NUTRIENT MANAGEMENT FOR SUSTAINABLE GROUNDNUT PRODUCTIVITY IN INDIA – A REVIEW

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Abstract

Groundnut is an unpredictable legume, since its response to nutrient application is always not optimistic. Excessive application of nitrogen and potassium often resulted in excessive vegetative growth. Considering the availability of the major elements in the soil and quantum of losses due to leaching and/or fixation of the individual elements expected, a proper method and the time of nutrient application are needs of the hour. These facts call for a concerted study on the possibility of more effective utilization of nutrients in divided dosages like basal and top dressing. The review is aimed to have better understanding on optimizing the nutrient requirement and uptake in increasing the pod yield of groundnut and benefits of interactions between the organic and inorganic fertilizers. In this paper, available literature on nutrient management practices viz., application of organic manure, NPK fertilizers and foliar nutrient spray in groundnut and their interactive effects on crop growth and yield are reviewed.

Keywords: Groundnut; Split application; Nutrient; Organic manure; fertilizers

1. Introduction

Groundnut (Arachis hypogaea), is a species in the legume family (Fabaceae) native to South America, Mexico and Central America. It is an annual herbaceous plant growing to 30 to 50 cm tall. The leaves are opposite, pinnate with four leaflets (two opposite pairs; no terminal leaflet), each leaflet 1 to 7 cm long and 1 to 3 cm broad. The flowers are a typical pea flower in shape, 2 to 4 cm (¾ to 1½ inch) across, yellow with reddish veining. After pollination, the fruit develops into a legume 3 to 7 cm long, containing 1 to 4 seeds, which forces its way underground to mature. Groundnut is also known as earthnuts, Peanuts, goobers, goober peas, pindas, jack nuts, pinders, manila nuts, g-nuts, and monkey nuts; the last of these is often used to mean the entire pod Annadurai et al., 2009. The growth rate of oilseed crops in terms of production was much higher after 1980’s as compared to other crops with the introduction of Technology Mission on Oil seeds (TMO) in 1986 and it brought “yellow revolution” in oilseed crops in India. One among the factors for higher production from groundnut after TMO was increase in area rather than increase in the productivity. The productivity enhancement target is still elusive. Hence with the increase in population, it is necessary to provide edible oils to each of them. On the basis of minimum requirement of oils and fats, it should be 5.49 million tonnes, against the present production of only 2.9 million tonnes, leaving a gap of 2.6 million tonnes. Meeting this gap is the most important problem in India today. This demand has been growing at the rate of six per cent per annum in the last 13 years. This would only show that there is an urgent need to step up oil seed production on a sustainable basis.

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The optimization of the mineral nutrition is the key to optimize the production of groundnut, as it has very high nutrient requirement and the recently released high yielding groundnut varieties remove still more nutrients from the soil. On contrary groundnut farmers, 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 due to inadequate and imbalance use of nutrients is one of the major factors responsible for low yield in groundnut. India is the world’s largest producer of groundnut where nutritional disorders cause yield reduction from 30-70 per cent depending upon the soil types. Thus it is high time to look into the mineral nutrition aspects of groundnut for achieving high yield and advocate the suitable package of practices for optimization of yield Singh, 2004.

2. Nutrient Management in Groundnut

Oilseeds are energy-rich crops and hence the requirement of major nutrients as well as secondary and micronutrients is very high. The nutrient removal varies considerably, depending upon crop productivity and soil fertility (Hegde, 2000). Groundnut removes fairly large quantities of nutrients from the soil. It depletes the soil nutrients rapidly unless the soil is adequately manured. Adequate manuring does not only improve the yield but also maintains the soil health and sustain the productivity (Lourduraj, 1999). Ghosh et al. (2002) further stressed that proper fertilizer management of groundnut crop with right kind of nutrients at right time adapting right method of application has significant effect on yield and quality.

Parasuraman et al. (1998) reported higher availability of plant nutrients consequently had higher growth parameters in the fertilized treatments and higher yield of groundnut. Remunerative responses of groundnut crop to fertilizer application have been observed both under irrigated and rainfed conditions in India (Kanwar et al., 1983). Increase in groundnut yield due to the application of NPK was also reported by Angadi et al. (1990).

However Subrahmaniyan et al. (2000) reported that application of NPK levels upto 100 per cent of the recommended doses of fertilizer (17:34:54 kg NPK ha⁻¹) gave significantly better effect on the growth and yield parameters and pod yield of 1848 kg ha⁻¹. Similarly Balasubramanian (1997) reported that application of N, P and K at 17, 34 and 54 kg ha⁻¹ was sufficient for optimum production of groundnut in red sandy loam soil. Prabhakaran et al. (1998) also reported that application of 100 per cent recommended dose of fertilizer to supply 17:34:54 kg NPK ha⁻¹ with gypsum @ 500 kg ha⁻¹ and micronutrient mixture @ 12.5 kg ha⁻¹ enhanced the yield of groundnut.

Thorave and Dhonde (2007) reported that application of 25:50:00 NPK kg ha⁻¹ gave the highest plant height and total dry matter per plant at harvest and yield attributes of summer groundnut. Shinde et al. (2000) found that the application of 75 per cent recommended dose of fertilizer (100 per cent RDF-25:50:00 kg NPK ha⁻¹) resulted in higher productivity of groundnut at Rahuri in Maharashtra. Fertilizer recommendations concerning the seven major oilseed growing states are given in the table below

<table>
<thead>
<tr>
<th>State</th>
<th>Recommended rates of NPK (kg/ha)</th>
<th>Farmyard manure t/ha</th>
<th>Gypsum kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rainfed</td>
<td>Irrigated</td>
<td></td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>20</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>20</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Gujarat</td>
<td>12.5</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>Karnataka</td>
<td>25</td>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>12</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>15</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>10</td>
<td>10</td>
<td>45</td>
</tr>
</tbody>
</table>


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).
Munda et al. (2004) observed increased branches per plant (10.1) and number of pods per plant (12.3) in groundnut as compared to control (9.9 and 9.2) when 20:60:40 kg N, P₂O₅, K₂O ha⁻¹ was applied.

Subrahmaniyan et al. (2000) observed linear response of confectionery groundnut cultures viz., ICGV 86564 and B 95 to NPK fertilizers. Increased dose of NPK fertilizers up to 150 per cent of the RDF (26:51:81 kg 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. Application of 34:64:108 kg NPK ha⁻¹ as three splits of N and K at basal (50 per cent N & K), flowering (25 per cent N & K) and peg formation stage (25 per cent N & K) and 100 per cent P as basal were found to be the optimum dose for getting the highest pod yield (Chitdeshwari et al., 2007).

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. 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.

2.1 Split application of NPK fertilizers

In general, application of required quantity of nutrients at right time by adopting proper method enhances the groundnut pod yield and quality (http://www.ikisan.com). Since the growth of groundnut is intensive from 30 DAS to 70 DAS, appropriate time of fertilizer application in required quantity is extremely critical to match the nutrient supply with demand prevailing the critical stages of groundnut.

Top dressing of N and K during first and second weeding (20 and 45 DAS respectively) increased the pod yield than all at basal application (CSM, 1990). Split application of potassium equally at sowing and at 35 DAS increased the pod yield of groundnut (Mondal and Goswami, 1991).

Chinnasamy (1993) reported that application of 50 per cent of N and K as basal and 50 per cent in three splits of 25 per cent on 25 DAS (soil), 12.5 per cent on 45 DAS (soil) and 12.5 per cent on 60 DAS (foliar) has favourably influenced the growth attributes and yield of groundnut. Deshmukh et al. (1992) reported that pod and haulm yield and total nutrient uptake of NPK in groundnut were significantly increased with the split application (75 per cent of K at sowing and 25 per cent at flowering stage).

Khokhani et al. (1993) reported that in split application of nitrogen, there was a decrease in nitrogen losses and thereby it significantly influenced the leaf area index at 60 DAS in sunflower crop. Split application of nitrogen equally at sowing and at 35 DAS increased the pod yield (Ravikumar and Raghavulu, 1995). Balasubramanian and Palaniappan (1996) reported that application of N and K in two equal splits at basal and 45 DAS improved the nutrient uptake and yield of groundnut. Ponmuswamy et al. (1996) reported that 150 per cent of the recommended dose of K (79 kg ha⁻¹) applied in two equal splits viz., 50 per cent at basal and remaining 50 per cent at 40 DAS gave significantly higher dry pod yield of 2383 kg ha⁻¹.

Prakasa Rao (2004) observed that supplemental nitrogen either through soil or foliage at 50 and 70 DAS in addition to recommended dose of NPK increased the yield of groundnut.

2.2 Nitrogen management in groundnut

Nitrogen in general is the major structural constituent of the plant cell. It plays an important role in plant metabolism by virtue of being an essential constituent of metabolically active components like amino acids, protein, nucleic acid, flavins, purines and pyrimidines, nucleotides, enzymes and alkaloids. The biological role of N is evidenced through the chlorophyll in harvesting solar energy, phosphorylated compounds in energy transformation, nucleic acid in the transfer of genetic information and regulation of the cellular metabolism and biological catalysts (Puntankar and Bathkal 1988).

Growth and development of crops depend largely on the development of root system. Nitrogen is the key plant nutrient that stimulates root and shoot growth (Jana et al., 1990). Nitrogen is closely linked to control the vegetative growth of plant and hence determines the fate of reproductive cycle (Wojnowska et al., 1995). Srinivas et al. (2005) stated that groundnut being a leguminous crop depended on two major sources of nitrogen for their growth viz., atmospheric nitrogen and mineral nitrogen benefit from the appropriate complementary operation of both biological nitrogen fixation by the species and by nitrate reduction. In general, the contribution of nitrogen in the legume would be 25 Kg ha⁻¹.
Groundnut showed a significant increase in plant height with increasing levels of N from 0 to 40 kg ha\(^{-1}\) in soils with low N status (Jakhro, 1984 and Barik et al., 1994). Sukanya et al. (1995) observed that increasing level of nitrogen increased the nodule number, nodule mass, total dry mass, total nitrogen content, pod yield and harvest index in groundnut.

Barik et al. (1998) reported that dry matter production, LAI and plant height were increased significantly with the enhanced rate of nitrogen supply at various stages of growth up to harvest and the highest 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 leaf net assimilation rate increased with an increase in nitrogen dose in all genotypes studied and concluded that 25 kg N ha\(^{-1}\) was necessary for optimal yield. Yield of groundnut tended to decrease with higher dose of N beyond 25 kg ha\(^{-1}\).

Kandil et al. (2007) reported that the increasing nitrogen levels increased number of leaves, stems, total pods and pod dry weight per plant, number of pods per plant, weight of pods per plant, number of seeds per plant, weight of seeds per plant, 100-pod weight, 100-seed weight, pod yield, straw yield, seed protein content and NPK contents. However, numbers of pods per plant and seed oil content were decreased by increasing nitrogen levels.

Cox et al. (1992) opined that application of nitrogen in the form of urea in two equal splits at the time of sowing and at 30 DAS significantly increased the dry matter with each increment levels. 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).

Reddy et al. (1992) observed considerable increase in pod as well as haulm yields with the application of 40 kg N ha\(^{-1}\) as compared to 20 kg N in alfisols having low availability of N. Yakadri et al. (1992) observed that 100 kernel weight was significantly increased with the application of 30 kg N ha\(^{-1}\) over unfertilized control in red sandy loam soils in Southern Telengana zone of Andhra Pradesh.

Application of 40 kg N ha\(^{-1}\) significantly increased the number of pods per plant, kernel and oil yield by 16.6, 18.8 and 24.7 per cent, respectively (Patra et al., 1995). 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 noted only up to application 40 kg ha\(^{-1}\). Similarly, Deka et al. (2001) indicated that increasing the level of nitrogen up to 40 kg ha\(^{-1}\) increased the nutrient uptake and resulted in significantly higher kernel and haulm yields of groundnut.

Chavan and Patil (1995) studied the response of four groundnut varieties to three levels of nitrogen and observed that the variety UF 70103 showed a consistent and significant response to increased levels of nitrogen up to 40 kg ha\(^{-1}\), while variety JL 24 showed a significant increase in yield in response to nitrogen levels up to 25 kg ha\(^{-1}\). Whereas SB XI was not consistent in its response pattern.

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).

### 2.3 Phosphorus management in groundnut

Phosphorus is required in small amount than N for plant growth but is equally important for crop growth (Chen et al., 1994).

Phosphorus is one of the major limiting plant nutrients (Nandwa 1998; Rao et al. 2004) in the tropical and sub-tropical soils. Agasimani and Babalad (1991) reported that response to P could be obtained when the available P status in the soil was less than 35 kg P\(_{2}O_{5}\) ha\(^{-1}\). Kulkarni et al. (1986) reported that phosphorus application up to 50 kg ha\(^{-1}\) increased the number pods per plant and dry matter production accumulation in the plant.

Patel et al. (1990) revealed that phosphorus is the most important nutrient which affects the yield and quality of leguminous crops including groundnut. P fertilization particularly at flowering and pod formation stages were beneficial (Singh et al., 1991). Groundnut responds to P application by increasing shelling percentage, oil yield and nodulation. 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\textsubscript{2}O\textsubscript{5} ha\textsuperscript{-1}.

Mudalagiriyappa et al. (1995) observed positive effect on pod yield due to P application @ 50 kg P\textsubscript{2}O\textsubscript{5} ha\textsuperscript{-1} in the form of single super phosphate in different proportions in vertisols. Mehta and Ram Mohan Rao (1996) reported that application of 50 kg P\textsubscript{2}O\textsubscript{5} ha\textsuperscript{-1} registered significantly higher number of pods per plant and 100 kernel weight. The increasing trend in pods and haulm yield was noticed upto 75 kg P\textsubscript{2}O\textsubscript{5} ha\textsuperscript{-1}.

Sharma and Yadav (1997) reported that phosphorus plays a beneficial role in legume growth promoting extensive root development and thereby ensuring a good yield. Barik et al. (1994) observed that the plant height increased linearly by the application of P and the highest value was observed at 80 kg P\textsubscript{2}O\textsubscript{5} ha\textsuperscript{-1}. Intodia et al. (1998) reported that application of 60 kg P\textsubscript{2}O\textsubscript{5} significantly increased number of pods per plant, shelling percentage, pod yield, haulm yield, harvest index and oil yield of groundnut. Phosphorus fertilization was investigated by several workers and recommended varied doses of P\textsubscript{2}O\textsubscript{5} kg ha\textsuperscript{-1} for increasing the yield and its attributes, i.e. 25 kg (Bhatol et al., 1994); 33 kg ha\textsuperscript{-1} (Kumar and Ray Chudhuri, 1997); 50 kg ha\textsuperscript{-1} (Patel et al., 1995); 60 kg ha\textsuperscript{-1} (Yakadri et al., 1992) and about 114 kg ha\textsuperscript{-1} (El-Far and Ramadan, 2000).

Rath et al. (2000) reported that application of 75 kg P\textsubscript{2}O\textsubscript{5} ha\textsuperscript{-1} produced the highest pod yield (21.51q ha\textsuperscript{-1}), whereas the highest oil yield was obtained with 50 kg P\textsubscript{2}O\textsubscript{5} ha\textsuperscript{-1} due to higher shelling percentage and oil content.

Bhatol et al. (1994) concluded that application of 25 kg P\textsubscript{2}O\textsubscript{5} ha\textsuperscript{-1} markedly increased the pod yield over control, but a higher rate of 50 kg P\textsubscript{2}O\textsubscript{5} ha\textsuperscript{-1}, the yield was significantly decreased. Similarly Choudhary et al. (1991) reported that deletion of P application had significantly reduced the pod and haulm yields of groundnut.

2.4 Potassium management in groundnut

Groundnut crop responds well for potassium (K) application and addition of K increased its concentration at all stages in groundnut crop. The concentration of K was high in initial stages and declined in the later stage, indicating that groundnut absorbs K rapidly in early stages (Madkour et al., 1992). Potassium is also required in large amount by oil seed crop (Singh, 2004).

Additional dose of 12 kg ha\textsuperscript{-1} apart from the recommended basal application of 54 kg ha\textsuperscript{-1} gave 10 per cent higher yield (CSM, 1990). Application of potassium at 100 kg ha\textsuperscript{-1} significantly increased the plant height, nodule weight, pod number, pod and haulm yields of groundnut (Singh and Vidya Chaudhari, 1996). Kankapure et al. (1994) observed beneficial effect of K on growth characters including dry matter of groundnut.

Jana et al. (1990) observed that K up to 49.8 kg ha\textsuperscript{-1} had increased the number of pods per plant, 100 seed weight, pod yield and oil yields. The response was quadratic and also influenced the K content of seeds. The pod and haulm yields of groundnut increased significantly with application of 40 kg K\textsubscript{2}O ha\textsuperscript{-1} over lower dose and further increase beyond this level did not increase the yield. Oil content in kernel increased with graded levels of K and the effect was marked to the higher at 60 kg K\textsubscript{2}O ha\textsuperscript{-1}. However, increase in protein content and protein yield was only up to application of 40 kg K\textsubscript{2}O ha\textsuperscript{-1} (Deshmukh et al., 1992).

Application of K also 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).

Hameed Ansari et al. (1993) found that application of potassium up to 45 kg ha\textsuperscript{-1} significantly improved the pod yield (3392 kg ha\textsuperscript{-1}) and its contributing characters compared to lower dose of 15 and 30 kg K ha\textsuperscript{-1}.

2.5 NPK content and uptake by groundnut

Rao and Narayan (1990) noticed that many groundnut cultivars had higher uptake and accumulation of N and P due to application of higher doses of N and P.

The difference in potassium uptake could only be due to differences in the pod and haulm yields because the crop received uniform potassium doses (Prameela Rani et al., 1991). Application of K, 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).

High nitrogen levels increased nitrogen and phosphorus contents and concentration of all plant components in early growth stage only (Loubser and Human, 1993). Manoharan et al. (1994) reported that the uptake of N, P and K increased with increasing levels of nitrogen. Zharare (1996) demonstrated that potassium application increased the nitrogen uptake but did not affect the uptake of phosphorus and potassium.

Sarmah et al. (1995) found that nitrogen uptake was maximum with 80 kg ha⁻¹. An experiment conducted in sandy loam soils of Bhuvaneswar indicated that nitrogen up to 60 kg ha⁻¹ increased the uptake of N, P and K (Mishra et al., 1995). 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). Combined application of N and K in equal split doses as basal and on 45 DAS coinciding with peg formation increased the uptake and availability of nutrients as well as groundnut production (Balasubramanian, 1997). Enhanced P content and uptake in groundnut leaf, stem and kernel could be attributed to increased availability of P in soil due to application of organic manures (Lupwayi et al., 1999).

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, nitrogen uptake increased significantly up to 40 kg ha⁻¹, which was however at par with 60 kg ha⁻¹.

Badole et al. (2003) studied the effect of organic and inorganic fertilizer on the uptake of groundnut at Parbani during summer season in the clay loam soil and found that integrated nutrient supply system (50 per cent of recommended nutrient content through organic and remaining by inorganic fertilizers) significantly improved the uptake of groundnut compared to control.

### Nutrient uptake/removal in groundnuts (kg ha⁻¹)

<table>
<thead>
<tr>
<th>Plant part</th>
<th>Yield</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pods</td>
<td>3 t ha⁻¹</td>
<td>120</td>
<td>11</td>
<td>18</td>
<td>13</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Haulms</td>
<td>5 t ha⁻¹</td>
<td>72</td>
<td>11</td>
<td>48</td>
<td>64</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>192</td>
<td>22</td>
<td>66</td>
<td>77</td>
<td>25</td>
<td>15</td>
</tr>
</tbody>
</table>

Source: Gascho, 2001

Dutta et al. (2003) reported that potassium content both in kernel and haulm was significantly increased by increased potassium application and the highest was observed at 50 kg K₂O ha⁻¹. Application of graded levels of potassium produced notable difference in uptake of N, P and K and the increase was significant at higher doses of potassium application (50 kg K₂O ha⁻¹).

Laxminarayana (2004) recommended that integrated application of organic and inorganic fertilizers showed higher uptake of NPK compared to sole application of organic manures due to increased nutrient availability and improvement in the physical condition of the soil. Chitdeshwari et al. (2007) reported that increasing levels of the respective nutrients (34:64:108 kg NPK ha⁻¹) increased the nutrient content in the crop and its uptake.

### 3. Organic manure management in groundnut

Organic manures, valuable byproducts of farming and allied industries, contribute to plant growth through their favourable effects on the physical, chemical and biological properties of soil. Organic manures also have a pronounced residual effect on the nutrient availability. Many benefits attributed to organic manures have well been documented (Stevenson, 1994).

Nziguheba et al., (1998) also reported that addition of organic materials causes mineralization of more recalcitrant fraction of P through increased microbial activity and resultant biochemical transformation. Christopher Lourduraj and Rajagopal (1996) reported that application of 15:42.5:67.5 kg NPK ha⁻¹ coupled with raw coir pith @ 12.5t ha⁻¹ could be recommended to enhance groundnut productivity. Application of P fertilizer in combination with FYM was found effective in enhancing the effectiveness of P fertilizers (Whalen and Chang, 2001).
Organic manure has a profound effect on improving soil physical, chemical and biological properties and enhancing productivity of field crops. In groundnut, application of FYM @ 10-15 t ha\(^{-1}\) increased the pod and haulm yields and improved the yield parameters like shelling percentage, 100 seed weight and sound mature kernel compared to the recommended dose of fertilizers (Subrahmaniyan et al., 2000).

Increased pod yield due to the application of pressmud either separately or in combination with inorganic fertilizer was reported by Sriramachandrasekaran (2001) and Manikandan (2003) in groundnut.

### 3.1 Farm yard manure management in groundnut

Application of farmyard manure (FYM) is common in India but availability of FYM has been declining because of increase in cropping intensity and area and other competitive uses of cowdung. In central India, mechanization has been increasing, number of farm animals is declining and area under cultivation is increasing, therefore, only a small quantity of FYM per ha is available. Further, FYM contains only small amounts of major nutrients and its cost of transportation is high.

Farmyard manure not only supplied nutrients but also improved soil conditions to produce higher yields (Jagdev and Singh, 2000). Suryanarayana Reddy (1991) have reported application FYM increased the 10% shelling percentage, 100 kernel weight 32 %, numbers of pods and pod yield per plant in groundnut crop.

Dharma (1996) found that FYM might have stimulated the activities of microorganisms that make the plant nutrients readily available to the crops. Balasubramanian and Palaniappan (1994) reported that use of microbial inoculants in combination with FYM favored groundnut production.

Asmus (1993) reported that application of FYM increased the nitrogen supply to soil. Das et al. (1992) reported that application of FYM and poultry manure to groundnut crop increase post harvest soil organic C and available Ca contents. The importance of organic to groundnut plants was emphasized by Ahmed et al. (1997) who stated that the highest dry matter accumulation, kernel yield and oil content were achieved by fertilization with farmyard manure. Ismail et al. (1998) reported significant increase in organic C, available N and P content of the soil with application of FYM possibly due to the increase in decomposition product of organic matter.

FYM application had increased the dry matter production, which might be due to increased release of macro as well as micronutrients in better extraction by the groundnut (Dosani et al., 1999).

Application of FYM increased the availability of potassium to crop, increasing moisture content of soils and enhanced the availability of potassium to plant. Addition of FYM might have restored soil from potassium depletion, exhibit positive potassium balance and maximum P fixation (Akbari et al., 2002).

Beneficial effect of FYM in conjunction with recommended dose of fertilizers may be due to the effect of organic matter in improving physical, chemical and biological environment of soil conducive to better plant growth (Deshmukh et al., 2005). Application of FYM @ 21.9 t ha\(^{-1}\) produced the highest DMP, pod yield and haulm yield, and gave higher net return and BCR (Chandrasekaran et al., 2007)

### 3.2 Poultry manure management in groundnut

In India, poultry arming is increasing. The poultry manure is relatively a cheap source of both macro nutrients (N, P, K, Ca, Mg, S)and micronutrients (Cu, Fe,Mn,B) and can increases oil carbon and N content, soil porosity and enhances oil microbial activity. As poultry waste contains a high concentration of nutrients, addition of small quantity of it in an integrated nutrient management system could meet the shortage of FYM to some extent. This paper highlights the most productive cropping system at different combinations of organics and inorganics, and compares the relative efficacy of three organic manures on productivity of three cropping systems.

Poultry manure is relatively resistant to microbial degradation. However, it is essential for establishing and maintaining optimum soil physical condition and important for plant growth (Rahman, 2004).

Poultry manure is excellent organic manure, as it contains high nitrogen, phosphorus, potassium and other essential nutrients. In contrast to mineral fertilizer, it adds organic matter to soil which improves soil structure, nutrient retention, aeration, soil moisture holding capacity, and water infiltration (Deksissa et al., 1999).
2008). Ammonium-N (NH\textsubscript{4}-N) is a significant part of total N in poultry manure, which additionally contains uric acid. Uric acid metabolizes rapidly to NH\textsubscript{4}-N in most soils, and the net result of the high NH\textsubscript{4}-N and uric acid contents in poultry waste is that a large percentage of N can be converted to nitrate-N (NO\textsubscript{3}-N) within a few weeks (Sims and Wolf, 1994). Poultry manure improves the number of pods per plant, pod yield and haulm yield in groundnut (Subrahmaniyan et al., 1999).

4. Foliar spray of nutrients on groundnut

Foliar feeding is often the most effective and economical way to correct plant nutrient deficiencies. During the last decades, foliar feeding of nutrients has become an established procedure in crop production to increase yield and improve the quality of crop products (Roemheld and El-Fouly 1999). Foliar application of nutrients could improve the nutrient utilization and lower environmental pollution through reducing the amounts of fertilizers added to soil (Abou-El-Nour 2002). Foliar feeding of a nutrient might have actually promoted root absorption of the same nutrient or other nutrients through improving root growth and increasing nutrients uptake (El-Fouly and El-Sayed, 1997).

4.1 Nutrient spray

Foliar application of nutrients normally reduces the loss through absorption, leaching and other processes associated with soil application and higher pod yield in groundnut with foliar phosphorus application at flowering stage was observed by Kene et al. (1991).

The experiments conducted at various research stations of TNAU on the combined nutrient spray, revealed that the groundnut yield was increased by 20 per cent as compared to control (CSM, 1990)

Xu et al. (2000) reported that supply of N either from foliar sources or symbiotic fixation resulted in greater nitrogen content in the leaf canopy and thus increased biomass production and leaf area. Besides, fermented sources of foliar application might have contained microbial metabolites in appreciable amount that would have helped in maintaining the opening of stomata for longer period both in optimum and adverse conditions during the crop growth which led to increased leaf area index providing stronger source for sink.

Subrahmaniyan et al. (2000) reported that the application of combined nutrients (Diammonium phosphate 2.5 kg + ammonium sulphate 1.0 kg + borax 0.5 kg + NAA (naphthalene acetic acid) @ 40 ppm) on 25\textsuperscript{th} and 35\textsuperscript{th} day after sowing (DAS), followed by foliar spray of NAA @ 40 ppm alone on 45\textsuperscript{th} and 55\textsuperscript{th} DAS significantly gave the highest values of growth and yield attributes and pod yield of groundnut. Ali and Mowafy (2003) observed that foliar spray of Zn (2 per cent) improved the groundnut yield attributes and yield as well as quality.

4.2 Panchagavya

Natarajan (2002) opined increased yield of crop plants with panchagavya application is due to enhancement in the biological efficiency of crop plants. The presence of beneficial bioactive compounds such as GA 3, IAA etc., in panchagavya and increased level of phosphorus and potassium and other essential nutrients present in composted pressmud might have contributed to increased yield (Somasundaram, 2003).

Galindo et al., (2007) reported that the use of fermented, liquid organic fertilizers, effective microorganism (EM) and fermented plant extracts (FPE) as foliar fertilizers have been introduced to modern agriculture in recent years to produce food with good quality and safety. Role of foliar applied panchagavya in production of many plantation crops had been well documented in India (Selvaraj, 2003). Poorter and Nagel (2000) found that increased allocation of food material to roots in turn enhances the root volume and thereby weight of root nodules concomitantly.

Kumawat et al. (2009) reported that application of panchagavya + neem leaf extract at branching and flowering is advantageous in increasing chlorophyll content, physiological growth, nutrient content and uptake, dry matter accumulation, yield and yield attributes and economics of groundnut.

5. Micronutrient management in Groundnut

Revaithi et al. (1996) reported that combined application of Zn, Fe, Cu, Mn, Ca, and Mg increased the pod and haulm yield of groundnut. Micronutrient application which might be due to involvement of boron in catalyzing
the metabolism of carbohydrates and Fe and Zn increases enzyme activity and other biological oxidation
recording higher pod yields wherever soil application of Zn was practiced in alluvial soils of Andhra Pradesh,
Bihar and Uttar Pradesh.

Partitioning of total uptake of macronutrients by growth stage

<table>
<thead>
<tr>
<th>Growth stage</th>
<th>Percentage (%) of total uptake</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Vegetative</td>
<td>10</td>
</tr>
<tr>
<td>Reproductive</td>
<td>42</td>
</tr>
<tr>
<td>Ripening</td>
<td>48</td>
</tr>
</tbody>
</table>

Source: Longanathan & Krishnamoorthy, 1977

The soil being deficient in N, P, Fe and Zn, it is appropriate that the crop had responded to the fertilizer
and micronutrients application. Earlier reports also say that the black calcareous soils of the command are highly
deficient in Fe and Zn (Vijashekar et al., 2000). Similar observations of increased groundnut yields with soil
application of Zn, B and S have been made by Chitdeshwari and Poongathai (2003). Patil et al. (2003) had also
observed significant increase in groundnut yield by soil application of Fe and Zn along with RDF in black soils
of north Karnataka.

6. Biofertilizer management in Groundnut

Biofertilizers are the source of microbial inoculants, which have brought hopes for many countries both
economically and environmentally. Therefore, in developing countries like India, biofertilizers can solve
problems of high cost of fertilizers and thus can save the economy of the country (Gupta et al., 2003). Due to
intensive farming in India is known as a heavy consumer of chemical fertilizers. The use of chemical fertilizers has
been doubled during the last two decades. Thus the coincident application of organic manures and bio-fertilizers
is frequently recommended firstly for improving biological, physical and chemical properties of soil and
secondary to get high and clean agricultural yield products free from undesirable high doses of heavy metals and
other pollutants. Biofertilisation, in contrast to the use of chemical fertilisers, is receiving steadily increased
attention and recognition from scientists because the microbial inoculants (including e.g. Rhizobium and
mycorrhizal fungal inoculants) introduced into soil or plant culture enhance plant productivity directly or
indirectly (Mahdi, 1993). The highest dry matter production in application of both Rhizobium and
phosphobacterium was due to the fact that it produced maximum shoot length, higher number of branches per
plant and leaf area index (LAI) (Chetti et al., 1995).

7. 15N labelled fertilizer application in groundnut

There are several concepts that are key to conserving nutrients in a soil-plant system. It is important to make
nutrient applications in line with crop uptake and utilization patterns. Therefore, the time (stage of crop
growth), method, and rates of application are all very important in achieving optimum crop uptake and
utilization of the applied nutrients. 15N as a tracer can be used to understand the plant demand on N during
different phonological stages, as well as its distribution within the plant (Wallace et al., 2007).

Bloom et al. (1988) observed that the apparent recovery of N by winter wheat (measured as the
difference between uptake from fertilized and unfertilized crops) varied from 40 to 88 per cent. The recovery of
applied 15N by the crop differed substantially depending on the rate and method of N application (Recous et al.,
1988).

8. Integrated nutrient management on groundnut

Continuous application of inorganic fertilizer decreased the C: N ratio of soil and also improved the activities
of microorganisms responsible for nitrogen mineralization (Sarkar and Rathore, 1992). Bocchi and Tano
(1994) reported that positive interaction between the combination of organic manures and urea as nitrogen
source.
Integrated nutrient use of both organic manures and inorganic fertilizers simultaneously is probably the most effective method to maintain healthy sustainable soil system while increasing crop productivity (Janssen, 1993). Sudha (1999) also reported the beneficial effect of integration of organic and inorganic fertilizers.

Toor and Bahl (1997) showed that the combined addition of poultry manure and fertilizer phosphorus had a synergistic effect and increased phosphorus uptake compared with fertilizer P alone.

Jagdev Singh and Singh (2000) reported that application of FYM combined with NPK also improved the soil environment, which encouraged proliferous root system resulting in better absorption of water and nutrients from lower layers and thus resulting in higher yield and nutrient uptake. John et al. (2004) had advocated for integral use of organic manure and inorganic fertilizers for the supply of adequate quantities of plant nutrients required to sustain maximum crop productivity and profitability, while minimizing environmental impact from nutrient use.

Desai et al. (1999) found a positive interaction between organic manures and urea as nitrogen sources. Groundnut crop responded favourably to organic and inorganic fertilizer application. Nutrient management of the soil on sustainable basis includes fertilizer types, amounts, time and methods of their application. Proper amount and time of fertilizer application is considered a key to the bumper crop (Jan and Khan, 2000).

Geethalakshmi et al. (1993) reported that integration of all the sources of nutrients (NPK + FYM + *Rhizobium* + gypsum) registered the highest pod yield of groundnut compared to NPK fertilizer alone. Similarly Deshmukh et al. (1995) reported that conjunctive use of inorganic fertilizer along with FYM significantly increased the number of pods and shelling percentage of groundnut. Higher shelling percentage, harvest index, oil yield and protein content were registered with application of 34:17:54 kg NPK ha⁻¹ +12.5 t FYM ha⁻¹ (basal) +17 kg P₂O₅ ha⁻¹ (30 DAS) + 400 kg gypsum ha⁻¹ (40 DAS). The recommended level of NPK (17:34:54 kg NPK ha⁻¹) alone recorded lower shelling percentage, harvest index, oil yield and protein content. (Kumaran, 2000).

Kadwe et al. (2003) reported that application of 75 per cent RDF along with press mud @ 5 t ha⁻¹ delayed days to 50 per cent flowering, peg formation and days to maturity and significantly increased plant height, number of branches, number and weight of nodules per plant, yield and harvest index.

Laxminarayana and Patiram (2005) reported that the integrated use of inorganic and organic manures by applying 40 kg N, 26 kg P and 33 kg K ha⁻¹, in combination with farmyard manure @ 15 t ha⁻¹ gave the highest pod and haulm yields, followed by NPK + pig manure @ 5 t ha⁻¹ and NPK + poultry manure @ 5 t ha⁻¹.

9. Economics

Subrahmanian et al. (1998) reported that the foliar application of combined nutrients @ 40 ppm on 25th and 35th DAS followed by the foliar spray of NAA @ 40 ppm alone on 40th and 55th DAS + 100 per cent NPK gave the highest pod yield of 2040 kg ha⁻¹ with a net return of Rs. 17320 ha⁻¹ and BCR (2.32) as compared to 100 per cent NPK alone. Subrahmanian et al. (2000 a) found that application of FYM @ 15 t ha⁻¹ enhanced the pod yield of groundnut (2890 kg ha⁻¹) and net return (Rs. 28607 ha⁻¹) compared to lower level of FYM and control under rainfed conditions.

10. Conclusions

Groundnut is the major oilseeds crop accounting for 45 percent of oilseeds area and 55 percent of oilseeds production of the country. As such this crop has to play a major role in bridging the vegetable oil gap in the country. But the current average yield level is very low as compared to what is being obtained in most of the groundnut growing other countries. In India, the reasons for low peanut yield are the use of low yield potential varieties, poor soil fertility and nutrient management. Peanut perform better in terms of yield and quality when good cultivar sown under optimum nutrient management coupled with organic and inorganic nutrient management. Groundnut being a leguminous crop, it is capable of fixing atmospheric nitrogen. Applications of fertilizer including gypsum in adequate quantities become more essential for obtaining higher yields. Adoption of an improved variety alone can increase the yield by about 20 per cent. Hence a proper understanding of management practices viz., season, suitable varieties; optimum plant density, optimum nutrient management with organic and inorganic nutrient management are necessary to enhance the productivity of groundnut which in turn helps our country to avoid shortage of edible oils and large scale imports at the expense of huge foreign exchange.
11. Reference


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