Review of Literature
II REVIEW OF LITERATURE

In the last few years, the yield levels of many crops are either declining or stagnating because of appreciable decline in the organic matter level and fertility of soils all over the country. In this direction, it is the need of the hour to lay emphasis on application of adequate quantities of plant nutrients a key aspect of increasing productivity of different crops particularly in the areas where farmers following intensive agriculture. In this regard, the available literature on “system based nutrient management for maize and groundnut cropping sequences” is presented in this chapter under the following headings.

2.1 Effect of NPK on growth and yield of maize
2.2 Effect of NPK on growth and yield of sunflower
2.3 Effect of NPK on growth and yield of groundnut
2.4 Nutrient uptake and economics in maize crop as influenced by NPK
2.5 Nutrient uptake and economics in sunflower crop as influenced by NPK
2.6 Nutrient uptake and economics in groundnut crop as influenced by NPK

2.1 Effect of NPK levels on growth and yield of maize

Rai (1961) noticed early tasseling, silking and maturity by 9 to 16 days with the application of 88 kg N ha\(^{-1}\) as compared to no nitrogen application. Shah et al. (1971) reported that increasing levels of nitrogen application reduced the days to silking. Mandloi et al. (1972) noticed 6 to 10 days early silking with the application of 160 kg N ha\(^{-1}\). Similarly
many research workers have reported that increase in nitrogen level had reduced the days to silking significantly (Halemani et al., 1976; Rathore and Singh, 1976 and Shukla and Bharadwaj, 1976).

Ahlawat et al. (1975) reported that increasing nitrogen levels from 0-300 kg ha\(^{-1}\) increased the dry matter accumulation up to 90 to 95 days after sowing. While in no nitrogen treatment dry matter accumulation ceased after 70 to 80 days after sowing. The total dry matter production per plant differed significantly due to nitrogen levels. Every increase in nitrogen level from 75 to 225 kg ha\(^{-1}\) increased the dry matter production from 266 to 323 g plant\(^{-1}\) (Setty, 1981).

Schenk and Barber (1979) reported that increasing P level increased the shoot yield but had little effect on the amount of roots. High soil P had linear relationship with P uptake but at lower soil P status, observed P uptake was double the predicted uptake.

Halemani et al. (1980) observed that plant height of maize increased from 130 to 193 cm with increase in nitrogen level from 0 to 240 kg ha\(^{-1}\). Setty (1981) recorded increase in plant height from 190 to 201 cm with increase in nitrogen from 60 to 180 kg ha\(^{-1}\). Manish Kumar (1998) also recorded similar trend and reported that plant height increased from 203 to 233 cm with increase in nitrogen from 30 to 150 kg ha\(^{-1}\).

Okajima et al. (1983) from their field trails reported that response to the applied nitrogen was up to 200 kg ha\(^{-1}\). Grain yield of maize increased from 0.91 t ha\(^{-1}\) with no nitrogen to 10.09 t ha\(^{-1}\) with 200 kg N ha\(^{-1}\).

Application of 180 kg N ha\(^{-1}\) recorded maximum values of growth characters of maize viz., leaf area index and dry matter per plant. An
increased nitrogen level resulted in increased N availability in the soil and higher uptake by plants to produce larger leaves, more photosynthesis and dry matter accumulation which alternatively affected the yield and its attributes (Banganwa et al., 1988).

Thanki et al. (1988) indicated that increasing K\textsubscript{2}O rates from 0 to 60 kg K\textsubscript{2}O ha\textsuperscript{-1} increased the grain yield of hybrid maize (Ganga Safed-2). Significantly higher yield of 5.32 t ha\textsuperscript{-1} obtained with the application of 60 kg K\textsubscript{2}O ha\textsuperscript{-1} compared to control (4.86 t ha\textsuperscript{-1}).

Potassium application hastened silking in corn, but did not shorten the total production cycle thus gave scope for longer period of grain filling and higher yield (Anon., 1990 a).

Roy and Ajaykumar (1990) revealed that application of 67 kg K\textsubscript{2}O ha\textsuperscript{-1} recorded significantly higher grain yield (4.29 t ha\textsuperscript{-1}) and stover yield (10.3 t ha\textsuperscript{-1}) compared to without K application (2.26 t ha\textsuperscript{-1}). The response of grain yield to K was 39 kg grain per kg K.

Al Zubaidi and Al Semak (1992) reported that there was significant increase in dry matter weight when potassium fertilizer was applied. The higher dry matter weight was obtained when 240 and 360 kg K\textsubscript{2}O ha\textsuperscript{-1} was applied to sandy loam and silty loam soils, respectively.

Ratna Prasad (1993) concluded that maize stover and grain yield were significantly influenced by the application of potassium at 75 kg ha\textsuperscript{-1} in Alfisol soils of northern Karnataka. Application of 62.5 kg K ha\textsuperscript{-1} provided the higher dry matter production and also improved the cob length, number of rows and grains per cob and test weight of Deccan-103 Hybrid maize (Shivashankar and Sudhakar Babu, 1994).
Misra et al. (1994) stated that increased levels of nitrogen from 100 to 200 kg ha\(^{-1}\) resulted in significant increase in number of rows cob\(^{-1}\), 1000 grains weight and yield of maize.

Significantly higher grain and stover yield of maize was observed with 175 kg N ha\(^{-1}\) due to increased growth characters like plant height and the yield attributes like cob length, cob width, number of grains per cob and 100 grains weight (Selvaraju and Iruthayaraj, 1994).

Prasad and Prasad (1996) conducted experiment in maize for a target yield of 30 and 40 q ha\(^{-1}\) along with different levels of compost and fertilizers. They reported that application of compost 5 t ha\(^{-1}\) and 55, 41 and 27 kg NPK ha\(^{-1}\) recorded 31.1 q ha\(^{-1}\) and 135, 85 and 68 kg NPK ha\(^{-1}\) resulted in 42.8 q ha\(^{-1}\).

Sarita Jha et al. (1997) reported that application fertilizer along with FYM (5 t ha\(^{-1}\)) for a target yield of 50 q ha\(^{-1}\) recorded significantly higher seed yield of maize (4.8 t ha\(^{-1}\)).

Application of 10 t ha\(^{-1}\) FYM along with 250:125:62.5 kg N, P\(_2\)O\(_5\) and K\(_2\)O recorded higher maize grain yield with distinct residual effect on the yield of subsequent groundnut in maize-groundnut sequence (Dev, 1998).

Nanjundappa (1998) revealed that application of 60 kg K\(_2\)O ha\(^{-1}\) recorded significantly higher grain yield (8407 kg ha\(^{-1}\)) and stover yield (8941 kg ha\(^{-1}\)) of maize as compared to 20 kg K\(_2\)O ha\(^{-1}\) (7666 kg ha\(^{-1}\)) and 40 kg K\(_2\)O ha\(^{-1}\) (7759 kg ha\(^{-1}\)) besides recording higher K uptake and K content in maize grain.

Suri and Verma (1999) evaluated the nutrient requirement of maize through targeted yield concept in wet temperate zone of Himachal Pradesh. The results indicated that it is possible to improve maize yield
up to 50 q ha\(^{-1}\) by targeted yield approach and this approach was found to be superior over soil test based approach. The results further showed that NPK fertilizer doses for attaining targeted yield decrease with time due to fertility build up.

Chandrashekara Reddy and Riazuddin Ahmed (2000) evaluated the fertilizer requirement of maize from fertilizer adjustment equations for attaining specific yield targets in farmer’s field. The results indicated that fertilizer requirement of N, P\(_2\)O\(_5\) and K\(_2\)O were found to be 1.66, 1.12 and 1.55 kg, respectively for producing one quintal of maize grain yield in Inceptisols. Fertilizer adjustment equations were developed by whole field method, yield maximum method and yield response method. The higher grain yield of maize was obtained in 50 q ha\(^{-1}\) yield target compared to general recommended dose.

Application of potash increased the corn yield significantly by 17 to 20 per cent. Average increase in grain yield ranged between 17.3 and 23.2 per cent with 112.5 kg K\(_2\)O ha\(^{-1}\) and 20.1 to 26.2 per cent with 225 kg K\(_2\)O ha\(^{-1}\) when compared with the NP treatment (Lei et al., 2000).

Application of additional 50 per cent NPK or FYM 10 t ha\(^{-1}\) in addition to RDF increased the grain yield of maize by 25.9 and 13.9 per cent, respectively. However, reducing fertilizer by 50 per cent NPK even with FYM 10 t ha\(^{-1}\) reduced the yield by 10.9 per cent. Growth and nutrient uptake followed the trend of yield level and increased with higher fertility levels (Anil Kumar et al., 2002).

Singh et al. (2003) reported that application of higher recommended level of nitrogen and potassium (180 kg N and 60 kg K\(_2\)O ha\(^{-1}\)) recorded significantly higher growth and yield parameters. Grain yield (71.1 q ha\(^{-1}\)) and stover yield (114.3 q ha\(^{-1}\)) of maize were
significantly greater than recommended levels of N and K (120 kg N and 40 kg K₂O ha⁻¹). The increase in N and K levels beyond 50 per cent did not show further improvement up to the level of statistical significance.

A field experiment was conducted in *Alfisols* of Ranchi with various levels of NPK in maize. An increase in grain yield to the tune of 33 per cent was noticed with the higher rates of NPK application (210:90:150 kg NPK ha⁻¹) over the state recommended levels (100:60:40 kg NPK ha⁻¹). Total NPK uptake by maize was significantly higher under modified rates of NPK compared with state fertilizer recommendations (Anon., 2004).

Singh *et al.* (2005) estimated the fertilizer requirement for specific yield targets of maize in the alluvial soil of the Indo-Gangetic plains. The requirement of N, P and K for one tonne of grain yield was 26.6, 4.5 and 25.3 kg, respectively. Experimental results indicated that application of 200:65:65 kg NPK ha⁻¹ recorded significantly higher grain yield (3.3 t ha⁻¹).

Verma *et al.* (2005) conducted experiment to ascertain the validity of soil test based fertilizer prescriptions for achieving specific yield targets for maize crop in wet temperate zone of Himachal Pradesh. They revealed that fertilizer recommendations based on targeted yield concept were found more precise and dependable. They recorded higher grain yield of maize (5.2 t ha⁻¹) with higher application of 162:102:85 kg NPK ha⁻¹ compared to 3.2 t ha⁻¹ by state level recommendation (120:60:40 kg NPK ha⁻¹).

Harvest indices were significantly (p≤0.01) greater at 224 kg N ha⁻¹ fertility level compared to 179 kg N ha⁻¹ and 134 kg N ha⁻¹ level. Neither effect on HI by different rates of K fertility used in the experiment nor any
significant interaction for HI noted between N and K fertility levels. Increased HI was observed at the greater N fertility rates indicating N facilitates translocation of photosynthate to developing maize kernels (Arnold and Wayne 2006).

Arvind Verma et al. (2006) evaluated the effect of integrated nutrient supply on the productivity of maize in sandy clay loam soils of Udaipur. Results indicated that maximum plant height, leaf area index and dry matter (g plant⁻¹) at harvest was observed by applying 150 per cent recommended NPK. Significantly higher grain yield (34.15 q ha⁻¹) and stover yield (47.65 q ha⁻¹) were obtained with the application of 150 per cent NPK though the results were on par with 100 per cent NPK plus FYM 10 t ha⁻¹.

Dhillon et al. (2006) recorded higher grain yield (27.6 to 46.0 q ha⁻¹) with the application of fertilizer based on targeted yield (45 q ha⁻¹) approach when compared to farmers practice, general recommendation and soil test based recommendation.

Jayaprakash et al. (2006) reported that application of higher levels of fertilizers (200, 175, 150 and 125 % NPK) increased the grain yield of maize by 30, 26, 22 and 11 per cent, respectively over 100 per cent recommended NPK. Application of 200 per cent NPK recorded significantly higher stover yield of 10.31 t ha⁻¹ over 100 per cent recommended NPK (9.10 t ha⁻¹).

Increasing P levels up to 60 kg P₂O₅ ha⁻¹ significantly increased the yield attributes, grain and stover yield of maize. While N and P uptake was increased significantly up to application of 80 kg P₂O₅ ha⁻¹ (Mahala et al., 2006).
Suryavamshi et al. (2008) conducted a field experiment to study the response of maize to nitrogen and phosphorus application in Vertisols. They concluded that in Vertisols having low available nitrogen and medium available phosphorous, the yield potential of maize (67.50 q ha\(^{-1}\)) was obtained by application of 250 kg N ha\(^{-1}\) and 67.5 kg P\(_2\)O\(_5\) ha\(^{-1}\). They inferred that maize crop responded quadratically to both the inputs of nitrogen and phosphorous.

Trinh et al. (2008) revealed that maize yields of 8 to 10 t ha\(^{-1}\) can be achieved in Tan chau, Angiang. The higher yield of 9.85 t ha\(^{-1}\) was recorded on alluvium soil in dry season and 8.58 t ha\(^{-1}\) in wet season. Improved planting density with higher NPK rate by SSNM concept gave extra grain yield of 0.7 t ha\(^{-1}\) and net benefit by 833 thousand dollars ha\(^{-1}\) and 786 thousand dollars ha\(^{-1}\) in 2006 dry season and 2006 wet season, respectively.

Onasanya et al. (2009) conducted experiment in southern Nigeria with twelve different rates of nitrogen and phosphorus fertilizers on growth and yield of maize (Zea mays L.). They revealed that application of 120 kg N and 40 kg P ha\(^{-1}\) significantly increased the growth and yield (7.13 t ha\(^{-1}\)) of maize than other treatments.

2.2 Effect of NPK levels on growth and yield of sunflower

The most important factor affecting growth and yield of sunflower is the mineral nutrition especially nitrogen, phosphorus and potassium. Balanced fertilization of nitrogen, phosphorus and potassium are needed for better yield (Shelke et al., 1988). Since sunflower is exhaustive crop, adequate nutrition plays an important role in boosting the production (Shaktawat and Bansal, 1999). One of the ways to increase the productivity of sunflower particularly in non-irrigated areas is through
judicious fertilizer use which is very crucial in view of the high fertilizer cost (Poonghauzhalan et al., 2002).

Chaudhari et al. (1978) observed that application of 80 kg N, 120 kg P₂O₅, and 80 kg K₂O ha⁻¹ recorded significantly higher grain yield of 682 kg ha⁻¹ than lower levels.

Hiray et al. (1992) reported significant increase in all yield contributing characters with increase in dose of nitrogen to sunflower up to 80 kg N ha⁻¹ level. Jagtap and Sabale (1994) also reported 80 kg N ha⁻¹ as an optimum dose of nitrogen for better sunflower yields.

Kharchenko and Hartchenko (1992) reported increased sunflower seed yield by 0.2 tonnes per ha with application of 90:90:90 kg NPK ha⁻¹ than that with the application of 45:45:45 kg NPK ha⁻¹. Sirbu and Ailincai (1992) found that application of 80 kg N + 80 kg P₂O₅ + 80 kg K₂O ha⁻¹ produced the highest seed yield of 3.50 tonnes per ha.

Rachewad et al. (1992) reported that use of P solubalizing inoculants in association with single super phosphate and mussorie rock phosphate increased the P uptake and biomass production in sunflower.

On clay soil of Navasari in Gujarat, nitrogen increased the head diameter, 1000 seed weight, grain yield per plant and seeds per head, whereas phosphorous had no significant effect on yield attributes except 1000 seed weight and number of seeds per head (Khokani et al., 1993).

At Hisar, higher plant height, stem thickness and number of leaves were obtained under irrigation condition with 62 kg N and 46 kg P₂O₅ ha⁻¹ compared to 31 kg N and 23 kg P₂O₅ ha⁻¹ (Sharma et al., 1994).
Mishra *et al.* (1995) obtained higher seed yield of sunflower with higher levels of N and P$_2$O$_5$ per ha. Reddy and Kumar (1996) during *rabi* season in sandy clay loam soil of Andhra Pradesh observed that significantly higher dry matter production (2251 kg ha$^{-1}$) was noticed by application of 90 kg N ha$^{-1}$ compared to 60 kg N ha$^{-1}$ which recorded a lower dry matter of 1977 kg ha$^{-1}$. Due to higher dry matter production, significantly higher seed yield per plant of sunflower (19.6 g plant$^{-1}$) was obtained with application of 90 kg N ha$^{-1}$ as compared to application of 60 kg N ha$^{-1}$ (15.7 g plant$^{-1}$).

Ramamurthy and Shivashankar (1995) obtained significantly higher dry matter production of sunflower at 56.25 kg P$_2$O$_5$ ha$^{-1}$ (37.90 g plant$^{-1}$) over 37.5 kg P$_2$O$_5$ per hectare (36.10 g plant$^{-1}$).

Ujjinaiah *et al.* (1995) from Bangalore reported that the seed yield of sunflower during summer season was increased from 1982 to 2366 kg ha$^{-1}$ with increasing doses of nitrogen (30 to 90 kg ha$^{-1}$), phosphorus (45 to 135 kg P$_2$O$_5$ ha$^{-1}$) and potassium (45 to 90 kg K$_2$O ha$^{-1}$).

Application of phosphorus at the rate of 100 kg P$_2$O$_5$ ha$^{-1}$ recorded significantly higher dry matter production at 30 DAS (6.65 g plant$^{-1}$) compared to 75 kg P$_2$O$_5$ ha$^{-1}$ (6.35 g plant$^{-1}$). Similar trend was observed at 60 DAS and physiological maturity stage. Whereas, application of phosphorus at the rate of 125 kg ha$^{-1}$ produced significantly higher seed yield of sunflower (1084.24 kg ha$^{-1}$) and it was on par with 100 kg P$_2$O$_5$ (1047.03 kg ha$^{-1}$) compared to application of 75 kg phosphorus ha$^{-1}$ (947.33 kg ha$^{-1}$) (Shivaprasad *et al.*, 1996).

Oberholzer and Barnard (1997) obtained higher seed yield of sunflower in South Africa with application of 24 kg P ha$^{-1}$ as superphosphate. The same study also revealed that P content in leaf increased with increase in P application.
Reddy and Sudhakarababu (1997) reported that sunflower yield of kharif base crop was significantly influenced by fertilizer levels. The seed yield of sunflower increased from 50 per cent RDF (1132 kg ha\(^{-1}\)) to 100 per cent (1303 kg ha\(^{-1}\)) and 150 per cent RDF (1433 kg ha\(^{-1}\)).

Tomar et al. (1997) at Meerut on sandy loam soils under irrigation condition observed that application of 120 kg N ha\(^{-1}\) increased the plant height, number of leaves, LAI and ultimately seed yield by 21.17 and 5.59 per cent over 40 and 80 kg N ha\(^{-1}\). Tamak et al. (1997) observed increase in head diameter, 100 seed weight and seed yield with increased phosphorus application up to 90 kg P\(_2\)O\(_5\) ha\(^{-1}\).

Nagavani et al. (1997) revealed that application of nitrogen at the rate of 100 kg per ha along with scheduling irrigation at IW/CPE ratio of 1.0 in sandy clay loam soil of Tirupati gave significantly higher values of all the growth parameters in sunflower such as plant height (143.43 cm), number of green leaves per plant (11.43), dry matter production at harvest (675.38 g m\(^{-2}\)) compared to lower levels of nitrogen.

Ravi Gadagi and Alagawadi (1998) observed that inoculation of P solubalizing biofertilizers *Pseudomonas striata* and biophos has significantly increased the head weight, 100 seed weight and seed yield in sunflower.

Nitrogen and phosphorus application at 120 kg N ha\(^{-1}\) and 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) improves head diameter from 11.59 cm to 18.09 cm, 100 seed weight from 4.58 to 5.64 g and stalk yield from 4795 to 7605 kg ha\(^{-1}\) (Singh and Singh, 1997). Similar findings were also quoted by Devidayal and Agarwal (1999).

Vasudevan et al. (1997) revealed that application of 60:80:50 NPK ha\(^{-1}\) significantly increased the leaf area index and shoot length of 3.38
and 21.8 cm, respectively at 60 DAS when compared to application of 60:40:50 NPK kg ha\(^{-1}\) which recorded lower LAI and shoot length of 3.14 and 20.5 cm, respectively.

Lal et al. (1998) observed taller plants (164.4 to 168.00 cm), increased head diameter (11.26 to 11.73 cm) due to increased combined application of nitrogen, phosphorus and potassium fertilization at 80 kg N ha\(^{-1}\), 120 kg P\(_2\)O\(_5\) ha\(^{-1}\) and 80 kg K\(_2\)O ha\(^{-1}\), respectively over 40 kg N ha\(^{-1}\), 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) and 40 kg K\(_2\)O ha\(^{-1}\), respectively under sandy clay loam soil during summer season.

Edara and Patel (2000) reported that application of nitrogen at the rate of 100 kg ha\(^{-1}\) and 80 kg ha\(^{-1}\) did not differ significantly in terms of seed yield of sunflower (2070 kg ha\(^{-1}\) and 2104 kg ha\(^{-1}\), respectively) in the clayey soil of Gujarat but recorded significantly higher seed as well as stalk yield as compared to the lower level of 60 kg N ha\(^{-1}\) (1868 kg ha\(^{-1}\) and 5255 kg ha\(^{-1}\), respectively). However, phosphorous fertilization did not exert marked influence on both growth and yield.

Maragatham and Chellamuthu (2000) reported that the application of 120, 60 and 50 kg N, P and S ha\(^{-1}\), respectively increased the seed yield, oil yield and protein content in sunflower.

Sunflower crop respond up to 100 kg N ha\(^{-1}\) by yielding seed yield of 11.90 q ha\(^{-1}\) at Hyderabad. Application of N beyond 100 kg ha\(^{-1}\) did not increase the seed yield significantly (Pavankumar Reddy and Shaik Mohammad, 2000).

Number of filled seeds per head (668 to 1177) and stalk yield (4755 to 6800 kg ha\(^{-1}\)) of sunflower significantly increased due to higher combined doses of nitrogen (120 kg N ha\(^{-1}\)), phosphorus (120 kg P\(_2\)O\(_5\) ha\(^{-1}\))
and potassium (60 kg K₂O ha⁻¹) fertilizers over no NPK fertilization during kharif season (Thavaprakash, 2000).

Reddy et al. (2002) reported that fertilizer combination of 100-60-60 NPK kg ha⁻¹ + 500 kg gypsum and 0.2 per cent borax spray during flowering stage recorded significantly higher yield (2140 kg ha⁻¹) compared to 50-30-60 NPK kg ha⁻¹ in Vertisol with low available nitrogen and organic carbon and medium available phosphorus and potassium.

Seed treatment of sunflower seeds with Azospirillum sp. and phosphobacteria along with a fertilizer dose of 60:90:60 NPK kg ha⁻¹ recorded the maximum head diameter, seed yield per plant (51 g) and seed yield per ha (1183 kg) (Renugadevi and Balamurugan, 2002).

Thavaprakash and Malligawad (2002) recorded increased seed yield (1949 to 3554 kg ha⁻¹) in sunflower with the application of NPK at 120 N ha⁻¹, 120 kg P₂O₅ ha⁻¹ and 60 kg K₂O ha⁻¹ over application of low nitrogen and phosphorus with 60 kg K₂O ha⁻¹.

Patel and Thakur (2003) reported that phosphorus application at the rate of 80 kg P₂O₅ ha⁻¹ significantly increased plant height, test weight and seed yield (1311 kg ha⁻¹) and oil yield (540 kg ha⁻¹) over 60 and 40 kg P₂O₅ ha⁻¹.

Vijay Kumar (2005) reported that application of 100 per cent recommended dose of phosphorus with dual inoculation of Bacillus megaterium and Glomus fasciculatum recorded higher seed yield (1519 kg ha⁻¹) with B:C ratio (6.54) over uninoculated treatment (1269 kg ha⁻¹ and 5.57 of seed yield and B:C ratio, respectively) in sunflower.

Yadav et al. (2009) conducted a field trial for 3 consecutive spring season from 2005-06 to 2007-08 on sandy loam soil to study the effect of nutrient levels on productivity and profitability of sunflower at Morena,
Madhya Pradesh. They observed that the nutrient treatment of 125 % recommended dose of fertilizer recorded significantly higher seed yield (1.76 t ha⁻¹), stalk yield (6.56 t ha⁻¹), NPK uptake, net income (₹ 11,784 ha⁻¹) and B:C ratio (1.80) over other nutrient levels.

Several research workers revealed that combined fertilization of higher doses of nitrogen and phosphorus along with potassium fertilizer had registered beneficial effects on increasing growth, seed yield, seed protein and seed oil content of sunflower.

2.3 Effect of NPK levels on growth and yields of groundnut

Groundnut farmers from most part of the semi-arid region use very less nutrient fertilizer and sometime only one or two nutrients resulting in severe mineral nutrient deficiencies and due to inadequate and imbalance use of nutrients, the groundnut yield was very poor in India. India is the world’s largest producer of groundnut where nutritional disorders cause yield reduction to the extent of 30-70 per cent depending upon soil types. Thus it is time to look into the mineral nutrition aspects of groundnut for achieving high yield and advocate the suitable fertilizer recommendation for optimization of yield (Singh, 2004).

Jadav and Matkhede (1982) reported that groundnut recorded higher dry matter accumulation, RGR, leaf area per plant and leaf area index with the application of 60 kg and 90 kg K₂O ha⁻¹ when compared to the control. Higher leaf area index in groundnut with application of 40 kg N ha⁻¹ as compared to lower doses (20 kg ha⁻¹) and control was also reported by Reddy et al. (1982).

Patel et al. (1983) observed that groundnut recorded higher plant height (17.1 cm) with the application of 25 and 50 kg N and P₂O₅ ha⁻¹,
respectively compared to the lower doses (12.5 and 25 kg N and P₂O₅ ha⁻¹, respectively) which recorded plant height of 16.3 cm.

Jakhro (1984) observed that the groundnut recorded higher mean number of pods per plant and nodule per plant with the application of 40 kg N ha⁻¹ compared to other levels.

Throve et al. (1989) obtained increased pod yield of groundnut with the increasing N levels from 0 to 40 kg ha⁻¹. At Maharashtra, the increased number of nodules per plant, pods per plant and 100 seed weight resulted into higher pod yield of 1.3 t ha⁻¹ with application of 40 kg N ha⁻¹ as compared to control (1.2 t ha⁻¹) (Joshi et al., 1989).

Additional dose of 12 kg ha⁻¹ to the recommended basal application of 54 kg ha⁻¹ gave 10 percent higher yield (Anon., 1990b). Number of branches per plant and number of pods per plant of groundnut were higher with application of 75 kg P₂O₅ per ha as compared to lower doses of phosphorus (Newase et al., 1990).

The pod and haulm yield of groundnut increased significantly with application of 40 kg K₂O ha⁻¹ over lower dose and further increase beyond this level did not increase the yield. Oil content in kernel was increased with graded levels of K and the higher effect was marked at 60 kg K₂O ha⁻¹. However, increase in protein content and protein yield was only up to application of 40 kg K₂O ha⁻¹ (Deshmukh et al., 1992).

Nimje (1992) reported that the growth parameters like rooting density, nodulation, pegging and dry matter accumulation were higher with the application of 90 kg P₂O₅ ha⁻¹ when compared to the lower doses and control at Bhopal during Kharif season.

Reddy et al. (1992) observed considerable increase in pod as well as haulm yield with the application of 40 kg N ha⁻¹ as compared to 20 kg N
in Alfisols having low availability of nitrogen. Yakadri et al. (1992) observed that test weight was significantly increased with the application of 30 kg N ha\(^{-1}\) over control in red sandy loam soils of Southern Telengana.

Studies on the response of three levels of nitrogen viz., 0, 15 and 30 kg ha\(^{-1}\) to groundnut during summer season was made and the results revealed that application of N at higher dose did not significantly improve the dry matter accumulation and yield attributes at harvest (Chawale et al., 1993).

Hameed Ansari et al. (1993) reported that increasing fertilizer dose up to 50:75:30 kg NPK ha\(^{-1}\) increased seed yield and oil content of groundnut and further increment of fertilizer did not have economical effect on seed yield and oil content.

Khalak and Kumar Swamy (1993) observed increased number of nodules per plant, nodule dry weight and nodule density with the application of 50:100:150 kg NPK ha\(^{-1}\) as compared to control at Bangalore.

Khan et al. (1993) observed higher pod yield of groundnut (3.1 t ha\(^{-1}\)) with application of 70 kg P\(_2\)O\(_5\) ha\(^{-1}\) as compared to the application of 40 kg P\(_2\)O\(_5\) ha\(^{-1}\) under irrigation condition.

Kankapure et al. (1994) observed beneficial effect of K on growth characters including dry matter production of groundnut. Pushpendra Singh et al. (1994) reported that phosphorus application brought about significant increase in biological yield in calcareous soils at Udaipur in Rajasthan. However, they observed significant differences at 40 and 60 kg over 20 kg P\(_2\)O\(_5\) ha\(^{-1}\).
Ved Singh et al. (1994) observed that groundnut crop applied with 60 kg P₂O₅ ha⁻¹ recorded higher oil content of 51 per cent as compared to application of 30 kg P₂O₅ ha⁻¹ during kharif season.

Mudalagiriyappa et al. (1995) revealed that inoculation of groundnut with Aspergillus awamori or Pseudomonas striata increased the efficiency of SSP and application of 75 % MRP + 25 % SSP + Pseudomonas striata resulted in higher growth, yield attributes and yield when compared to 100 % SSP alone.

Patra et al. (1995) observed that application of 40 kg N ha⁻¹ increased the pod yield by 15 per cent and oil yield by 20 per cent over control (No nitrogen) and 45 kg K₂O ha⁻¹ increased pod yield by 25.9 per cent and oil yield 356.3 per cent over control (No potassium). Further, application of 50 kg K₂O ha⁻¹ significantly increased growth attributes (plant height, leaf area index and dry matter production), pod and oil yield as compared to control.

Sukanya et al. (1995) observed that increasing level of nitrogen increased the nodule number, nodule mass, total dry matter production, pod yield and harvest index in groundnut.

Asha Mehata et al. (1996) observed that seed inoculation with Pseudomonas striata resulted in significantly higher number of pods and haulm yield in groundnut. The increase in net realization under inoculation with Pseudomonas striata was 41.58 per cent over control.

Application of potassium resulted in higher uptake of NPK and also increased the pod and kernel yield. Quality parameters were also enhanced by the application of K which reflected in oil and protein content (Lakshmamma et al., 1996).
Mehta and Ram Mohan Rao (1996) reported that application of 50 kg P$_2$O$_5$ ha$^{-1}$ registered significantly higher number of pods per plant and 100 kernel weight. The increasing trend in pods and haulm yield was noticed up to 75 kg P$_2$O$_5$ ha$^{-1}$.

Barik and Mukherjee (1997) reported that application of 40 kg N ha$^{-1}$ recorded higher nodulation and pod yield and as N rate increased beyond 40 kg N ha$^{-1}$ there was decrease in nodulation and pod yield.

Ghatak et al. (1997) reported from Kalyani that application 60 kg K$_2$O ha$^{-1}$ recorded higher pod yield of 1.87 t ha$^{-1}$ and it was on par with 30 kg K$_2$O ha$^{-1}$ (1.83 t ha$^{-1}$) on silty loam soil during summer season.

Shelke et al. (1997) reported significantly higher pod yield (2893 kg ha$^{-1}$) with application of 60 kg P$_2$O$_5$ per hectare over lower dose of 30 kg P$_2$O$_5$ ha$^{-1}$.

Tiwari and Dhakar (1997) revealed that groundnut crop recorded increased pod yield with application of 30:80 kg N and P$_2$O$_5$ ha$^{-1}$ as compared to control under irrigated condition. Application of N and P$_2$O$_5$ up to 60 and 50 kg as basal dose recorded higher pod yield compared to 0:0, 30:25 and 90:75 kg N and P$_2$O$_5$ ha$^{-1}$ (Mahalanobis and Maiti, 1998).

Barik et al. (1998) reported that dry matter production, LAI and plant height were increased significantly with the enhanced rate of nitrogen supply and the higher value was observed with 40 kg ha$^{-1}$. However, the results of the research experiment conducted by Edna Antony et al. (2000) revealed that leaf area duration, leaf area index and net assimilation rate were increased with increase in nitrogen dose in all genotypes studied and concluded that 25 kg N ha$^{-1}$ was necessary for optimum yield. Yield of groundnut tended to decrease with higher dose of nitrogen.
Intodia et al. (1998) reported that application of 60 kg P$_2$O$_5$ significantly increased number of pods per plant, shelling percentage, pod yield, haulm yield, harvest index and oil yield of groundnut.

Prabhakaran et al. (1998) concluded that application of biofertilizers along with 50 per cent RDF significantly increased the pod yield of groundnut to the tune of 11 per cent compared to 100 per cent RDF application without biofertilizers.

Gogoi et al. (2000) compared the response of different levels of N viz., 0, 20, 40, 60 and 80 kg ha$^{-1}$ to groundnut and found that increased level of nitrogen application up to 80 kg ha$^{-1}$ increased the number of branches, pegs, pods per plant and shelling percentage. However, significant increase in yield and yield attributes were noticed only up to application 40 kg ha$^{-1}$.

Subrahmaniyan et al. (2000) observed linear response from confectionery groundnut varieties viz., ICGV-86564 and B-95 to NPK fertilizers. Increased dose of NPK fertilizers up to 150 per cent of the RDF (26:51:81kg NPK ha$^{-1}$) recorded significantly higher plant height, more number of matured pods per plant, higher 100 kernel weight, shelling percentage, sound matured kernel percentage and pod yield of groundnut.

Significant increase in pod yield of groundnut was observed at a fertilizer level of 30:60:30 kg NPK ha$^{-1}$ and increase in yield was 30 per cent higher than lower level of fertilizer doses (Vinod Kumar et al., 2000).

The available N and P in soil were improved with the application of biofertilizers *Azatobacter* sp. and *Pseudomonas striata* along with organic and inorganic fertilizers in groundnut (Kachot et al., 2001).
Application of phosphorus solubilizers increased the pod yield of groundnut by 10.26 and 9.8 per cent in two consecutive years besides increasing number of pods, number of kernels and 100 kernels weight (Ramesh and Sabale, 2001).

Increasing nitrogen levels up to 60 kg N ha\(^{-1}\) significantly increased the pod yield of groundnut and it did not respond to N beyond 60 kg N ha\(^{-1}\) (Singh and Singh, 2001).

Application of 20:40:20 kg NPK ha\(^{-1}\) to groundnut crop with basal application of 3 kg PSB ha\(^{-1}\) gave the maximum pod yield of 1336 kg ha\(^{-1}\), which was 260 kg ha\(^{-1}\) more than yield obtained by recommended dose of NPK (20:80:20 kg ha\(^{-1}\)) (Trivedi et al., 2001).

Munda et al. (2004) observed increased branches per plant from 9.9 to 10.1 and number of pods per plant from 9.2 to 12.3 when 20:60:40 kg N, P\(_2\)O\(_5\) and K\(_2\)O ha\(^{-1}\) was applied to groundnut as compared to control.

Mirhat et al. (2006) observed that increasing rate of phosphorus fertilizer from 30 to 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) significantly increased vegetative growth, yield and its components as well as seed quality.

Application of 34:64:108 kg NPK ha\(^{-1}\) as three splits of N and K at basal (50 per cent), flowering (25 per cent) and peg formation stage (25 per cent) and 100 per cent P as basal were found to be the optimum dose for getting the highest pod yield (Chitdeshwari et al., 2007).

Kandil et al. (2007) reported that the increasing nitrogen levels increased growth parameters, yield parameters, pod yield, haulm yield, seed protein content and NPK contents in plant.
Kuligod et al. (2007) reported that higher doses of fertilizer (150 per cent of recommended dose) application had resulted in increased yield (22.5 q ha\(^{-1}\)) compared to the farmer practice of manure and fertilizer application (17.7 q ha\(^{-1}\)).

### 2.4 Nutrient uptake and economics in maize crop as influenced by NPK

Potassium fertilization at 400 lb acre\(^{-1}\) increased the corn yield (188 bu acre\(^{-1}\)) and total income ($423 acre\(^{-1}\)). However, the net returns was higher with the application of 200 lb acre\(^{-1}\) (Anon., 1998).

Arya and Singh (2000) reported that application of 90 kg P\(_2\)O\(_5\) ha\(^{-1}\) resulted in significantly higher grain and straw yield, nutrient uptake and protein yield of maize compared to 60, 30 and 0 kg P\(_2\)O\(_5\) ha\(^{-1}\).

Rekhi et al. (2000) reported showed that the continuous application of 150 per cent NPK or their combinations with organic manures in maize- wheat cropping system, raised the available P from initial 3 mg kg\(^{-1}\) soil to 11.5 mg kg\(^{-1}\) soil.

Application of 90 kg N ha\(^{-1}\) recorded higher agronomic efficiency of nitrogen (20.01 kg kg\(^{-1}\) N) compared to 45 kg N (32.5 kg kg\(^{-1}\) N) in maize. Further, it was enhanced when N was applied along with FYM at 15 tonnes ha\(^{-1}\) (24.07 kg kg\(^{-1}\) N) (Purushotham Kumar and Puri, 2001).

Higher net returns by maize was obtained by the application of 137 lb P\(_2\)O\(_5\) acre\(^{-1}\) compared to lower levels of P and N in three years (Reetz et al., 2001).

Surendra Singh and Sarkar (2001) studies in Jharkhand indicated that application of 210:90:150 kg NPK ha\(^{-1}\) recorded
significantly higher grain yield up to 33 per cent, higher value of produce (₹ 19,500 ha⁻¹), net profit (₹ 4500 ha⁻¹), benefit: cost ratio (2.92) and NPK uptake (158:73:160.7 kg ha⁻¹) in maize-wheat cropping system compared to state recommended dose of 100:60:40 kg NPK ha⁻¹.

Tolessa et al. (2001) conducted field experiment in Alfisols of Bangalore and results indicated that the application of enriched FYM along with nitrogen at 150 kg ha⁻¹ enhanced N (233 kg ha⁻¹), P₂O₅ (73.3 kg ha⁻¹) and K₂O (238 kg ha⁻¹) uptake by maize.

In Nagaland, the N and P uptake by grain and stover increased significantly with the application of 150 and 80 kg N and P, respectively. These levels recorded N uptake of 52.89 and 33.76 kg ha⁻¹ in grain and stover, respectively. The higher phosphorus uptake by grain was found to be 12.6 kg ha⁻¹ and stover was 20.8 kg ha⁻¹ with N₁₅₀ and P₈₀ combination and it increased with increasing levels of nitrogen and phosphorus (Manoj Kumar and Singh, 2003).

The higher net return of maize (₹ 20,951 ha⁻¹) and benefit cost ratio (2.92) was observed by application of 150 % RDF compared to 100 % RDF + 10 t FYM ha⁻¹ (Anilkumar et al., 2002).

A field experiment was conducted by Anil Kumar et al. (2005) in Himachal Pradesh to work out an integrated nutrient management schedule for maize-gobhi sarson cropping system under rainfed condition. The experimental results showed that the total grain production was significantly higher (110.5 q ha⁻¹) when both crops in system were given 150 % of recommended NPK. The gross returns (₹ 56,786 ha⁻¹) and benefit cost ratio (2.68) were also higher in the same treatment.
Harikrishna et al. (2005) reported that application of 200 per cent RDN registered significantly higher uptake of NPK and readily available N over 100 per cent RDN and was on par with 150 per cent RDN. Whereas, 150 per cent RDN application in four splits resulted in higher nitrogen use efficiency (NUE), gross income (₹ 30,064 ha⁻¹) and net income (₹ 21,865 ha⁻¹) and B:C ratio (2.03) compared to 100 and 200 % RDN.

Fertilization to maize based on SSNM for targeted yield enhanced the grain yield of maize by 5 to 15 per cent with an average yield increase of 1,025 kg ha⁻¹ and net income improved by 1 to 23 per cent with the average being US$ 100 ha⁻¹ (Hongting Wang et al., 2005).

The N, P and S concentration in corn grain increased with the P fertilization and required 13 kg N, 6.5 kg P and 1.0 kg S per tonne of grain production (Pablo Prystupa et al., 2005).

Sutaliya and Singh (2005) from Varanasi reported that fertility level up to 180, 90 and 60 kg N, P₂O₅ and K₂O ha⁻¹ significantly improved the growth, yield and yield attributes of maize. The increase in yield was 83 per cent with over 60, 30 and 20 kg N, P₂O₅ and K₂O ha⁻¹. The uptake of NPK (188.1, 59.1 and 247.7 kg ha⁻¹, respectively) also increased with increased NPK levels.

Dhillon et al. (2006) revealed that farmers were benefited to the extent of ₹ 3,162 by applying fertilizers based on targeted yield approach in maize crop over existing method of fertilizers application in Ludhiana.

Grain and stover yield of maize was significantly increased up to application of 60 kg P₂O₅ ha⁻¹. Whereas, the available P status of the soil after harvest was higher in plots which received up to 80 kg P₂O₅ ha⁻¹. The residual effect of increasing P levels up to 80 kg P₂O₅ ha⁻¹
significantly increased the seed and straw yield, nutrient uptake and the available P status of soil after mustard harvest. The residual effect of FYM also had a significant positive impact on these aspects of mustard crop (Mahala et al., 2006).

Anita Bindhani et al. (2007) conducted experiment during the rainy season at Bhubaneswar, Orissa to study the effect of nitrogen levels on baby corn. They noticed that application of nitrogen at higher level (120 kg ha\(^{-1}\)) gave significantly higher yield (1491 kg ha\(^{-1}\)) with higher gross returns (\(¥84,694\) ha\(^{-1}\)), net returns (\(¥84,694\) ha\(^{-1}\)) and B:C ratio (5.90). The nitrogen per cent (2.59 %) and total nitrogen uptake (101.39 kg ha\(^{-1}\)) were also found to be higher with application of 120 kg N ha\(^{-1}\).

Application of 120 kg N ha\(^{-1}\) resulted in significantly higher grain yield (5432 kg ha\(^{-1}\)) and stover yield (5962 kg ha\(^{-1}\)), nutrient content, total NPK uptake (150.3, 31.4 and 189.17 kg ha\(^{-1}\)) and protein content (10.44 %) compared to 80, 40 and 0 kg N ha\(^{-1}\) (Omraj Meena et al., 2007).

Ashok Kumar (2008) conducted an experiment during 2005 and 2006 at New Delhi on effect of varied nitrogen levels on productivity and economics of sweet corn and pop corn and revealed that higher net return of \(¥41,590\) ha\(^{-1}\) and \(¥49,420\) ha\(^{-1}\) by pop corn and sweet corn was found at higher nitrogen level of 120 kg ha\(^{-1}\) compared to lower levels. The higher net returns were directly contributed by higher grain yield of pop corn (3.48 t ha\(^{-1}\)) and green cobs of sweet corn (13.46 t ha\(^{-1}\)).
2.5 Nutrient uptake and economics in sunflower crop as influenced by NPK

Mahesh Pal (1979) observed higher uptake of nitrogen (77.9 to 148.4 kg N ha\(^{-1}\)), phosphorus (13.5 to 28.0 kg P\(_2\)O\(_5\) ha\(^{-1}\)) and potassium (89.8 to 183.9 kg K\(_2\)O ha\(^{-1}\)) by sunflower at higher levels of combined application of nitrogen, phosphorus and potassium (120 kg N ha\(^{-1}\) + 120 kg P\(_2\)O\(_5\) ha\(^{-1}\) + 60 kg K\(_2\)O ha\(^{-1}\), respectively) over no nitrogen, phosphorus and potassium fertilization under sandy loam soil during \textit{rabi} season at Kanpur.

In a field trial during \textit{rabi} on calcareous soil, uptake of N, P and B increased linearly up to 90 kg P\(_2\)O\(_5\) ha\(^{-1}\) in sunflower (Cv. Morden). Dry matter production and uptake of N, P and B was the higher with boronated superphosphate (Ateeque and Malewar, 1992).

Higher nitrogen levels increased nitrogen and phosphorus contents in all the plant parts of sunflower (Loubser and Human, 1993). Manoharan \textit{et al.} (1994) reported that the uptake of N, P and K increased with increasing levels of nitrogen.

An experiment conducted in sandy loam soil of Bhubaneswar indicated that nitrogen up to 60 kg ha\(^{-1}\) increased the uptake of N, P and K in sunflower (Mishra \textit{et al.}, 1995).

Reddy and Sudhakara Babu (1997) from Hyderabad reported that application of 150 % NPK to \textit{kharif} sunflower and recommended NPK for \textit{rabi} groundnut gave higher net returns (₹ 17,263 ha\(^{-1}\)). In sunflower-sunflower sequence also higher net returns (₹ 15,452 ha\(^{-1}\)) was obtained by the same treatment (150 % for \textit{kharif} and 100 % for \textit{rabi} season crop).

Singh and Singh (1997) revealed that uptake of nitrogen (61.4 to 76.2 kg N ha\(^{-1}\)), phosphorus (21.3 to 26.5 kg P\(_2\)O\(_5\) ha\(^{-1}\)) and potassium
(45.9 to 50.1 kg K₂O ha⁻¹) increased when sunflower was fertilized with higher doses of NPK (80 kg N ha⁻¹ + 40 kg P₂O₅ ha⁻¹ + 40 kg K₂O ha⁻¹, respectively) over lower doses of NPK (40 kg N ha⁻¹ + 20 kg P₂O₅ ha⁻¹ + 20 kg K₂O ha⁻¹) under sandy clay loam soil during summer season.

Prasad and Singh (2000) recorded higher net returns (10,323 ha⁻¹) in sunflower with the application of NPK at 80 kg N ha⁻¹ over no NPK fertilization. Combined application of NPK at 120 kg N ha⁻¹, 120 kg P₂O₅ ha⁻¹ and 60 kg K₂O ha⁻¹ increased the net returns from ₹ 10,993 to 24,249 ha⁻¹ over application of no nitrogen and phosphorus with 60 kg K₂O ha⁻¹ (Thavaprakash and Malligawad, 2002).

Combined fertilization at 120 kg N ha⁻¹ + 120 kg P₂O₅ + 60 kg K₂O ha⁻¹ increased the uptake of NPK from 54.98 to 186.27 kg N ha⁻¹, 10.44 to 21.14 kg P₂O₅ ha⁻¹ and 50.58 to 126.68 kg K₂O ha⁻¹ by sunflower over control (Thavaprakash, 2000).

Reddy et al. (2002) reported that fertilizer combination of 100-60-60 NPK kg ha⁻¹ + 500 kg gypsum and 0.2 per cent borax spray during flowering stage recorded higher net returns (₹ 17,277 ha⁻¹) with B:C ratio of 2.06 as a result of significantly higher seed yield (2140 kg ha⁻¹) compared to 50-30-60 NPK kg ha⁻¹ in a Vertisols with low available nitrogen and organic carbon and medium available phosphorus and potassium.

In maize-sunflower-cowpea cropping system, significantly higher phosphorus uptake by maize and sunflower crops was noticed in recommended level of P plus PSB treated plot compared to other treatments. The soil available phosphorus was also higher in the same treatment after harvest of cow pea crop (Kumaresan et al., 2003).
The long term field experiment conducted at Bellary from 1978 to 1993 indicated that significantly higher build up of available phosphorus was observed with application of FYM at 5 t ha\(^{-1}\) and NPK on recommended basis (38.9 kg ha\(^{-1}\)) followed by application of FYM at 5 t ha\(^{-1}\) plus NPK on soil test basis (28.1 kg ha\(^{-1}\)) over control (4.8 kg ha\(^{-1}\)) and initial status (9.5 kg ha\(^{-1}\)) (Nalatwadmath et al., 2003).

Application of 125 % recommended dose of fertilizer recorded significantly higher seed yield (17.6 q ha\(^{-1}\)) and stalk yield (65.6 q ha\(^{-1}\)) with net income of ₹ 11,784 ha\(^{-1}\) and B:C ratio 1.80 over other nutrient levels (Yadav et al., 2009).

2.6 Nutrient uptake and economics in groundnut crop as influenced by NPK

Thorve et al. (1989) reported that higher pod yield (12.48 q ha\(^{-1}\)) with B:C ratio of 2.89 was obtained by application of 40 kg N ha\(^{-1}\) over control and plot treated with 20 kg N ha\(^{-1}\).

Application of potassium in general increased N, P and K content in all the plant parts at harvest stage. On an average 137.3, 16.6 and 63.34 kg N, P and K ha\(^{-1}\), respectively were removed by groundnut crop (Deshmukh et al., 1992).

Combined application of FYM, rhizobium, azospirillum and phosphobacterium with recommended dose of fertilizer gave higher pod yield (2,875 kg ha\(^{-1}\)) with B:C ratio of 2.59 over single inoculation of bio fertilizers (Balasubramanian and Palaniappan,1994).

Ved Singh et al. (1994) observed that groundnut recorded higher P uptake (37.79 kg ha\(^{-1}\)) with application of 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) as compared to application of 30 kg P\(_2\)O\(_5\) ha\(^{-1}\).
Yakadri and Satyanarayana (1995) reported that there is a close relationship between nutrient uptake and dry matter production in groundnut. Application of N, P and K at 30, 60 and 60 kg ha\(^{-1}\), respectively could result in higher N, P and K uptake and total dry matter production.

The results of field experiment conducted at Coimbatore for two years (1994-1995) revealed that application of 150 % NPK plus coir pith compost gave higher net returns of ₹ 2,405 with B:C ratio of 3.97 compared to other treatments (Christopher Lourduraj and Rajagopal, 1996).

Balasubramanian (1997) observed numerically higher uptake of NPK (89.8-17.52-34.6 kg ha\(^{-1}\)) by groundnut with the application of 25.5-51-81 NPK kg ha\(^{-1}\) compared to application of 17-34-54 NPK kg ha\(^{-1}\). Increase in available N might be due to the direct addition of N through inorganic fertilizers to the available pool as reported by Bellakki and Badanur (1997).

Tiwari and Dhakar (1997) observed that application 40 kg N plus 80 kg P ha\(^{-1}\) gave significantly higher pod yield (29.9 q ha\(^{-1}\)) with net returns of ₹ 24,550 compared to 20 kg N plus 40 kg P ha\(^{-1}\).

Barik et al. (1998) conducted experiment on groundnut under varying levels of nitrogen. They noticed that application of 40 kg N ha\(^{-1}\) gave higher pod yield (1025 kg ha\(^{-1}\)) with higher net returns compared to other levels.

Deka et al. (2001) studied the effect of lime and N on nutrient uptake in groundnut and the results revealed that with each successive increase in the dose of nitrogen up to 40 kg ha\(^{-1}\), the nitrogen uptake also increased significantly. However, it was at par with 60 kg ha\(^{-1}\).

Significantly higher pod yield (29.52 q ha\(^{-1}\)), oil content (51.6%) and higher phosphorus uptake (49 kg ha\(^{-1}\)) were obtained by application of 75 kg P\(_2\)O\(_5\) ha\(^{-1}\) along with phosphorus solubilizer for summer groundnut (Ramesh and Sabale, 2001).

Application of 125 % recommended NPK with organic manure to groundnut crop gave higher pod yield (1791 kg ha\(^{-1}\)), net profit (₹ 11,349) and B:C ratio (1.67) compared to recommended NPK alone (Kavimani et al., 2002).

Mandal et al. (2002) reported that on an average groundnut required 160-180 kg of N, 20-25 kg of P and 80-100 kg of K to produce 2.0 to 2.5 t ha\(^{-1}\) of economic yield.

Dutta et al. (2003) reported that potassium content both in kernel and haulm was significantly increased by increased potassium application and the higher values were was observed at 50 kg K\(_2\)O ha\(^{-1}\). Application of graded levels of potassium produced notable differences in uptake of N, P and K and the increase was significant at higher doses of potassium application (50 kg K\(_2\)O ha\(^{-1}\)).

Chitdeshwari et al. (2007) conducted experiment on influence of levels and split application of fertilizers on groundnut. They opined that application of 34:64:108 kg NPK ha\(^{-1}\) at a split of 50:25:25 per cent N and K at basal, flowering and peg forming stage and 100 per cent P as basal was found to be an optimum dose for getting higher pod yield and B: C ratio (1.89) with higher nutrients uptake compared to higher level of fertilizers.

The uptake of boron by pod (191.08 mg pot\(^{-1}\)) and haulm (646.17 mg pot\(^{-1}\)) was higher in groundnut crop due to application of 15 kg boron ha\(^{-1}\). The soil available boron was also higher 0.43 ppm in the same
treatment compared to initial value (0.17 ppm) (Srinivasan and Angayarkanni, 2007).

Application of higher level of K$_2$O (75 kg ha$^{-1}$) and Ca (50 kg ha$^{-1}$) along with recommended NP gave higher net returns (₹ 17464 ha$^{-1}$) and B:C ratio (2.66). The higher B:C ratio was mainly due to higher pod yield (1810 kg ha$^{-1}$) and haulm yield (3515 kg ha$^{-1}$) (Yeledhalli et al., 2007).

Karunakaran et al. (2010) conducted experiment to study the effect of integrated nutrient management on growth and yield of groundnut. The results revealed that application of 125 % RDF + 5 t ha$^{-1}$ enriched compost increased the growth and yield attributes that led to its significantly higher productivity (2.25 t ha$^{-1}$), net returns (₹ 15,704 ha$^{-1}$) and NPK uptake (171, 20.7 and 75 kg ha$^{-1}$) in groundnut crop besides enriching soil available nitrogen and phosphorus after harvest of groundnut.