CHAPTER – II

REVIEW OF LITERATURE
REVIEW OF LITERATURE

The main function of review of literature is to determine the type of work, both theoretical and empirical, that has been done previously, assist in the definition of the problem area, provides a basis for theoretical frame work, provide insight into method and procedures, suggest operational definitions of the major concepts and provides a basis for the interpretation of the findings based on this understanding. It gives an idea about the work already conducted in any direction of the issue which is considered for further study. This also helps to acquire broad general background in the given field. Similarly, review of literature helps to support or reject any findings of the study.

Much work has been already done by many research workers on various parameters of groundnut for different durations. With the available information, an attempt is made to review the present study with the available information. The available literature is furnished under the following heads:

2.1 Effect of chemical fertilizers with main stress on phosphorus
2.2 Effect of molybdenum and other micro nutrients
2.3 Effect of vermicompost and organic manures including FYM
2.4 To estimate proximate principles like proteins, fat and carbohydrates in the groundnut kernels of the experiment
2.5 To determine the oil content of the experimental treatments under study
2.1 EFFECT OF CHEMICAL FERTILIZERS ON GROWTH AND YIELD OF GROUNDNUT

The response of groundnut to fertilizer application has always been highly variable (Loganathan et al., 1996). Though it is a leguminous crop, nitrogen also has to be applied to enhance the vegetative growth, production and development of pods (Angadi et al., 1990). Phosphorus has to be applied for normal growth, establishment of root system, seed formation and for hastening the crop maturity. Application of potassium plays an important role for the uptake of nutrients and their movement within the plant body. Potassium increases the yield and improves the quality.

Among various factors of crop production, favourable soil physical environment, and judicious nutrient supply are important inputs for realizing higher groundnut yield and oil out turn. The results of a field experiment conducted during 1987, 1988 and 1989 at ARS, Aliyar Nagar to find out the optimum production factors for rainfed groundnut revealed that the selection of an improved variety (JL-24), adoption of a spacing of 15 x 15 cm, providing one supplemental irrigation between 50 to 90 days and fertilizing the crop with N:P₂O₅:K₂O @ 15:30:45 kg ha⁻¹ resulted in highest pod yield (14.61 q ha⁻¹) while lowest pod yield (839 kg ha⁻¹) was recorded by growing the variety like POL-2, in 30 cm x 10 cm spacing with a fertilizer schedule of N:P₂O₅:K₂O @ 10:10:45 kg ha⁻¹ and providing one supplemental irrigation at 90 to 110 days of crop growth (Geetalakshmi et al., 1991 a).
In view of the above conditions chemical fertilizers need to be applied to the groundnut crop for increase in yield.

**Dry matter production**

Plant growth is predominantly influenced by weather, nutrients and different fertility levels, which significantly affect the yield attributes. The effect of various nutrients was assessed in terms of the percentage increase or decrease of the dry matter production over that of control.

Maximum dry matter yields of groundnut were reported when N, P$_2$O$_5$, and K$_2$O @ 25:75:37.5 was applied in balanced way. Application of N at 50 kg ha$^{-1}$ or N: P$_2$O$_5$ @ 25:50 were also resulted in higher dry matter yields than at lower levels of N.

**Pod yield**

Contribution of a particular input to total yield may vary with crop and location as it is altered by agro-climatic conditions of the given region. The contribution of different production factors in the productivity of groundnut indicated that the improved variety contributed 45.5% in yield increase, which was followed by protective irrigation (34.6%), seed treatment (19.9%), recommended spacing (11%), weed control (4%), recommended dose of fertilizer (4%) and plant protection (3%) (Subrahmaniyan *et al.*, 1999). Among the major nutrients, P is one of the nutrients which are required in large quantity for the growth of groundnut. Khan *et al.* (1991) ranked six nutrients on the basis of (per cent) contribution of nutrients to groundnut yield as soil P (62%), fertilizer P (28%), soil N (28%), soil K (21%), fertilizer N (12%) and
fertilizer K (5%). Thus, soil P contribution to groundnut yield was maximum followed by fertilizer P.

The fertilizer N, P and K requirement for production of 30 q ha\(^{-1}\) of groundnut at average soil test values of 200, 15 and 327 kg ha\(^{-1}\) of N, P and K were 23, 28 and 19 kg ha\(^{-1}\), respectively (Reddy and Ahmed, 1999). The nutrient requirement of N, P\(_{2}O_{5}\) and K\(_{2}O\) to produce 1 q of dry pods of groundnut (cv. JL-24) in Vertisols of Maharashtra was found to be 2.92, 1.43 and 0.72 kg, respectively (Tamboli et al., 1996), while Reddy and Ahmed (1999) reported that the N, P and K requirement for producing 1 q of groundnut in Inceptisols of Jagtial region of Andhra Pradesh was 5.28, 1.58 and 2.64 kg, respectively. In general, the pod and haulm yields of groundnut increased significantly with increasing levels of fertilizers. The relevant literature pertaining to the effect of inorganic sources of nutrients on pod yield of groundnut has been reviewed hereunder. The maximum pod yield of groundnut and the corresponding nutrient application rates as reported by various workers were as follows:

The pod yields of groundnut were found to vary from 10.41 q ha\(^{-1}\) to 38.05 q ha\(^{-1}\) among different levels of N application with a tendency to show higher yields at 30 to 40 kg ha\(^{-1}\). Similarly, pod yields were found to be influenced by P levels; the maximum being observed at 40 to 60 kg P\(_{2}O_{5}\) ha\(^{-1}\) levels. Combined application of N and P\(_{2}O_{5}\) was found to be better than the N and K\(_{2}O\) application to groundnut crop. Application of N: P\(_{2}O_{5}\): K\(_{2}O\) @ 20:60:40 or 25:75:37.5 was found beneficial.
Haulm yield

Similar to pod yield, haulm yield of groundnut also increased significantly with increased fertility levels. The relevant literature pertaining to the effect of inorganic sources of nutrients on haulm yield of groundnut has been reviewed hereunder. The maximum haulm yield of groundnut and the corresponding nutrient application rates as reported by various workers were as follows:

The haulm yields showed the influence of N levels; maximum being observed at 50 kg N ha\(^{-1}\). The haulm yields were found to be higher at 35 to 60 kg P\(_{2}O\_5\) ha\(^{-1}\) level. Combined application of N and P\(_{2}O\_5\) at 40:80 or 37.5:75 seems to improve the haulm yields. Application of 37.5:75:45 or 25:75:37.5 kg N: P\(_{2}O\_5\): K\(_{2}O\) ha\(^{-1}\) resulted in maximum haulm yields as observed by a few workers who reported the effects of all these major nutrients on groundnut (Yakadri and Satyanarayana, 1995; Patel et al., 1994; Singh et al., 1994; Quadri et al., 1991).

Nutrient uptake

Modern farming leads to heavy withdrawal of nutrients from soils and its success depends largely on the external application of nutrients commensurate with the nutrient uptake. Nutrient uptake is the total amount of nutrients taken up by a crop during the period it is in the field. Nutrient removal by the crops depends on the plant parts which are harvested, their composition and their share in total dry matter production. Though groundnut is a self fertilizing crop, it is very exhaustive compared to the other legumes
as very little portion of the plant is left in the soil after harvesting. In general, the uptake of N, P and K by groundnut significantly increased with increasing levels of fertilizers. The relevant literature pertaining to the effect of inorganic sources of nutrients on N, P and K uptake by groundnut has been reviewed hereunder.

N uptake

The N uptake increased with increase in level of N and P applications to groundnut crop. Application of N at 37.5 to 60 kg ha⁻¹ and P at 60 to 90 kg ha⁻¹ appears to increase the N uptake by groundnut. Together application of N and P₂O₅ or N, P₂O₅ and K₂O improved the uptake showing highest values at 37.5:75 and 30:60:60 kg ha⁻¹, respectively (Yakadri and Satyanarayana, 1995; Patel et al., 1994; Prasanti and Perumal, 1992).

P uptake

The maximum P uptake by groundnut and the corresponding nutrient application rates were reported by Rao and Shektawat (2002), Deka et al. (2001) and Dosani et al. (1999).

2.1.2 Effect of Phosphorus and other chemical fertilizers on growth and yield of Groundnut

Solanki et al. (2006) conducted a field experiment during 1999, 2000 and 2001 on groundnut in kharif seasons and reported that application of FYM @ 10 t ha⁻¹ recorded significantly higher pod yield (2785 kg ha⁻¹) and gross returns of Rs.31,4471 ha⁻¹ and significant increase in available N, P₂O₅ and K₂O.
Kanumurmu et al. (2006) evaluated the agronomic efficiency of phosphate rock enriched FYM in groundnut (Arachis hypogaea L.) in rabi 2005-2006 on sandy soils of Agricultural College, Bapatla. Maximum crop growth nodulation filled pods plant\(^{-1}\) and yield with the treatment that received from made of double the recommended dose (DRD) of P\(_{2}O_{5}\) through PR and FYM in 1:4 ratio which was significantly superior to other.

Experimental results of Kishorbabu (2003) indicated that variable nitrogen phosphorus and potassium on the soil significantly varied with the treatments. The available nitrogen has maximum at flowing stage due to application of FYM than N alone. Phosphorus availability was maximum with NPK + gypsum + Zinc sulphate and increased from initial to flowering stage. The maximum a available K Content in the soil was increased during flowering except in control and N P treatment. The availability NPK was higher at flowering stage and there after decreased from maturity.

Deka et al. (2001) reported that application of P\(_{2}O_{5}\) at 50 kg ha\(^{-1}\) significantly improved the uptake of NPK by groundnut crop in sandy loams at Jorhat (Rajasthan). Shelke and Khuspe (1980) reported that the uptake of phosphorus was significantly higher by kernels and haulms at 40 kg P\(_{2}O_{5}\) ha\(^{-1}\) in the clayey soils.

Maximum leaf area (3.12) index was reported by Reddy and Gajendragiri (1989) with phosphorus at 40 kg P\(_{2}O_{5}\) ha\(^{-1}\) during kharif at IARI, New Delhi. However, Jadhav and Narkhede (1982) and Raghuram (1987) obtained maximum leaf area with application of 60 kg P\(_{2}O_{5}\) h\(^{-1}\).
Jain (1983) found the increased rates of phosphorus from 0 to 80 P$_2$O$_5$ ha$^{-1}$ did not affect the plant height significantly in sandy loam soils with medium phosphorus status during kharif season at Gwalior.

### 2.1.3 Dry matter production and yield

In general seed inoculation with the PGPR isolates resulted in increased root length plant biomass nodule number and dry weight and pod yield of groundnut (cv. JL 24) in plots during kharif season of 2000 with best performance recorded with PGPR$_1$ PGPR$_2$ PGPR$_4$ in a field trial during kharif 2000 seed bacterization of groundnut (cv. GG$_2$) with PGPR isolates enhanced pod yield (13 to 32%) haulm yield nodule number and dry weight, route length 100 kernel weight etc. significantly. Uptake of N and P were also enhanced significantly due to inoculation both in pot culture and field trial (Pal et al., 2004).

A field experiment was conducted by Panwar and Singh during the rainy season of 2000-2001 to study the effect of conjunctive use of phosphorous and bio organics on groundnut. Application of 60 kg P$_2$O$_5$ ha$^{-1}$ markedly influenced the growth and yield attributes resulting in significant increase of pod yield by 14.01% over the control. Seed inoculation with phosphorus solubulizing micro organism (PSM) marginally improved yield but their combined use increased pod yield significantly both the organics i.e. FYM and neem cake. But when half quantity of these organics work integrated with rhizobium and PSM, the highest pod yield of 31.80 q/ha with
FYM 5 tones / ha + rhizobium + PSM was obtained. Neem cake @ 1.5 tones ha\(^{-1}\) in the presence of same bio fertilizer was next to it.

An experiment was conducted by Srilatha (2002) on groundnut cultivar TMV-2 in rabi 2002 in Agricultural college farm Bapatla with 11 treatment combinations consisting of different sources and levels of phosphorus and sulphur in simple RBD replicated thrice. Application of phosphorus up to 60kg P\(_2\)O\(_5\) ha\(^{-1}\) levels significantly increased the pod yield of groundnut irrespective of the P source (SSP/DAP) application of 60kg P\(_2\)O\(_5\) ha\(^{-1}\) through DAP along with 500 kg Gypsum/ha applied either as top dressing flowering or in two equal splits at sowing at flowering application of 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) through SSP along with 250 kg gypsum ha\(^{-1}\) applied as topdressing at flowering were found to be on a par in influencing pod and haulm yields of groundnut and uptake of all the nutrients studied.

A field experiment was conducted by Rao and Shektawat (2002) to evolve the nutrient management practice for high yield of groundnut (*Arachis hypogaea* L.) under rain fed condition. Application of farmyard manure (FYM) @ 10 tons ha\(^{-1}\) and poultry manure @ 5 tons ha\(^{-1}\) increased mature pods/plant, pod weight/plant said mature kernel (%) and 100 kernel weight as compared with the control. Pod yield of groundnut increased by a mean of 14.0 and 11.3% owing to FYM and poultry manures application respectively, over the control (16.2 q ha\(^{-1}\)) Phosphorous 60 kg ha\(^{-1}\) significantly improved mature pods/plant pod/weight / plant filled pods (%) and mature kernel and 100 kernel weight over 20 kg P\(_2\)O\(_5\) ha\(^{-1}\) and thereby
pod yield of groundnut also. Significant improvement in yield attributes and pod yield was also noticed. Where gypsum was applied at 250 kg ha\(^{-1}\) either full at sowing or half at sowing N, half at sowing + half at 35 DAS interaction effect of organic manure and gypsum treatments were significant. Maximum pod yield was obtained with application of FYM + gypsum in 2 splits. The economic optimum dose of phosphorous was computed under the application of FYM + gypsum in 2 splits at 54.0 kg P\(_2\)O\(_5\) ha\(^{-1}\) and at this level 21.47 q ha\(^{-1}\) pod yield was predicted.

Srilatha (2002) reported that nutrient composition and oil content of kernels increased with increasing levels of P up to 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) level. At this level SSP was found to be superior to DAP. Nutrient and oil comparison further increased with application of gypsum along with phosphorus. In case of nutrient content and oil yield the treatments DAP\(_{60}\) + 500 G. Td (T\(_9\)), DAP\(_{60}\) + 250 G. basal + 250 G Td (T\(_{11}\)), SSP\(_{60}\) T 250 G Td (T\(_7\)) recorded significantly higher values and were on a par with each other. In case of oil content, the treatment SSP\(_{60}\) + 250 G, Td (T\(_7\)), DAP\(_{60}\) +250 G. basal + 250G Td (T\(_{11}\)) recorded higher values and were on a par with each other.

A field trial was conducted by Umamahesh (2001) to study the phosphorus use efficiency of groundnut through different sources and methods of application. A application of 75% of recommended phosphorus as basal to soil and the remaining 25% through mono ammonium phosphate as foliar spray at 30 and 60 DAS along with PSB inoculation resulted in
significantly higher dry matter production, pod yield and phosphorus use efficiency.

A field experiment was conducted by Babita and Reddy (2001) to identify the plant characters related to water use efficiency transpiration efficiency (TE) of the genotypes utilizing the specific leaf area (SLA) values recorded on the genotypes. TE had significant positive correlation with chlorophyll content in leaves and mineral ash content of leaves. Total dry matter (TDM) at harvest had significant positive correlation with TE only in simulates drought. Nitrogen content in leaves at 80 DAS showed significant positive relationship with TE under both adequately irrigated and simulated drought treatments. Leaf temperature had significant negative relationship in adequately irrigated and simulated drought size of the leaflets had a significant negative correlation with TE under drought stress treatment only. Harvest index showed no significant correction with TE.

Field experiments were conducted by Majumdar (2000) on individual and interactive effects of phosphorus and zinc on yield of groundnut. Yield attributes nutrient composition and quality of groundnut grown in phosphorus and zinc deficient during kharif 1999-2000. The yield (pod and straw) number of pods/plant and shelling percentage increased significantly with increasing doses of phosphorus and zinc. The content of groundnut (Kernel & Straw) increased significantly with the application of P and Zn, but the Zn content reduced significantly with increasing levels of phosphorus. Interaction effect of Zn and P was significantly positive for P
concentration in pods and straw while negative for Zn concentration in pods and straw. Phosphorous and Zn application significantly increased the protein and oil content of groundnut and this interaction effect was also spectacular.

A field experiment was conducted in summer groundnut var. JG-63 at Indira Gandhi Agriculture University, Raipur, during 1997. According to findings, application of *Pseudomonas striata* performed better over as per gullies awamori when both were applied with or without inorganic P fertilizer. Significantly response to both phosphate solubulizing microbes (PSM) was also recorded when inoculated alone or along with the phosphate fertilizers on all the yield parameters. The height pod yield (1476.17 kg ha\(^{-1}\)) was obtained with P striate with application of 50 Kg P\(_2\)O\(_5\) ha\(^{-1}\) as rock phosphate against 1264.90 kg ha\(^{-1}\) yield received due to awamori with the same level of rock phosphate which was 35 and 15 percent higher than yield obtained due to rock phosphate application alone respectively. It was further noticed that the application of single super phosphate SSP alone gave higher yield over rock phosphate but the combined application of P solubulizer with rock phosphate was found superior over un-inoculated control while maximum uptake was found in plants raised from seeds inoculated with *P. striata* in P fertilizer field @ 50 kg P\(_2\)O\(_5\) ha\(^{-1}\). The uptake of N was significant higher than un-inoculated control except alone application of rock phosphate as well as a awamori (Singh et al., 1997).
Sammi and Minajurahasan (1997) reported higher pod and haulm yields due to application of P @ 26.4 kg ha\(^{-1}\) over all other treatments in Entisols of Kalyani (West Bengal). Vasisht and Pandey (1999) reported that application of P @ 40 kg ha\(^{-1}\) significantly increased the pod and kernel yield.

A field experiment was conducted by Kachot et al. (1997) at Junagadh during the rainy season of 1996 and 1997 to study the effect of organic, inorganic and biological sources of nutrients on yield, quality nutrient content and uptake of same spreading groundnut (*Arachis hypogaea* L.) as well as nutrient status of soil, combine application of FYM @ 20 tons ha\(^{-1}\) + 100% recommended dose of Fertilizer + *Azatobacter* SSP + *Pseudomonas striata* recorded significantly higher shelling percentage protein content and yield oil yield, mean yield of pod and haulm as well as grass reetrains than the control at application of only FYM @ 10 tons ha\(^{-1}\) *Azatobacter* SSP + *Pseudomonas striata*, 50% N of recommended dose of fertilizer + *Pseudomonas straita* 50% P\(_2\)O\(_5\) of recommended dose of fertilizer + *Azatobacter* SSP and 50% recommended dose of fertilizer, while net returns were obtained maximum when crop was fertilized with only 100% recommended dose of fertilizer, similar trend was also observed for NPK content and uptake. Available nitrogen and phosphorous in soil was also improved with combined application of organic, inorganic and bio-fertilizer.

A field experiment was conducted by Ramesh and Sabala (2000) during the summer season of 1994 and 1995 to study the effect of phosphate...
fertilization P solubulizer and plant population on yield & quality of summer groundnut (*Arachis hypogaea* L.) the pod yield was significantly higher under 75 kg P$_{2}O_{5}$ ha$^{-1}$ application along with P solubulizer and with a population density of 0.33 million plants ha$^{-1}$ (30 cm x 10 cm).

Application of N, P and K in the order of 40, 75 and 45 kg ha$^{-1}$ has significantly increased the leaf area index (LAI) (Patra *et al.*, 1995). Reddy and Gajendragiri (1989) reported that application of P$_{2}O_{5}$ @ 40 kg ha$^{-1}$ significantly increased the LAI. Navase *et al.* (1995) observed that application of 75 kg P$_{2}O_{5}$ ha$^{-1}$ gave significantly higher leaf area and LAI.

Rao *et al.* (1995) concluded that in groundnut crop the highest pod yield was resulted when it received 15 kg N ha$^{-1}$ than the control treatments.

Navase *et al.* (1995) reported that application of P @ 75 kg ha$^{-1}$ significantly increased the pod yield and harvest index in sandy clay loams of Dapoli.

Application of 60 kg P$_{2}O_{5}$ ha$^{-1}$ in medium black cotton soils at Khargone of Madhya Pradesh (Mishra, 1994); 26.4 kg P$_{2}O_{5}$ ha$^{-1}$ in Entisol at Kalyani (Sammi and Minajurahasan 1997) and 40 kg P$_{2}O_{5}$ ha$^{-1}$ (Vasisht and Pandey, 1999) significantly increased the shelling per cent and 100-kernel weight. But under West Bengal conditions, Patra *et al.* (1995) observed that N application from 0 to 40 kg ha$^{-1}$ and potassium application at 45 kg ha$^{-1}$ did not show any significant influence on shelling per cent.
Conversely, Satpathy and Patro (1992) found that pod and haulm yields of groundnut were not affected with increasing levels of phosphorus from 0 to 60 kg P$_2$O$_5$ ha$^{-1}$ at Bhubaneswar. Choudhary et al. (1991) reported no significant increase in pod yields of groundnut with 60 kg P$_2$O$_5$ ha$^{-1}$ at Akola.

Quadri et al. (1991) reported that application of P @ 60 kg P$_2$O$_5$ ha$^{-1}$ significantly increased the pods plant$^{-1}$ in clay soils at Parbhani (Maharashtra). Patra et al. (1995) reported that higher number of pods plant$^{-1}$ were recorded with 40 and 45 kg N and P$_2$O$_5$ ha$^{-1}$, respectively in loamy soils at Kalyani (West Bengal).

Quadri et al. (1991) found significant increase in dry matter production with increase in levels of phosphorus from 0 to 60 kg P$_2$O$_5$ ha$^{-1}$ during kharif at Pharbini, Maharashtra. Reddy and Murthy (1984) reported significant increase in dry matter accumulation over control when 60 kg P$_2$O$_5$ ha$^{-1}$ was applied in sandy loam soil.

Jana et al. (1990) found that increased levels of phosphorus from 0 to 80 kg P$_2$O$_5$ ha$^{-1}$ increased the pods per plant and 100-kernel weight on a silty loam alluvial soil at Kalyani, West Bengal.

Phosphorus application at 40 kg ha$^{-1}$ significantly increased the dry matter production (Sarathi et al., 1990 and Rayar, 1986).

Reddy and Gajendragiri (1989) and Sarathi et al. (1990) reported higher pod and haulm yields with 40 kg P$_2$O$_5$ ha$^{-1}$. Several research workers
reported an increase in pod and haulm yields with 60 kg P₂O₅ ha⁻¹ (Raju et al., 1985; Dubey et al., 1986; Chauhan et al., 1987); Venkateswarlu and Nath 1989; Quadri et al., 1991 and Dimree et al., 1993).

Phosphorus at 100 kg P₂O₅ ha⁻¹ as boronated super phosphate and single super phosphate increased the drymatter significantly (Wani et al. 1988). Nimjee (1992), while working on a deep Vertisol at Bhopal, obtained significant response in drymatter with increasing phosphorus levels from 30 to 90 kg P₂O₅ ha⁻¹. Similarly, Singh and Ahuja (1985) reported significant increase in drymatter with increased phosphorus levels from 30 to 90 kg P₂O₅ ha⁻¹ on a sandy loam soil at Bichpuri, Agra.

The highest seed and straw yields in nitrogen were obtained with combination of compost + 10 kg N ha⁻¹ and 40 kg P ha⁻¹ (Sharma and Dixit, 1987).

Budhar et al. (1986) noticed an increase in pod yield with increased phosphorus levels from 60 to 120 kg P₂O₅ ha⁻¹ on a red sandy loam at Palyur, Tamil Nadu.

According to Dubey et al. (1986) the number of filled pods plant⁻¹ were increased with increasing phosphorus levels from 0 to 60 kg P₂O₅ ha⁻¹ on a black clay soil at Jabalpur. Phosphorus at 25 kg P₂O₅ ha⁻¹ significantly increased number of pods plant⁻¹ and 100-kernel weight. Different levels of both P₂O₅ and K₂O (Jana et al., 1990) and P₂O₅ alone (Singh et al., 1994) resulted in a significant increase in the number of pods plant⁻¹ over control.
Mallareddy (1983) observed a significant increase in plant height with increased rates of phosphorus from 0 to 40 kg P$_2$O$_5$ ha$^{-1}$. Similar results were reported by Sarathi et al. (1990) and Raju et al. (1985).

Jain (1983) found that increased rates of phosphorus from 0 to 80 kg P$_2$O$_5$ ha$^{-1}$ did not affect the plant height significantly in sandy loam soils with medium phosphorus status during *kharif* season at Gwalior.

Tomar *et al.* (1983), Raghuram (1987) and Narayanarao (1989) reported increased plant height at 60 kg P$_2$O$_5$ ha$^{-1}$. Quadri *et al.* (1991) reported increased drymatter production due to application of P$_2$O$_5$ at 60 kg ha$^{-1}$. Barik and Mukherjee (1997) reported higher number of nodules plant$^{-1}$ from 45 DAS onwards at a fertilizer dose of 40, 60 and 40 NPK ha$^{-1}$, respectively in a sandy loam soil at Gay-espur (West Bengal).

Jadhav and Narkhede (1982) observed an increase in the number of developed pods per plant with application of nitrogen. Chavan and Kaira (1983) recorded more pods plant$^{-1}$, 100-kernel weight and shelling percentage with phosphorus @ 75 kg P$_2$O$_5$ ha$^{-1}$ at Dapoli, Maharashtra.

Phosphorus at 20 kg P$_2$O$_5$ ha$^{-1}$ increased the pod yield on Tolewal loamy sand at Ludhiana (Alkhula *et al*., 1980). At Junagadh, on clayey soil with medium available phosphorus an increase in pod yield was recorded with 25 kg P$_2$O$_5$ ha$^{-1}$ (Modhawadia *et al*., 1981).

Muralidharan and George (1971) reported that application of “P” at 50 kg P$_2$O$_5$ ha$^{-1}$ resulted in significant increase in plant height. There was no response to 75 kg P$_2$O$_5$ ha$^{-1}$ level at Vellayani, Kerala.
2.1.4 Nutrient uptake

Deka et al. (2001) reported that application of \( P_2O_5 \) at 50 kg ha\(^{-1} \) significantly improved the uptake of NPK by groundnut crop in sandy loams at Jorat (Rajasthan). Shelke and Khuspe (1980) reported that the uptake of phosphorus was significantly higher both by kernels and haulms at 40 kg P\(_2\)O\(_5\) ha\(^{-1}\) in the clayey soils.

Yakadri and Satyanarayana (1995) reported that application of NPK @ 30, 60 and 60 kg ha\(^{-1}\) significantly increased nutrient uptake both by pods and haulms at harvest. Groundnut cultivar TMV2 removed higher amounts of NPK (39.0, 13.3 and 55.1 kg ha\(^{-1}\)) from the soil compared to Kadiri-3 in a sandy loam soil at Hyderabad when P\(_2\)O\(_5\) and K\(_2\)O were applied at 60 and 40 kg ha\(^{-1}\), respectively (Lakshmamma and Shivraj, 1997).

Sathone and Babulkar (1991) found an increase in phosphorus uptake with increasing phosphorus levels from 0 to 75 kg ha\(^{-1}\) in calcareous Vertisol of Vidharba region of Maharashtra.

2.2 EFFECT OF MOLYBDENUM AND OTHER MICRONUTRIENTS ON GROWTH AND YIELD OF GROUNDNUT

Krishnappa et al. (1992) found that molybdenum at 1.08 g kg\(^{-1}\) seed increased the number of nodules plant\(^{-1}\) in groundnut during kharif season at Dharwad in two experiments with medium black soil.

In soybean, molybdenum soil application at 11.7 g ha\(^{-1}\) exerted a significant influence on plant growth at Bhubaneswar on loamy sand (Nayak et al., 1989).
In groundnut, seed treatment with 1.56 g molybdenum resulted in scorching of root tip resulting in production of 3-4 new lateral roots (Shivashankar, 1987).

Gupta and Potalia (1987) recorded an increase in growth of peanut with soil application of molybdenum at 0.35 kg ha\(^{-1}\).

### 2.2.1 Yield attributes and yield

In soybean, increased yields were recorded with molybdenum seed treatment at 1.56 and 3.1 g kg\(^{-1}\) seed (Shivashankar and Shivaramu, 1990).

In groundnut, pot culture experiment showed an increase in pod yield and 100 seed weight when the plants were sprayed twice with total molybdenum application of 108 kg ha\(^{-1}\) (Saad et al., 1989). At Kanpur, Saxena and Mehrotra (1988) obtained higher yields of groundnut with 0.30 and 0.60 kg ha\(^{-1}\). Dakshinamoorthy et al. (1987) recorded a significant increase in yield of groundnut on red loamy sandy soil with molybdenum at 0.29 kg ha\(^{-1}\).

Kadam and Desai (1983) reported that pod yield of groundnut increased with molybdenum application at 1.2 g kg\(^{-1}\) seed whereas Vajranabhaiah et al. (1984) stated that application of 54 to 108 g ha\(^{-1}\) molybdenum as foliar spray to groundnut before flowering increased the number of filled pods plant ha\(^{-1}\), 100 seed weight and also pod yield.

De and Chatterjee (1976) working on sandy loam soil in West Bengal recorded increased pod yield in groundnut with molybdenum at 0.78 g ha\(^{-1}\).
In a pot culture experiment Kabeerathumma (1977) reported highest yield with 0.195 kg ha\(^{-1}\) molybdenum using red loam soil in soybean at Vellayani, Kerala. Sanjeevaiah (1969) recorded a pod yield of 2049 kg ha\(^{-1}\) on a sandy loam soil at Hebbal, Bangalore in groundnut. From the above review, it can be inferred that molybdenum application ranging from 54 to 10 g ha\(^{-1}\) as foliar spray or 1.2 g to 3.1 g kg\(^{-1}\) seed as seed treatment (144 to 372 g ha\(^{-1}\)) or soil application of molybdenum ranging from 190 to 600 g ha\(^{-1}\) resulted in higher yield of groundnut or soybean.

2.2.2 Interaction of molybdenum with phosphorus and others on growth and yield of groundnut

Wankade et al. (1992) from Akola reported that maximum nodule number and weight of nodules plant\(^{-1}\) were recorded with rhizobium + molybdenum at 4 g kg\(^{-1}\) seed in groundnut.

Shivashankar (1987) reported increase in yield of groundnut with molybdenum seed treatment at 2.34 g kg seed along with 75 kg P\(_2\)O\(_5\) ha\(^{-1}\).

In Soybean, seed treatment with 1.56 g kg\(^{-1}\) seed molybdenum increased the plant height significantly along with incorporation of 3 tons of paddy straw ha\(^{-1}\) (Shivashankar, 1977).

2.2.3 Molybdenum uptake

A field trial was conducted by Gayathridevi (2005) to study the effect of integrated case of biofertilizers viz., Rhizobium and PSB, chemical fertilizers and FYM on the nutrient uptake of groundnut crop and fertility status of sandy loam soils. Significant increases in uptake of major nutrients
(NPK) and micro nutrients (Fe, Mn, Cu, and Zn) was recorded by the treatments where in 75% RNP Rhizobium PSB and FYM were used in combination. Fertility status of the soil in respect of major and micro nutrients was significantly increased after crop harvest in the plots where bio fertilizers, chemical fertilizers and FYM were used conjunctively chemical fertilizer applied plots recorded higher NPK uptake as compared to FYM treated plots but with respect to nutrient buildup in soils FYM fared well.

Gouri et al. (2004) conducted an experiment and results indicated that increase in vapour pressure deficit (atmospheric dryness) during reproductive and pod filling phases adversely affected the partitioning of dry matter to pod but favoured the total dry matter production.

Maiti and Singh (2003) observed that application of sewage sludge caused significant increase in DTPA extractable micronutrient contents of soil. They also reported that the relative toxicity of metals to mustard plants followed the order of Cd > Ni > Zn.

Ramani et al. (2002) carried out an experiment at college farm of Anand Agricultural University. The micronutrients in the form of formulations for seed treatment were tested with two sources of elements viz. Zn, Mn and Mo and compared with standard recommended soil/foliar application of individual micro nutrient the seed treatment with solutions as such of Zn, Mn and Mo was made to groundnut seed @16.12 and 6 ml / kg containing 30 25 and 125% of Zn, Mn and Mo, respectively. The groundnut pod haulm and total yields were increased significantly over control under
different treatments. The seed treatment with Zn @16 ml/kg seeds containing 30%, Zn was also comparable in increasing yield of groundnut with soil application of ZnSO$_4$ @ 5 kg ha$^{-1}$. Increase of Mn, the seed treatment @ 12 ml kg$^{-1}$ seed containing 25% Mn through Mn increased groundnut pod yield by about 2 q ha$^{-1}$ over control. Similarly the seed treatment with ammonium molybdate @ 6 ml kg$^{-1}$ of seed of 12.5% Mo concentration was also found superior over other Mo treatments to increase pod, haulm and total yields. The uptake of micronutrients by groundnut was significantly higher over central due to treated clay soil.

Sheriff et al. (2001) reported that the contents of micronutrients increased significantly with increasing rates of sludge application i.e. from 4.12 to 25.44, 1.84 to 35.97 and 2.56 to 21.73 mg kg$^{-1}$ for Fe, Zn and Mn, respectively. But Cu differed in its response to sludge application. Cu did not respond significantly to the sludge addition.

Field experiments were conducted by Venkatesu et al. (2002) to study the response of groundnut (*Arachis hypogaea* L.) to sulphur, boron, and FYM levels. Sulphur application @ 40 kg ha$^{-1}$ resulted in maximum yield quality and residual soil nutrient status. Boron application @ 3 kg/ha was beneficial for getting maximum pod yield, protein content, sulphur and boron uptake and residual nutrient status. FYM @ 5 t ha$^{-1}$ significantly increased the yield and quality of groundnut. Interaction of sulphur and boron levels were significant for sulphur and boron uptake by kernels and soil available sulphur status where as interaction of sulphur and FYM was
significant for sulphur and boron uptake and soil available boron was also significantly and positively influenced by boron and FYM interaction.

A field experiment was conducted by Parusuraman and Mani (2000) to evaluate the effect of integrated nutrient management with 4 levels of N and 3 integrating factors (Biofertilizer, enriched farmyard manure and composted coirpith) for groundnut (*Arachis hypogaea* L.) The use of composted coirpith provided better nutritional environment in the soil far groundnut. The 75 and 100% soil test based levels of N along with composted coirpith rated better accounting for higher yields.

A field experiment was conducted by Nagaraj *et al.* (1998) on black clay loams during post rainy/summer seasons of 1997-98 to evaluate the effect of Plant Density (PD) and Fertilizer Management Practices (FMP) on yield of groundnut. The results revealed that plant density of 1.48, 148 plants ha⁻¹ recorded higher dry pod yield (1717 kg ha⁻¹) compared to lower plant density of 74, 074 plants ha⁻¹ (1491 kg ha⁻¹) and 1, 11, 111 plants ha⁻¹ (1535 kg ha⁻¹) FMP involving the application of Recommended Dose of Fertilizer (RDF) 25 Kg N, 32.7 kg P and 20.72 kg ha⁻¹ + FYM @ 7.5 t ha⁻¹ + Vermi compost @1 t ha⁻¹ + Micronutrients (4.5 kg Fe ha⁻¹ + 5 kg Zn ha⁻¹ + 0.25 kg Mo ha⁻¹) produced significantly higher dry Pod yield of groundnut (1796 kg ha⁻¹) compared to FMP involving RDF only (1475 kg ha⁻¹) among the intersection effects FMP involving application of RDF + Vermi compost @ 1 ton ha⁻¹ + Micronutrients (4.5 kg Fe ha⁻¹ + 5 kg Zn ha⁻¹ + 0.25 kg Mo ha⁻¹) 1, 11,111 plants/ha⁻¹ gave higher
dry pod yield (1941 kg ha\(^{-1}\)) and kernel yield (1265 kg ha\(^{-1}\)) compared to fertilizer management practice with application of recommended dose of fertilizers only at same plant density 1308 and 847 kg ha\(^{-1}\) respectively.

Mathur (1997) found decreased availability of Zn, Cu, Fe and Mn due to continuous cropping of cotton-wheat. However, application of FYM significantly increased Zn and Mn in soil compared to rest of the treatments.

Bellakki and Badanur (1997) found that application of organic manures either alone or in combination with fertilizers significantly increased the micronutrient status of the black soils.

Hedge (1996) observed that the integrated nutrient supply increased the available soil Mn and Fe, while available Cu and Zn remained unaffected.

Venkatesh and Omanwar (1994) reported that continuous rotation cropping with rice-wheat-cowpea fertilization or without fertilization in an Alfisol decreased DTPA extractable micronutrients indicated these nutrients were utilized from soil to meet the requirements of crops.

Rajeevkumar et al. (1993) reported that available micronutrients in soil were highest with NPK + FYM application resulted in variation in pH which ultimately altered the available micronutrient status.

Kabeeruthamma et al. (1993) observed that Zn and Cu declined under continuous cropping of cassava with addition of only chemical fertilizers. However, addition of FYM increased soil available Zn and Cu.
A field experiment was conducted by Laxminarayana (2001) during rabi 1992 to study the effect of mixing of black clayey soils and different levels of potassium on a sandy soil on yield attributes and nutrient composition of groundnut. Number of filled pods per plant, number of kernels per pod test weight, shelling percentage pod yield, haulm yield and crude protein content were significantly increased with the addition of clay through vertisol and potassium to a low potassium sandy soil. Nutrient concentration of NPK Ca Mg, S, Fe, Cu, Mn and Zn at mid flowering and harvest stages was increased with the addition of black clayey soil which acts as a reservoir for various nutrients.

Polara et al. (1991) observed that the uptake of micronutrients in whole pant tended to increase gradually as the crop growth progressed. Yang et al. (1990) found that organic manures improved the availability of Zn and Mn in soils, but their effects were more pronounced on the availability of Mn than Zn. Sureshlal and Mathur (1989) concluded from the permanent manurial experiment conducted at Ranchi in an acid red loam soil under maize and wheat cropping sequence, that the removal of zinc was lower in the presence of lime and more so with farm yard manure application. He also reported that continuous application of FYM over 30 years increased DTPA extractable Zn, Cu, Mn and Fe in Alfisol.

Sharma and Minhas (1986) reported that in soybean, the molybdenum seed treatment at 140 g ha⁻¹ increased the uptake of molybdenum in seed to 0.810 g ha⁻¹. Hansaraj and Gupta (1986) reported significantly higher wheat
grain yield and marked increase in Zn concentration with the addition of
farm yard manure. In a pot culture experiment with groundnut conducted by
Reddy and Raju, (1985) using red sandy loam soil obtained uptake of
molybdenum as 0.047 mg pot⁻¹ in haulm and 0.022 mg pot⁻¹ in seed with soil
application of 2.42 kg ha⁻¹ molybdenum.

Minhas and Mehta (1984) reported a depressive effect of higher
levels of NPK fertilizers on zinc content in soil due to excess removal of Zn
by the crop or because of insoluble zinc phosphate formation with abundant
P from increased fertilizer. Kanwar et al. (1983) found that the
concentration of micronutrients in groundnut plant were 5 to 55, 1.25 to
18.0, 33.0 to 150.0 and 19.0 to 183 and 7.0 to 40.5, 12.5 to 12.50, 66 to
226.0 and 12.0 to 260.0 of Zn, Cu, Fe and Mn at vegetative and fruiting
stages respectively.

In a green house experiment conducted on a sandy soil at HAU,
Mahendrasingh and Vinodkumar (1979) reported that in soybean soil
application of molybdenum at 0.875 kg ha⁻¹ increased the uptake from
0.026 to 0.05 mg pot⁻¹ and 0.04 to 0.09 pot⁻¹ at 45 and 110 days,
respectively.

In a permanent manurial experiment on saline-sandy loam soil with
wheat-maize sequence at Ludhiana (Punjab), Sharma and Meelu (1975)
found decreased DTPA extractable zinc content with continuous application
of phosphorus, due to negative P-Zn interaction. They showed that
application of phosphorus has reduced the concentration of zinc in maize
and wheat crops, while FYM and K has increased the concentration of zinc in crops grown in non-saline sandy loam soil in permanent manorial trial at Ludhiana.

Muralidharan and George (1971) obtained significant increase in height of plants, number of leaves, production of drymatter and weight of nodules with application of 75 kg P$_2$O$_5$ and 1 kg Na Mo$_4$ ha$^{-1}$.

Boswell et al. (1967) conducted five trials over years on effect of applied molybdenum on groundnuts as related to dolomite lime stone, nitrogen, time and method of molybdenum application, varieties and soils. Molybdenum content of the leaf petiole and kernels samples increased with the increasing rates of applied molybdenum and soil pH. Yield values were not well correlated neither with molybdenum content of leaves and kernels nor with soil pH. In areas where molybdenum increased yields, the best results were obtained by application to seed and top foliage three weeks after early flowering stage. In most trials molybdenum application increased plant size and vigour but visual responses were not useful criteria for predicting yield increases.

In a field experiment Giller (1966) found that groundnut plants treated with molybdenum had darker leaves, showed better growth and had larger, heavier and more numerous nodules than untreated plants. Molybdenum also increased pod yield and leaf nitrogen content.

Welch and Anderson (1962) reported that molybdenum application at 0.22 kg ha$^{-1}$ to a sandy loam soil in Georgia resulted in the uptake of
molybdenum in groundnut as 1.39 ppm in leaf and 5.15 ppm in kernel. Regarding the effect of FYM and compost on groundnut, the information available from pot culture experiments and trials in the fields, reported positive response of groundnut crop growth to the application of FYM and compost. FYM and compost release nutrients slowly into the soil and continuously throughout the crop growth period. Due to this phenomenon, the plant never develops undesirable levels of succulence, which indirectly help in resisting pest attack. It was also found that FYM and VC applied plots recorded minimum population of aphids and mites in chilli. Drymatter production of TMV-2 was found to be higher at 5 t FYM ha\(^{-1}\) compared to control on a sandy loam soil of Tirupati.

### 2.3 EFFECT OF VERMICOMPOST ON GROWTH AND YIELD OF GROUNDNUT

The compost prepared by using earthworms is called vermicompost. Vermicompost is regarded as a valuable bio-fertilizer and an important component of organic farming package. It is rich in plant nutrients, beneficial soil microbes, vitamins, antibiotics and plant hormones. Its role in enriching nutrient status of the soils and maintaining soil reactions, favourable for promoting plant growth, yield and quality is now very well appreciated.

The application of vermicompost to the fields improves the soil fertility by improving the soil structure. Vermicastings are a rich source of macro and micronutrients, besides its neutralization of soil pH by buffering
action, reduction of soil toxicity, arresting soil erosion and leaching, preventing soil degradation and enhancing soil fertility and enhancing quality, shelf life and nutritive value of horticultural crops enabling value addition to the produce. Host plants develop resistance by balanced nutrition provided by vermicompost and soil microorganisms including earthworms (Koteswararao, 2005).

2.3.1 Growth, Yield attributes, yield, quality parameters, nutrient uptake and incidence of insect pests

Singh (2007) observed that application of bacterial fertilizer (Vrikhamitra) had significantly increased the pod yield of groundnut at RDF + 16 kg Vrikhamitra while lowest was found at RDF alone.

Groundnut varieties (TGS1, TKG19A, TG22 and ICGS 49) did not differ significantly in number of pods/plant kernel/pod and Shilling percentage due to various levels of gypsum application. However 100 kernel weight was highest in ICGS 49 pod yield, kernel yield and harvest index were higher in variety ICGS 49 over TG22 TKG 19A and TGS1. Haulm yield was highest in TG22 followed by ICGS 49. Application of gypsum @ 400 kg ha⁻¹ significantly increased the number of pods/plant, kernal weight, shelling percentage, oil content, protein content pod yield, kernel yield, oil yield and harvest index (Sammi et al., 2006).

Ghosh et al. (2005) revealed that combined application of FYM @ 20 t ha⁻¹ + 100 per cent recommended dose of fertilizer + Azatobacter spp. + Pseudomonas straita recorded significantly higher shelling percentage,
protein content, oil content of groundnut crop over control and application of only FYM @ 10 t ha\(^{-1}\) + *Azatobacter* spp. + *Pseudomonas straita* + 50 per cent recommended dose of fertilizers.

A field experiment was conducted by Laxminarayana (2004) at ICAR Mizoram centre. The results revealed that application of optimum dose of NPK in combination with FYM @ 15 t ha\(^{-1}\) recorded highest pod yield haulm yield and other yield attributes. Graded doses of NPK application significantly increase the pod yields over control, that yield response was quite high with the optimum doses of NPK. The available nutrient status of the soil significantly improved with the combined application of organic and inorganic manures.

Poornesh *et al.* (2004) reported that effects urban garbage compost and sewage sludge on yield of ragi and soil properties. They concluded that application of 10 tonnes urban garbage compost + 4 tonnes sewage sludge resulted in a slight increase in soil pH. However, significant increase in organic carbon and lower electrical conductivity values of amended soil were observed when compared with control.

Residual effects of organic manures (farm yard manure, *Sesbania aculata*, green manure, press mud and vermicompost, N fertilizers (60, 120 or 160 kg ha\(^{-1}\)), 90 kg N ha\(^{-1}\) + *Azatobacter* and 100% NPK were shown that the organic manures significantly increased the content and uptake of N and P in grain and straw of cereal fodder-wheat system. In both the years the highest N content of grain and straw were obtained with 160 kg N ha\(^{-1}\) and 100% NPK on
soil test basis, whereas highest P contents of grain and straw were obtained with 120 kg N ha$^{-1}$, 160 kg N ha$^{-1}$, 90 kg N ha$^{-1}$ + Azotobacter and 100% NPK on soil test basis (Kathuria et al., 2004).

Rao (2003) reported that application of vermicompost induced the production of phenols and tannins in groundnut indicating the importance of induced resistance in plants. This was evidenced by the fact that incidence of groundnut leaf miner Aproaerema modicella, tobacco caterpillar Spodoptera litura and gram pod borer Helicoverpa armigera on groundnut showed positive relationship with nitrogen, protein content, amino acids and carbohydrates and negative relationship with phenols and tannins.

Wali and Vinodkumar (2003) reported that application of organic manures @ 1% (vermicompost, sheep manure, poultry manure and pig manure) enhanced urea hydrolysis in case of laboratory studies. This enhanced urea hydrolysis in different soils is due to the increased clay content and decreased with exchangeable sodium percentage.

Field experiments were conducted by Reddy et al. (2003) during rabi seasons of 2000 and 2001 application of 100% N through compost to preceding rice crop has resulted in the highest total dry matter Number of pods / plant, pod weight, Kernel weight, pod and haulm yield as well as nitrogen uptake of groundnut. The increase in pod yield of groundnut with application of 100% N through FYM to preceding rice crop was 14.84 and 18.24% over no nitrogen to rice and 10.71 and 13.73% over 100% N through fertilizer to rice during 2000 and 2001 respectively.
Reddy et al. (2005) conducted field experiments during the summer seasons of 2001-02 and 2002-03 at university of Agricultural Sciences, Bangalore to study the effect of composted poultry manure, sewage sludge and urban garbage, compost on yield quality and economics of groundnut. Conjunctive use of inorganics and organics (25:75:40 kg N P₂O₅ and K₂O+10 tones FYM ha⁻¹) recorded higher yield (pod, haulm, oil and protein) and economics (not returns oil benefit cost ratio) compared to application of organic manures alone. Among different organic manures composted poultry manure performed better in terms of yield and economics and was followed by sewage sludge.

Reddy and Reddy (2002) reported that organic sources at higher proportions can only sustain the nutrient status of soil to produce reasonable residual effect. Significant carry over effect due to substitution of nitrogen with higher proportions of organic sources to rich on the succeeding crops.

A survey conducted by Venkatesu et al. (2002) to study the nutrient status and groundnut grown in the Entisols of Nellore dist in Andhra Pradesh revealed that the available P status was sufficient in the surface horizons and deficient in the subsurface horizons of all the pedons. The available P and K decreased with soil profile depths while the exchangeable Ca, Mg, available S, Fe, Zn, Cu, Mn increased with depth. In general the soil was sufficient in available P, exchangeable Ca and Mg and available Fe and Mn while deficient in available K, S, Zn and Cu contents.
Chinnamuthu and Venkatakrishnan (2001) reported that application of vermicompost @ 2 t ha\(^{-1}\) recorded the highest seed yield compared to FYM application alone in control treatments in sunflower. They also reported that application of vermicompost @ 5 t ha\(^{-1}\) had significantly increased the availability of different nutrients in soil compared to FYM @ 10 t ha\(^{-1}\).

Mani and Duraisami (2001) observed the residual effects of *Azospirillum* enriched farm yard manure and composted coir pith @ 5 t ha\(^{-1}\), singly or in combination with N fertilizers (0, 50, 75 or 100% RDF 40 kg ha\(^{-1}\) on horsegram. All the treatments significantly enhanced yields, yield net returns, cost benefit ratio, N uptake by grain, P uptake by grain and haulms and soil phosphorus content. The application of 75% of the RDF + composted coir pith to ragi had the most beneficial residual effects on horsegram.

Nasser and Hussain (2001) compared that the application of farm yard manure, town refuse and compost on physico-chemical properties of sunflower grown soil and they concluded that FYM and town refuse were more efficient in decreasing the soil pH and ESP than compost.

Karthik and Dikshit (2001) reported that highest seed and haulm yields were obtained in groundnut by applying 50 percent recommended NPK + 10 t ha\(^{-1}\) compost than inorganic fertilizers alone or control.

Reddy *et al.* (2001) studied the beneficial effect application of sewage sludge, urban compost and FYM in various combinations and reported that sewage sludge, urban compost proportion at 1:1 gave maximum yield when
compared with sewage sludge, urban compost (2:1) ratio or only sewage sludge application. Soil physical and chemical properties like pH, EC, available N, P and organic carbon were highest among the combined application of sewage sludge and urban compost 1:1 in proportion.

Malligawad et al. (2000) reported that application of vermicompost (1 t ha$^{-1}$) and in situ vermiculture (release of earthworms @ 50,000 ha$^{-1}$) produced 12.3 and 10% higher yield in groundnut over control (27.5 t ha$^{-1}$). Singh (2000) reported that introduction of earthworms @ 60,000 t ha$^{-1}$ produced higher pod yield over conventional system in sandy loams at Mainpuri (U.P.). Pattar et al. (1999) reported the highest N, P and K uptake in vermicompost treated plots (2 t ha$^{-1}$) followed by FYM (10 t ha$^{-1}$). Rao and Yadagirireddy (1999) reported an increase of 20 per cent yield with 5 t vermicompost ha$^{-1}$ in hybrid rice plots in all the treatments of hybrid rice trial conducted at KVK, Gaddipalli, Nalgonda district.

Application of FYM @ 7.5 t ha$^{-1}$ or vermicompost @ 10 t ha$^{-1}$ along with 100 kg N ha$^{-1}$ produced grain and straw yields of wheat as well as biological yields that were on par with the recommended dose of fertilizers (120 : 60 : 25 kg N, P$_2$O$_5$, K$_2$O ha$^{-1}$) during both years of study (Ransinghranwa and Singh, 1999). Sreerekha and Narsa Reddy (1999) reported significantly higher drymatter production in groundnut due to application of 10 t FYM ha$^{-1}$ in the trial conducted at Agriculture College Farm, Bapatla, A.P.
Field experiments were conducted on red soils at Manoli, Hanumana Matti and Kulegen during summer 1995 and 1996 under irrigated condition to know the effect of different levels of copper ore tailing (COT) at 200, 400, 600 and 1000 kg per hectare and CuSO$_4$ at 10, 20 and 30 kg per hectare on groundnut (TMV-2) pooled date of two years of all the three locations indicated that application of COG @ 1000 kg COT ha$^{-1}$ significantly increased the concentration and uptake of Cu, Zn, Fe and Mn in haulm and kernels of groundnut. The highest uptake of Cu (56.12 g ha$^{-1}$), Zn (93.38 g ha$^{-1}$), Fe (1767 g ha$^{-1}$) and Mn (197.67 g ha$^{-1}$) in haulm and Cu (77.24 g ha$^{-1}$) Zn (93.38 g ha$^{-1}$) Fe (612 g ha$^{-1}$) and Mn (50.15 g ha$^{-1}$) in kernels of groundnut was obtained with 1000 kg COT ha$^{-1}$ application. The application of COT and CuSO$_4$ used as source of copper increased the uptake of other micro nutrients which helped for increasing the pod yield (24.30 g ha$^{-1}$) with 1000 kg COT ha$^{-1}$ significantly (Gundlur and Manjunathaiah, 1998).

A field experiment was conducted by Malligawad et al. (1998) on medium black clayey soils during three consecutive Kharif seasons of 1993, 1994 and 1995 to evaluate the effect of Vermi – treatment (vermicopost and in situ vermiculture) and fertilizer management practices on Yield of groundnut. Mean of the three years data revealed that the application of FYM @ 4 at t ha$^{-1}$ + 50% RDF (12.5 kg N 30 kg P$_2$O$_5$ and 12.5 kg K$_2$O ha$^{-1}$) recorded significantly higher dry pod yield of groundnut 3232 kg ha$^{-1}$ compared to either RDF (25 kg N, 75 kg P$_2$O$_5$ and 25 kg K$_2$O ha$^{-1}$ alone 3148 kg ha$^{-1}$ or no application 2742 kg ha$^{-1}$. Application of vermicompost @
1 ton ha\(^{-1}\) recorded higher pod yield 3090 kg ha\(^{-1}\) application and RDF + Vermicompost @ 1+ t ha\(^{-1}\) recorded higher dry pod yield (3389 kg ha\(^{-1}\)) compared to application of FYM @ 4 ton ha\(^{-1}\) + 50% RDF + Vermicompost @ 1 ton ha\(^{-1}\) (3249 kg ha\(^{-1}\)) application of vermicompost @ 1 ton ha\(^{-1}\) recorder higher net returns of Rs.20,636 ha\(^{-1}\) compared to control of Rs.18,580 ha\(^{-1}\).

Aruna (1998) reported that plant height, leaf area index, drymatter production of soybean were significantly increased by the application of 15 t ha\(^{-1}\) of vermicompost. Drymatter production, number and weight of functional nodules in greengram were significantly higher in vermicompost applied plots than FYM applied plots.

Lourduraj et al. (1998) confirmed that addition of farm yard manure, coir pith and composted coir pith along with inorganic fertilizer increased soil organic carbon but organic manures significantly increased the organic acid, lowered the bulk density as compared to inorganic fertilizers. Soil pH, oil contents were not significantly influenced by fertilizer levels or organic manures and stated that coir pith application favourably influenced certain soil physical properties like infiltration rate, hydraulic conductivity and moisture holding capacity.

Conversely, Agasimani (1996) observed that application of FYM did not show any significant effect on growth characters of groundnut. Mohammed Ali et al. (1974) also reported that no FYM application recorded
a 6.3 per cent increase in yield of groundnut as compared to 12.6 t ha\(^{-1}\) FYM application on red gravely loam soil at Bhavani Sagar (Tamil Nadu).

Geetalakshmi et al. (1993) reported that FYM at 12.5 t ha\(^{-1}\) with NPK and rhizobium increased the pod yield in groundnut at Aliyarnagar, Tamil Nadu. Dongale and Zende (1976) found positive response in increasing the groundnut yields from a field study with 5.5 t ha\(^{-1}\). They further reported that uptake of N, P and K increased at harvest with FYM under field conditions.

Sen and Bains (1953) also observed that certain organic acid and CO\(_2\) evolved during decomposition of organic manure produced solubulizing effect on Fe, Al, Mg and Ca Phosphate.

Jeevanrao (1992) reported the characteristics of urban solid waste of Hyderabad city. Compost pH ranged from 8.85 to 9.6 with a mean of 9.1, EC ranged from 130 to 500 \(\mu\text{S}\,\text{m}^{-1}\) with a mean of 266.3 \(\mu\text{S}\,\text{m}^{-1}\). CEC ranged from 63.33 to 115.0 cmol (p+) kg\(^{-1}\) waste and OC ranged from 5.3 to 6.23 per cent. Total N 0.38 to 0.50 per cent, total P 0.14 to 0.80 per cent and total K 0.19 to 0.45 per cent. Total contents of Fe, Mn, Zn, Cu, Pb, Ni, Co, Cr and Cd were 4863, 409.3, 234, 113, 135, 16, 5.5, 30 and 2.03 ppm’s, respectively.

Jankowski (1992) pointed out the effects of different organic manures like municipal sewage sludge, town refuse compost and farm manure alone or in combination with inorganic fertilizers on black meadow earth. The organic matter contents were 45, 12 and 73% for compost, sewage sludge and farm yard manure, respectively showing higher micro elemental...
Microbial activity was highest in compost + fertilizer treatment and increase in pH also was noticed in case of sewage sludge + fertilizer treatment only.

Vermicompost (1.5 t ha\(^{-1}\)) was as effective as FYM (5 t ha\(^{-1}\)) in increasing pod yield of groundnut. Among the four organic materials (FYM, compost, green leaf manure of *glyricidia* and groundnut shell) evaluated during *kharif* season at Tirupati, the highest pod yield was obtained with 5 t ha\(^{-1}\) of groundnut shell (Vivekananda *et al.*, 1992).

Ramachandran and D'Souza (1990) found that the characteristics of compost prepared from Bombay city wastes were pH 7.7, organic carbon 10.4%, total chromium content of 51.0 ppm and available Cr only in traces, total and available Mn contents as 622 and 45 ppm respectively.

Tester (1990) observed sewage sludge compost, cattle manure and fertilizer effects on physical properties of loamy sand soil. He concluded that the addition of sewage sludge compost significantly reduced the bulk density, increased the water holding capacity, soil water content and modified the pH to greater depths as compared to control.

Petruzzelli *et al.* (1989) studied the soil in which compost was treated for four years for heavy metal extractability. Copper concentration increased from 16.0 to 25.4 ppm; Zn from 21.1 to 37.4 ppm; Pb from 9.2 to 16.1 ppm; Ni from 3.8 to 6.7 ppm in DTPA extractable form. Soil pH increased by 0.50. The electrical conductivity increased from 0.07 dS m\(^{-1}\) to 0.11 dS m\(^{-1}\) following the treatments with a low rate of compost up to 0.20 dS m\(^{-1}\) for the highest addition.
(30 t ha$^{-1}$ yr$^{-1}$), highest rate of compost increased soil organic carbon from 0.09 to 0.17 per cent.

Chittapur and Angadi (1989) from Karnataka reported that FYM @ 2 t ha$^{-1}$ has increased the pod yield of groundnut on a fine textured soil during kharif season. An increase in yield of groundnut by 64 per cent was obtained with FYM at 7.5 t ha$^{-1}$ on a sandy loamy soil in Orissa (Rout et al., 1990); on red sandy loams of Andhra Pradesh (Reddy, 1991) and on a silty clay loam soil at Akola, drymatter and root also increased (Chawale et al., 1993).

Riffaldi and Levi-Minzi (1983) stated that with vermicomposting organic manure decomposes faster and present a slightly higher degree of humification. Regular application of worm cast to the arable crops has been found to improve the physico-chemical and biological properties of soil (Kale et al., 1990).

Kowald et al. (1982) reported that the application of 40, 80 or 120 t ha$^{-1}$ refuse compost over a two year period increased the soil pH from 5.1 to 5.9, 6.2 and 6.5 respectively. Carbon contents of the soil increased from 1.25 to 1.59% and phosphorus and potassium contents increased with increasing rate of application, cereal yields were not more than with chemical fertilization.

Subbaiah and Sreeramulu (1981) reported that addition of sewage sludge increased the organic matter content in the main crop and that was decreased in the next crop which could be attributed due to microbial
decomposition of added sludge with time. They also revealed that maximum improvement in physical conditions of soil.

Total N in worm castings increased with an increase in the rate of fertilizer application (Vleeschauwer and Lal 1981). Edward (1981) reported that the fertilization value of earthworm castings had beneficial effect on plant growth and crop improvement which was related to higher available mineral nutrients, exchangeable cation content and the basic exchange capacity.

Worms are beneficial to crop production in improving soil physical properties, in rendering some soil nutrients into readily available form and decreasing nutrient loses through leaching by temporarily mobilizing them in their biomass and excrement (Vleeschauwer and Lal, 1981).

Suka and Adachi (1980) found that application of refuse compost to soil increased the humus and exchangeable Ca of the AP horizon.

Ehlers (1975) observed that the earthworms are very much useful in improving the physical conditions of the soil. The honey comb-like structure is commonly observed under a forest cover in the tropics is partly attributed to the activity of earthworms (Nye, 1955).

According to Balasubramanian et al. (1972) organic manures / composts are invariably associated with large populations of bacteria, actinomycetes and fungi and are also able to stimulate the growth of those already present in the soil. The application of organics helps the soil microorganisms to produce polysaccharides, which build up better soil
structure. Nitrogen fixation and Phosphorus solubulization are also increased due to improved microbial activity in the organic amended soil.

Barle and Jennings (1959) showed that a vast population of non available nitrogen present in organic matter became available to plant through the process of vermicompost.

Uhlen (1953) reported from Sweden that two species of earthworms had increased barley yields in heavily manured soils in garden farms.

Waters (1952) reported that earthworms could increase plant yields even in soils which they had been removed. He revealed that *A. caliginosa* increased pasture production by between 28% to 100% and increased yields by as much as 110%.

The damage of leaf hoppers and thrips in groundnut was found to be lowest in vermicasting and vermicompost treated plots as compared to other situations. The difference in damage can be attributed to the provision of higher level of K₂O through vermicompost and vermicastings. The higher level of K₂O increases the turgidity of plant cell and as a result most of the sucking pests find difficulty in probing their mouth parts into the cell.

### 2.3.2 Yield attributes

Balasubramaniyan (1997) reported that FYM alone @ 12.5 t ha⁻¹ produced significantly higher pod yield in groundnut. Application of cattle manure @ 5 t ha⁻¹ registered 46 per cent higher pod yield over control in red Alfisols of Indonesia (Taufiq and Sudaryono, 1998). Ramaswamy *et al.*
(1999) reported that application of enriched FYM registered significant increase in pod yield of groundnut.

Chittapan et al. (1993) and Geethalakshmi et al. (1993) observed that application of FYM @ 12.5 t ha\(^{-1}\) resulted in significantly higher kernel weight in groundnut crop. Pranthi and Perumal (1992) concluded that farm compost @ 10 t ha\(^{-1}\) significantly increased the pod and haulm yields in groundnut. These results are in conformity with the results of Geethalakshmi et al. (1993), Desmukh and Dev (1995), Kadam et al. (2000), Chawale et al. (1993) and Chittippan et al. (1993).

Chittapur and Angadi (1989) from Karnataka reported that FYM @ 2 t ha\(^{-1}\) has increased the pod yield of groundnut during kharif season while

### 2.3.3 Nutrient uptake

Nasser and Hussain (2001) compared that the application of farm yard manure, town refuse, and compost on physico-chemical properties of sunflower grown soil and they concluded that FYM and town refuse were more efficient in decreasing the soil pH and ESP than compost.

Loganathan et al. (1996) reported significantly higher nitrogen uptake with the application of FYM @ 6.25 t ha\(^{-1}\) compared to zero FYM application. Sreerekha and Narsa Reddy (1999) reported that application of FYM alone @ 10 t ha\(^{-1}\) significantly influenced the uptake of NPK over zero application of FYM.

Prasad and Singhania (1995) found that phosphorus enriched manure maintained a higher level of phosphorus in soil solution for longer period.
Nitrogen, phosphorus and potassium uptake increased with the application of 5 t FYM ha$^{-1}$ in sandy loam soils of Tirupati during *kharif* season (Anonymous, 1988).

Jankowski (1992) pointed out the effects of different organic manures like municipal sewage sludge, town refuse compost and farm yard manure alone or in combination with inorganic fertilizers on black meadow earth. The organic matter contents were 45, 12, and 73 per cent for compost, sewage sludge and farm yard manure respectively showing higher micro elemental contents. Microbial activity was highest in compost + fertilizer treatment and increase in pH also was noticed in case of sewage sludge + fertilizer treatment only.

Yadav *et al.* (1991) reported that uptake of phosphorus and potassium by pods, roots and haulms of groundnut was more due to application of FYM. Enriched FYM and compost enhanced the NPK uptake by groundnut (Sagare *et al.*, 1992, Prasanthi and Perumal, 1992).

### 2.4 EFFECT OF PROXIMATE ANALYSIS

The literature available on proximate analysis i.e. proteins, fats and carbohydrates is furnished hereunder.

Reddy and Murthy (1989) suggested that percentage protein can be calculated by multiplying nitrogen per cent with 6.25 and nitrogen in kernels was determined by Microkjeldal method (A.O.A.C. 1955). Ratner *et al.* (1979) reported that there was an inverse relationship between seed protein and oil content of groundnut levels. It was reported by Nijhawan (1962) that there was inconsistent effect on the applied nutrients on seed protein. Chopra and Kanwar
(1966) and Singh et al. (1970) reported that applied nutrients have influenced indifferently in the accumulation of amino acids

2.5 OILS AND FATS

Reddy and Murthy (1989) reported that phosphorus application had significantly increased the oil content of groundnut kernels and also reported that differential response to applied phosphorus on oil content of kernel may be due to differences in supply of nature phosphorus.

While conducting an experiment on determination of oil content with application of molybdenum, Satyanarayana and Krishnarao (1962) observed that there was not much importance of molybdenum in increasing the oil content of groundnut kernels. There was slight increase in oil content of groundnut kernels as per the observations made by Chopra and Kanwar (1966) and Yadav and Singh (1970) in their studies. Punnose and George (1975) also reported that phosphorus application had slight influence on oil content of groundnut kernel.