Review Article

Nutrient Management for Unpredictable Legume – "Groundnut"

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Abstract

Groundnut (*Arachis hypogaea* L.) is considered as one of the country's main oilseed cash crops due its high oil content. Groundnuts al one account for 70% of total edible oil production. Being a legume, it requires more phosphorus. It is an oilseed crop so it requires more sulphur which helps in increasing oil content and calcium for appropriate shell formation and pod filling. Groundnut requires about 58 kg N, 5 kg P, 18 kg K, 11 kg Ca, 4 kg S and 9 kg Mg to yield one tonne pods per hectare. An ideal level of organic carbon in the soil (0.5–0.75 percent) must be maintained to sustain the overall health of the soil and continuing good harvests. High yielding varieties and chemical fertilizers are the most important input for modern agriculture. Farmers use very little or no phosphorus and micronutrients for groundnut cultivation. This review aims to better optimize the macro and micronutrient requirement in improving the yield of groundnut and soil productivity.

Keywords: groundnut, nutrient management, productivity, sustainability

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Introduction

Groundnut botanical name is *Arachis hypogea*. The word *Arachis hypogea* comes from two Greek words: arachis, which denotes legume, and hypogea means below the ground or soil. It is a member of the Leguminaceae family. Peanut, earthnut, and monkey-nut are all names for groundnut (*Arachis hypogea* L.), an annual erratic legume cum oilseed crop. The most significant oilseed crop on the planet is groundnut [1]. Economic contribution both in terms of acreage and productivity is substantially contributed by oilseed crops in Indian agriculture. The oil content of groundnut seeds (kernels) is 40-50 percent while the protein content is 20-30 percent. The nutrition sources like magnesium (mg), iron (Fe), calcium (Ca), phosphorus (P), zinc (Zn), riboflavin, niacin, vitamin E, thiamine, and potassium (K) are all found in groundnut seeds. Groundnut kernels can be eaten raw, boiled or roasted and the oil extracted from its kernel can be used as a cooking oil [2]. Groundnut is also useful for preparing animal feed (seeds, green material, straw and oil pressings) and raw material of industries (fertilizer and oil cakes). It is a wonderful cash crop for the home market as well as for international trade in numerous developing and established countries because of their various uses. Trypsin inhibitor and Phytic acid are antinutritional agents (inactivated by boiling and roasting). Aflatoxin (mycotoxin) is produced by *Aspergillus flavus* and *Aspergillus parasiticus*, both facultative saprophytes that infest groundnut before, during, and after harvest. In animals, aflatoxins cause liver cirrhosis and cancer [3]. The maximum amount of aflatoxin that can be consumed by humans is 30 g/kg. Because groundnuts have such high nutritional requirements and the recently released high-yielding varieties (HYVs) of groundnut consume even more resources from the soil therefore, optimal mineral nutrition to this crop is critical factor for sustaining high yield [4]. On the other hand, groundnut growers in most semi-arid regions uses substantially less nutrient fertilizers [5]. One of the key causes responsible for groundnut low yield is inadequate and imbalanced nutrient usage. Sometimes just only one or two nutrients result in stark mineral nutrient shortages and loss of yields below critical levels only due to inadequate and imbalanced nutrient use. India is the world's greatest producer of groundnuts, with yield reductions ranging from 30 to 70 percent depending upon nutritional disorders. As a result, it is the high time to investigate the mineral nutrition elements for sustainable groundnut production with higher yields and to advocate for an appropriate package practice for optimal outputs [6]. Area production and productivity is represented in below **Figures 1** and **2** [7].

Nutrient management

It's a system for controlling the amount, form, placement, and timing of nutrients applied to the plants (whether manure, commercial fertilizer or other forms of nutrients).

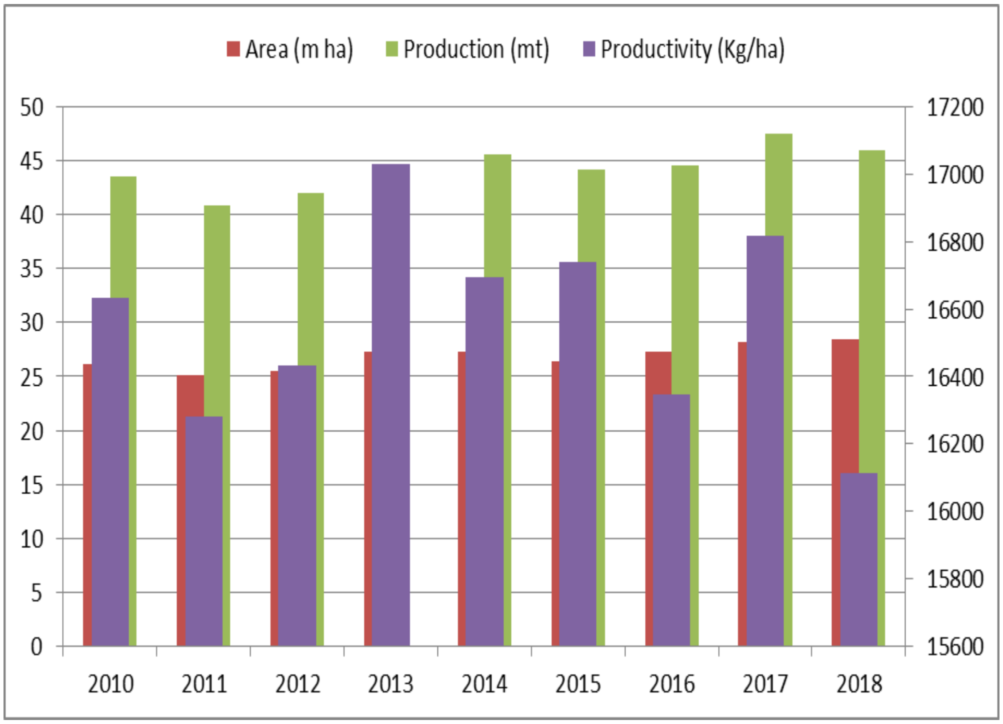

Figure 1 World scenario of groundnut

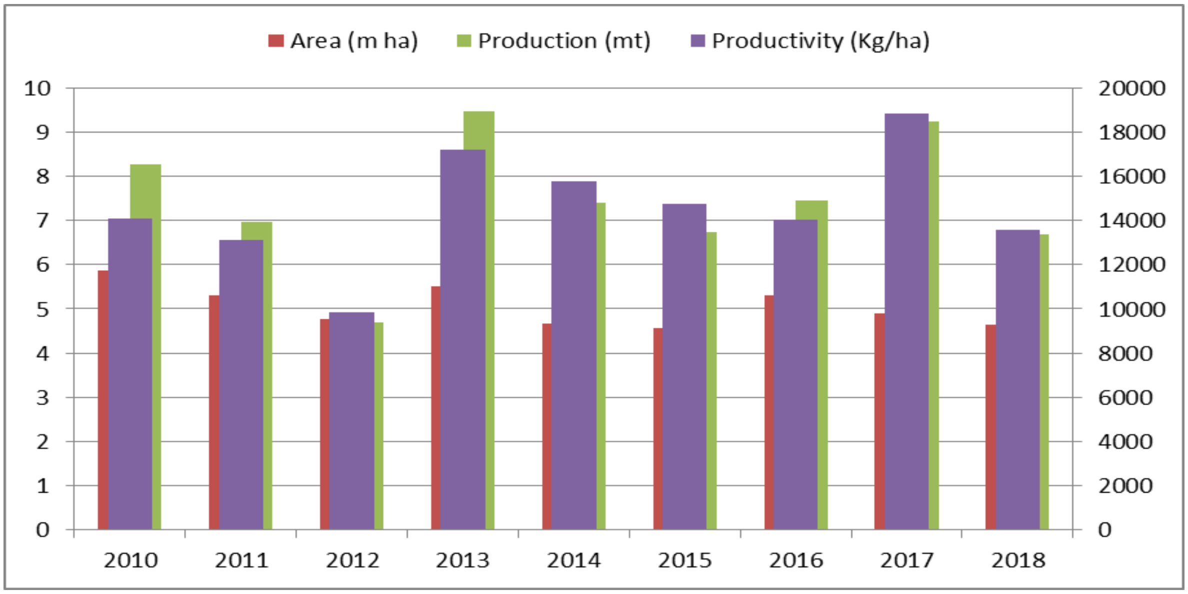

Figure 2 India scenario of groundnut

Need for nutrient management

Nutrient management is the key for improving productivity. It helps in maintaining the growth and vigour of the plant. The aim of nutrient management is increasing the fertilizer use efficiency to obtain a higher yield and return. It reduce the cost of production and improve the quality of produce [8].

Four R principles of nutrient management

- **Choose the right source:** Make sure you have a balanced supply necessary nutrient.
- **Appropriate rate:** Evaluate soil nutrient supply and plant needs before making decisions.
- **At the right time:** Gain access to and make decisions for right time application based on crop uptake patterns, soil supplies, and nutrient loss concerns.
- **The right spot:** Manage spatial heterogeneity within the field to fulfil site-specific crop needs while minimizing possible losses.

Yield losses of groundnut due to nutritional disorders

Even though nutrient deficiencies and reactions are recorded, no systematic methodologies are presently developed to determine yield losses associated with deficiency or toxicity of a specific nutrient. The oilseeds are high in energy, they have a high demand for major, secondary, and micronutrients. Depending on crop production and soil fertility, nutrient loss varies significantly. Groundnut depletes the soil's nutrient levels significantly. Unless the soil is sufficiently manured, it quickly depletes the nutrients in the soil. Not only can proper manuring increase production, but it also maintains soil health and boosts productivity [9]. Fertilizing groundnut crops with the balanced nutrients at right time and using the appropriate application method has a great impact on production and quality [10]. Given that India ranks first globally in groundnut production, however the nutrients problem may cause yield reductions of 10-60 % subjected to different land use soil nutrient status, and groundnut varieties used. Providing an adequate supply of nutrients can increase production by 50%, allowing India to meet future challenges. The mean yield increased by 24 percent by application of calcium in the pegging zone. Sulphur (S) and iron (Fe) deficiency reduced 15-29 and 14-40 % yield in medium black calcareous soils, respectively [11, 12]. Fe deficiency produces full crop failure in calcareous soil, with no pod production in extreme cases. In medium calcareous soils in Junagadh, sulphur and iron induce yield losses of 15-29 and 14-40 percent, respectively [13].

Nitrogen management

In comparison to 15 kg N/ha and control, the application of 30 kg N/ha has a more complementary effect on nodule numbers, nodule's dry weight and dry matter/plant at different growth stages [14]. Applying a higher nitrogen dose, i.e. 60 kg/ha, considerably increases groundnut plant height, branches number and accumulation of dry matter/plant in comparison to control [3]. A considerable influence of managing nitrogen on growth and yield characteristics of Groundnut was also observed [15]. Nitrogen application @ 40 kg N/ha led to increment in growth as well as yield *viz.* maximum pod and biological yields. Incorporating N and P fertilizer had a substantial impact on photosynthesis, development of root, yield contributing features and pod yield. The plants that received 60 kg N and 39 kg P/ha had a more extensive root system, a higher photosynthetic rate (PR) and better yield attributes which contributed to the highest pod production [16]. At harvest, T_6 showed significantly higher nitrogen uptake by ground shell (6.16 kg/ha) and kernel (48.56 kg/ha), however significantly lower nitrogen uptake by groundnut shell (0.73 kg/ha) and kernel (26.34 kg/ha) was reported in T_1 treatment (Table 1) [17].

Phosphorus management

Phosphorus is a key nutrient for promoting root arrangement and it provides better soil and root contact, which further leads to increased phosphorus uptake [18]. With increasing phosphorus level from 0 to 26.4 kg/ha, an increased leaf area index (LAI) and accumulation of dry matter plant^{-1} in groundnut was obtained [10]. When the phosphorus dose was increased up to 60 kg/ha, the weight and number of pods/plant, grain/pod and test weight increased significantly [19]. The treatment of 75 kg P_2O_5/ha of phosphorus improved yield indices such as pods/plant, pod length or pod weight/plant, grains/pod and grain weight/plant, which were statistically comparable to 50 kg P_2O_5/ha but higher than 25 kg P_2O_5/ha and control [20]. Applying recommended phosphorus doses through P-enriched vermicompost with a placement method maximized pod and stover yield, phosphorus uptake, recovery and use efficiency, oil and protein content, net return and benefit-cost ratio of groundnut crop compared to placing P-enriched compost and broadcasting P-enriched vermicompost [21]. The parameters including LAI, number of pegs and total pods/plant, primary and secondary branches/plant, dry matter, weight of 100-pods and seeds, seed and stover yield, pod yield and harvest index were observed to increase with the rise in phosphorus fertilizer levels, peaking at 60 kg P/ha [5]. The maximum phosphorus uptake was in shell (0.86 kg/ha) and kernel (6.74 kg/ha) of groundnut under T_6 treatment (Table 1) [17].

Potassium management

Supplementary potassium application increased tolerance to salinity with respect to development (height, primary and secondary branches, length and weight of root); yield based parameters (100-pod weight, kernel weight and shelling percent); and yield (kernel, pod and haulm) [22]. The detrimental effects of salt stress were reduced when potassium was applied externally. The successive increases in potassium levels had a substantial influence on the quality of groundnut and yield. The maximum dry pod (3169 kg/ha), kernel (2213 kg/ha) and haulm yields (3894 kg/ha) were obtained with the application of 40 kg/ha K_2O, while the maximum yields (2770, 1926, and 3664 kg/ha) were obtained with SOP (2770 kg/ha), which was equivalent to MOP (1926 kg/ha) and Schoenite (3664 kg/ha). The treatment of 40 kg/ha K_2O and SOP provided significantly higher oil yields than the other levels and sources of K

(1053.7 kg/ha and 914.55 kg/ha, respectively) [23]. The maximum and minimum potassium uptake in shell (4.78 & 0.92 kg ha^{-1}) and kernel (19.29 & 6.05 kg/ha) of groundnut was found under T_6 treatment, respectively (**Table 1**) [17].

Table 1 Effect of phosphorus levels on nitrogen, phosphorus and potassium uptake in groundnut [17]

Treatments	N (kg/ha)		P (kg/ha)		K (kg/ha)	
	Shell	Kernel	Shell	Kernel	Shell	Kernel
T_1	0.73	26.34	0.14	1.87	0.92	6.05
T_2	1.28	29.77	0.23	2.26	1.47	7.58
T_3	1.88	33.60	0.35	3.02	2.06	10.30
T_4	2.43	40.56	0.46	4.35	2.75	13.24
T_5	3.97	43.32	0.61	5.37	3.56	15.79
T_6	6.16	48.56	0.86	6.74	4.78	19.29
T_7	4.32	47.33	0.69	5.83	3.95	16.12
T_8	4.24	47.50	0.67	6.24	3.75	16.54
T_9	4.39	48.04	0.69	6.48	3.78	17.25
CD (P=0.05)	0.58	4.51	0.057	0.84	0.44	1.50

Treatment details- T1: RDNK + 20 kg P2O5 ha^{-1}, **T2:** RDNK + 75 % of 20 kg P2O5 ha^{-1} through chemical fertilizers (CF) + 25 % through FYM, **T3:** T2 + PSB, **T4:** RDNK + 30 kg P2O5 ha^{-1}, **T5:** RDNK + 75 % of 30 kg P2O5 ha^{-1} through chemical fertilizers (CF) + 25 % through FYM, **T6:** T5 + PSB, **T7:** RDNK + 50 kg P2O5 ha^{-1}, **T8:** RDNK + 75 % of 50 kg P2O5 ha^{-1} through chemical fertilizers (CF) + 25 % through FYM and **T9:** T8 + PSB

Calcium and sulphur management

Secondary key plant nutrients like as calcium (Ca) and sulphur (S) are required for many groundnut growth processes. Groundnut plants require Ca from the time the pegs to the fruit ripening and pods maturity. Poorly filled pods, aborted seeds (empty pods) and shrivelled fruit such as discoloured plumules & pods without seed are all caused by a lack of Ca [24]. Root development and nodulation, as well as the production of S-containing amino acids and vitamins, all processes require S [25]. Plants employ sulphur in the form of sulphate for a number of metabolic and enzymatic processes as it is a component of succynyl Co-A, it is also a component of glutathione, a molecule that is thought to promote plant respiration. S is necessary for the production of chlorophyll. The varying levels of gypsum influence groundnut growth and yield substantially [8]. A remarkable boost in growth indices and yield was reported when gypsum @ 200 kg/ha was applied. In Coimbatore (Tamil Nadu), a nano-sulphur application of 30 kg/ha led to increase in number of roots and shoots, kernels and improved shell dry matter than a typical sulphur application of 40 kg/ha. At the harvest stage, chlorophyll a, b and soluble protein content of nano-sulphur (@ 30 kg ha^{-1}) over conventional sulphur was found to increase by 6.8 percent, 4.3 percent and 9.4 percent, respectively. Nano-sulphur fertilisation at 30 kg S/ha increased the pods number, hundred kernel weights and shelling percentage much higher than traditional sulphur fertilisation at 25, 13.8 and 1.8 percent, respectively [26]. Fertiliser doses of P (0, 25 and 50 kg ha^{-1}), Ca (0, 110 and 165 kg Ca ha^{-1}) and Boron (B) (0, 2 and 2.5 kg ha^{-1}) were used to evaluate the effects of P, Ca, and B on groundnut cv. BARI Cheenabadam 7 growth and yield. Number of branches/plant, plant height, dry weight/plant, LAI and crop growth rate (CGR) were the most important growth indicators in the P (25 kg/ha) x Ca (0 kg/ha) x B (2 kg/ha) treatment combination at 100 days after sowing (DAS). Among the yield contributing factors, P (0 kg/ha) x Ca (110 kg/ha) x B (2 kg/ha) produced maximum number of total pods/plant, 100 pod weight/plant, pod yield, straw yield, and harvest index. Plant with the least amount of total pods was P (25 kg/ha) x Ca (0 kg/ha) x B (2 kg/ ha) [24]. Slag-based gypsum (SBG), being synthetic gypsum is alkaline in nature and contains a significant quantity of calcium and sulphur. Five treatments were used in the field, with two proportions of SBG (500 and 625 kg/ha) as the base and base + split, respectively, and one proportion of NG (500 kg/ha) as the base. SBG application, both basal and basal + split, significantly increased yield and availability of nutrients in the post-harvest soil [27].

Micronutrient management

Spraying Zn and B boosted biomass of plant, LAI and chlorophyll content significantly, and that the rise grew more pronounced as the concentration of Zn and B applied in the spray dose [28]. Plant physiology was altered more by Zn application alone than by B application alone. The administration of Zn and B together boosted plant growth and nutrient content in the pod. Increased doses of Zn and B impacted leaf area and chlorophyll content, resulting in higher nutrient uptake and pod output. The number of nodules significantly increased with zinc up to 5 kg ha^{-1} [29].

The micronutrient application: Zn, Fe, B, Mo, and mixed @ 2 ppm pot^{-1} and @1 kg ha^{-1} in field as their salt along with basal NPK doses (30: 60:40) significantly increased nodulation and N- fixation in groundnut crop [30]. This might be due to the role of Zn and Mo in enzymes activities as they are essential constituent of N_2 fixing enzymes "nitrogenase" which is responsible for increase in leghemoglobin which ultimately increase nodulation and N-fixation in groundnut. The Cultivar JL-24 with $ZnSO_4$ application @ 30 kg ha^{-1} + RDF recorded maximum number of nodule in groundnut at most active growth stage of crop i.e. (45 DAS). The increase in nodulation could be due to enzymatic activity and auxin synthesis [1].

Organic manure as nutrient source

Organic agriculture is a type of farming that has the potential to reduce environmental degradation while also ensuring ecosystem services as well as agricultural sustainability [37]. Organic sources of nutrients include bulky organic manures and concentrated organic manures, however nutrients are not available in optimal quantities for high-nutrient-demanding crops like groundnut [38]. In the current context [37], people's choice for chemical-free food is growing, making it a challenging task to increase crop yield in a sustained and high-quality manner. Furthermore, increased production regardless of soil health or environmental conditions is not advisable, hence agriculture must prioritise sustainability [39]. A plant's nutritional demand cannot be met by a single resource. Taking all of this into account, combined and careful application improves soil quality and provides long-term crop productivity. Integrated application of FYM (5t/ha) and specified fertilizer dose is advised for improved and early crop growth and yield [40]. Treatment of 75 percent RDF + 25 percent N through FYM significantly improved growth parameters such as height of plant & its spread, number of root nodules/plant, and root length, number of primary and secondary branches/plant, yield attributes such as mature pods, pod weight/plant and yield *viz.* pod yield (2324 kg/ha) and haulm yield (3080 kg/ha) and quality parameters such as 100 kernel weight, shelling percent and root length [41].

Table 2 Comparative analysis of different experiments conducted with different nutrient levels on plant growth attributes and yield

Treatment	Inferences	References
125% RDF+ 5t/ha enriched compost	Growth, yield attributes and nutrient uptake increased leading to higher productivity and haulm yield.	Karunakaran *et al.* (2010) [31]
BARI Cheenabadam-8 with 60 kg/ha	Maximum plant growth attributes with high seed yield (2.48t/ha), pod yield (3.03t/ha) and shelling percentage (81.84%)	Mouri *et al.* (2018) [32]
Nitrogen to phosphorous ratio 0.50 (30 kg N, 60 kg P_2O_5, 25 kg K_2O/ha)	Higher dry pod yield (3310 kg/ha), number of filled pods/plant (17.47), total number of pods/plant (18.80) and 100 kernel weight (38.50 g).	Shiva kumar *et al.* (2014) [33]
15 kg N and 46 kg P_20_5/ha	Average pod yield increased by 85.4% for a combined application of 15 kg/N ha and 46 kg P_2O_5/ha fertilizers compared to the control plots.	Tekulu *et al.* (2020) [34]
Fertilizer dose as per STCR (Soil test crop response approach) equation (25 q/ha)	Application of fertilizer as per STCR (25 q/ha) equation recorded maximum and significantly higher dry pod yield (23.08 and 24.49 q/ha) than recommended dose of fertilizer.	Pacharne and Tumbare (2016) [35]
100% RDF as basal + 50% RDF as topdressing (30 days) + FYM@ 7.5 t/ha	Higher pod yield and net returns (2936 kg/ha and Rs. 91789/ha, respectively) and were comparable with RDF (75 %) as basal + RDF (75 %) as top dressing at 30 DAS along with 7.5 t/ha of FYM.	Vasuki (2020) [36]

*RDF-Recommended dose of ferilizer

Bio-fertilizer for biological nitrogen fixation and nutrient solubilization

Agricultural sustainability can be achieved through integrated approach i.e. chemical fertilizers, biofertilizers and organic manure. Rhizobacteria promote plant growth in a variety of ways, including symbiotically, non-symbiotically, and by nutrient solubilization, as in the case of phosphate and potassium. Rhizobium (fix nitrogen symbiotically) plays an essential function in groundnut plant growth and yield qualities through biofertilizer inoculation [42]. Inoculation of seeds with phosphatic biofertiliser improved spread of plant and primary branches per plant over control, but had no effect on height of plant at harvesting [43]. Groundnut inoculation with Phosphobacterium led to considerable increment in pod as well as haulm yield compared to control, which could be attributed to enhanced nutrient availability [16]. In comparison to uninoculated groundnut, inoculation with phosphorus solubilizing bacteria

(PSB) and Rhizobium significantly boosted nodule weight/plant, pod and haulm yield. Rhizobium inoculation with a local strain resulted in considerably more nodules/plant, nodule dry weight/plant and plant dry weight than the control [44]. An experiment was conducted with four fertility levels (25 percent RDF, 50 percent RDF, 75 percent RDF and 100 percent RDF) and three biofertilizer inoculations {control (no bio-formulations), liquid Bio-NPK + Zn solubilizing bacteria and bio-grow combinations} under groundnut crop resulted in the highest yield and nutrient uptake (N, P, K and Zn). With 100 percent RDF and bio-grow inoculation, the highest levels of N, P, and K were found in the soil. With varying fertility levels, DTPA extractable Zn in soil was non-significant, while biofertilizer inoculation considerably enhanced soil Zinc levels [2]. The comparative analysis of various sources of nutrients is represented in **Table 2**.

Conclusion

Low peanut yields can be caused by various factors, including the choice of low yield potential cultivars, inadequate soil fertility, and poor fertilizer management. When a suitable cultivar is sown under optimal nutrient management, in combination with organic as well as inorganic nutrient management, peanut yield and quality improves. It may be inferred that implementing a well-balanced nutrient management strategy will ensure increased productivity. To increase groundnut productivity, optimal nutrition management with organic and inorganic nutrient management is required. As calcium is needed for groundnut growth and seed yield, proper applications of fertilizer, especially gypsum, become increasingly important for achieving higher yields.

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