient to inoculate 75-80 kg of seed. However, if soils are poor in organic carbon and where soybean is being planted for the first time, the rate of culture should preferably be doubled. Care should be taken to ensure that culture has adhered uniformly on seed, culture mixed seed is not exposed to bright sunlight and it is used immediately for sowing. Always mix culture just before sowing (Chandel and Sasena, 1986).

Indian soils normally do not have the strain of Rhizobium japonicum capable of nodulating the cultivated variety of soybean since this crop has not been under large scale cultivation. This is to reason why soybean inoculum has been extensively imported into India (Subbaras and Bala sundaram, 1971). However, the success of the process of rhizobial symbiosis in the root nodules of legumes depends on the survival of the introduced strain of the bacteria (Vincent, 1958).

Nodulation is the important biological process occurring on the root surface of the legumes. It varies with the crop and also with the variety. Nutman, (1980) reported that the root nodules varied six-fold between varieties of subterranean clover. Coldwell and Vest, (1968), while working on the nodulation interaction between genotypes and zero groups of Rhizobium japonicum reported that the soybean genotypes grown in successive
years in different fields showed significant differences in their acceptance of *Rhizobium japonicum* strains of specific zero groups.

Legume cultivation chiefly of grain pulses in this country has been carried out without any artificial inoculation. Spectacular yield increases have been recorded through rhizobial inoculation of legumes in some countries where specific and promising strains are being commercially produced (Erdman and Wilkins, 1928; Fred et al. 1952; Burton and Allen, 1949 and Abel and Erdman, 1964).

The most favourable soil $p^H$ for the growth of rhizobia appears to be neutral (Allen and Allen, 1960). Though rhizobia survive at high $p^H$ value, $p^{H10}$ is critical for them and acidity in particular is unfavourable (Graham and Parker, 1964). The poor nodulation of lucern in acid soils is probably because of the sensitivity of rhizobia to low $p^H$ (Norris, 1964 and Burton, 1967).

Hunt et al. 1981, reported that inoculation increased growth and total Nitrogen accumulation in pods, petioles and leaves of bragg soybean under irrigated conditions. Under non irrigated conditions, the increased infection of grain 110 appeared to induced a negative response in the vegetative growth of bragg soybean. Nitrogen concentration was also significantly favour
in the leaves and pods of non-irrigated inoculant plants. Hunt also reported that Rhizobial inoculation significantly increased grain yield. Numerical increase in nodule growth has not rejected in grain yield. Lime application increased both grain yield and nodulation.

Abel and Erdman, (1964) have also reported that rhizobial strains appears to show latitudinal specificity within the U.S.A. Differences in nodulation amongst strains of rhizobia are very well known and were reported amongst others by Agati and Gareia, (1940), Singha (1941); Boyee and Bond, (1942); Chhonkar and Negi, (1971); Balasundaram et al. (1972) and Chatterjee et al. (1973). Smith and Ellis (1960) reported that soybean nodulation may be influenced by seedling vigour and that seedlings with uniform vigor should be utilised when conducting nodulation evaluations.

According to Norris, (1965), rhizobium japonicum infecting soybean belongs to the alkali secreting group and does not necessarily need lime for nodulation. At high levels of nitrogen the extent of nodulation in soybean is greatly reduced (Sears and Lynoh 1951; Hallsworth, 1958; Abu-Shakva and Bashiri, 1972 and Chatterjee et al. 1971).

For efficient nodulation the minimum number of viable rhizobial cells has been suggested at $10^3$ (Vinocent, 1958).
Obaton and Holler, 1970, however, suggested that 1 million rhizobial cells/seed were required for effective nodulation and this was found to increase seed yields by 208-335% and protein by 21-33% but the oil content was reduced by 15-16%.

Increased seed yields of soybean resulting from rhizobia inoculation were reported by Jethalmalani et al. (1969 and 1971) Rao et al. (1972) and Mehrotra and Lehri (1970). Marked increase in nodulation and dry wt. of nodules was recorded by presoaking the seeds in water for 4 hrs and then drying for 1 hr. before inoculation with *Rhizobium japonicum* compared with unsoked inoculated or uninoculated seeds (Iswaran, 1970). Iswaran and Jahuri (1969) also reported that pelleting the seeds with rock phosphate or lime after inoculation also markedly increased the number of nodules/plant and the dry wt. of plant compared with seeds which were inoculated without pelleting.

Barthakur and Sarma (1985) reported that the performance of rhizobium culture is dependent on the nutrient status and reaction of the soil. They conducted an experiment and reported that seed inoculation with *Rhizobium* culture in general resulted in significant increase in yield of 'Alankar (P-71-21) Soybean. The strain from Patnagar gave the highest yields which was on a par with IARI-3 strain in 1977. In 1978 the highest yield was obtained when the seed was inoculated with IARI-3 strain, which
was on a par with Pantnagar and Bangalore strains. JNKVV-2 strain gave the highest yield in 1979 and was on a par with Naya-Bunglow and Pantnagar 2 strain. In 1981 JNKVV-3 strain gave the highest yield, and was on a par with Bangalore, Naya-Bunglow, Pantnagar, AAU, JNKVV-1, JNKVV-2 and PAU strains. Nodulation was profuse in all the inoculated plots. The differences in yield of soybean may be attributed to the differences in the adaptibility of Rhizobium strains under variable soil conditions and seasonal fluctuations in climatic parameters. They suggested that strains from Pantnagar, IARI, JNKVV and Naya Bunglow are adaptable to the acid soils of Assam.

Vigne et al. (1977) reported that soybean were grown hydroponically to determine the effect of urea and nitrate-N sources on nodulation. Urea allowed effective nodule development and function, as evidenced by nodule mass, acetylene reduction and difference between the total Kjeldahl N gain per plant and urea uptake measurements. Plants grown in solution with as high as 18 mm Urea-N produced nodules capable of N\textsubscript{2} fixation (C\textsubscript{2}H\textsubscript{2} reduction assay) while concentration as low as 2 mm inhibited nodulation. The amount of N fixed by nodules of plant grown on urea varied from 27 to 71 per cent of total plant N, depending on urea concentrations of the nutrient solution. Urea uptake by the plant was slower than NO\textsubscript{3} uptake, regardless of urea concentration supplied.
Therefore, internal concentration of N or N compounds in the plants were likely lower with urea than with NO₃ nutrition, which may have partially accounted for the degree and effectiveness of nodulation. Growth on urea is a convenient hydroponic method of producing healthy, vigorous, nodulated soybean that are capable of N₂ fixation.
Growth regulators were first identified in the early 1930s as significant in crop production. Much has been transpired since then. To-day many natural and synthetic chemicals challenge the scientists in a way to understand their characters, behaviour and mode of action. They bring new possibilities in circumventing environmental limitations, relaxing genetics restraints, improving the quality and avoiding the production, harvesting and preservation of food and other crops. It is recognised more or less that in plants, hormones regulate the chemical reactions that comprise the life symptom of the organism. Besides, scientists have also developed some synthetic substances. These natural and synthetic chemicals, have a powerful effect on the growth and health of the plants even when applied in small quantity. The use of individual growth regulators and its effects in increasing yield may be dependent on the cultivator used as different results have been obtained by Stutte, (1974) in case of soybean crop.

Stutte (1974) again investigating the response of different varieties of soybean to the application of growth regulators reported that the increase in yield with individual growth regulator are strictly dependent upon the cultivator. Arthur and Myrs also drawn similar conclusion when they studied the different varieties of soybean with some growth regulators. The application of growth regulators increase the number of effective pods per plant and control the percentage of reproductive organs (Shedding 1942, 1948 and 1959).
Intensified research has been in progress in recent years for ascertaining the usefulness of growth regulators to improve and modify the existing pattern of plant growth and ultimately the yield and quality of farm produce to meet the increasing needs of both consumers and farmers. A complete survey of literature concerning multiple aspects of growth regulators and their effects on plant is beyond the scope of this review. However, only the information pertinent to this present investigator is revised here.

Baz et al. (1985) conducted an experiment on soybean cv. Clark grown during 1980-81. He treated plants with foliar sprays of 50, 100 or 150 ppm GA\(_3\), CCC and IAA at 45, 70 and 110 days after sowing. The treatments increased plant vegetative growth, nodulation, total contents of N and reducing sugars and the percentage oil and N content of dried seeds. GA\(_3\) was more effective than cycocel (CCC) or Indol acetic acid (IAA).

The effects of 500 mg IAA, 100 mg GA\(_3\) and 100 mg kinetin/l applied to the 3rd top leaf on CO\(_2\) assimilation and \(^{14}\)C photosynthate release into seeds were investigated in soybean. All the compounds applied individually or in combinations increased photosynthetic rates IAA and kinetin increased source-sink translocation of \(^{14}\)C assimilates. GA\(_3\) caused high accumulation of \(^{14}\)C solutes in petioles and delayed their outflow, modes of their action. (Karpov and Belozerova, 1986).
Winter crop of soybean cv. Williams G-7-R 315 or winter and spring crops of cv. vavilov 63-17 were given 0.5 or 50 mg gibberellin $A_3$ (GA$_3$) per plant on the leaves of flower initiation. Flower and fruit number/plant were highest in G7-R315 given 50 mg GA$_3$ at 41.4 and 18.6 respectively and 100 seed Dry wt. was highest (24.6 gm) in vavilov 63-17 without GA$_3$. GA$_3$ decreased flower and fruit abscission by approx. 10% in all cv. and resulted in yield increases in cv. G.7-R315 and Williams which were highest 7.0 g/plant and 5.8 g/plant respectively at 50 mg, GA$_3$/plant. Seed weight of cv. Vavilov was decreased by GA$_3$. (Castro et al. 1987).

Bhattacharya, (1977) indicated that irradiation of dry soybean seed with gamma-rays at 10 KR increased growth and seed yield; irradiation at 20-50 KR inhibited growth. Soaking the irradiated seeds in 50 mm IAA or GA soln. considerably reduced the inhibitory effect of higher irradiation doses and increased the yield. GA was more effective than IAA.

Nooden, (1986) reported that GA$_4$.or GA$_4$+7 delayed leaf senescence by up to 16 days when supplied in the transpiration stream in soybean explants (leaf with pods and subtending stem segment) in combination with cytolefinin, although Gibberelline alone only delayed leaf senescence by 1-2 days and cytokinin alone by 4 days. Pod yellowing was delayed by 2-4 days on treatment with Gibberellins + Cylokinin.
Howell et al. (1960) studied the response of soybean to seed treatment with gibberellin at eight locations from Winnipeg, Man to Coahoma, Miss. Stands and yields were reduced by application of either 2 or 8 g potassium gibberellate/bushel of seed. While treated plants were taller in the seedling stage, at maturity the untreated plants were 5 inches taller than treated one in most cases. Maturity and oil and protein contents of the seed were not affected consistently by gibberellin treatment.
FIG. 3-1 MEAN MONTHLY METEOROGICAL DATA DURING 1985