➔DOI : 10.15740/HAS/AJBS/12.1/36-47
e ISSN-0976-8343 | ■ Visit us : *www.researchjournal.co.in*
ASIAN JOURNAL OF BIO SCIENCE
Volume **12** | Issue 1 | Apr., 2017 | 36-47

A REVIEW

Integrated nutrient management practices in summer groundnut

B. K. BEHERA[1], H. PATRO[2] **AND M. RAY[2]**

[1]Department of Agronomy, Orissa University of Agriculture and Technology, BHUBANESWAR (ODISHA) INDIA
[2]Regional Research and Technology Transfer Station (O.U.A.T.), KEONJHAR (ODISHA) INDIA
Email : monikarayouat@gmail.com

Article Info : Received : 07.11.2016; Accepted : 28.03.2017

Groundnut is an important oilseed crop of Odisha grown in *Kharif, Rabi* and summer season and average yield is well below the national average. It is an exhaustive crop and reported to remove higher quantity of nutrients from the soil than a normal rice crop does. This problem is more visualized with increased use of high yielding genotypes across the state and country. Use of high analysis fertilizers containing no micronutrients, little or no use of organic manure and imbalance and injudicious application of nutrient fertilizer create problem of multi nutrient deficiencies which result in low yield. Information on yield reduction due to omission of any nutrient and their interaction effect is very much limited. Keeping in view the above facts, the present investigation was aimed to maximize the yield in groundnut through integrated nutrient management practices.

Key words : Yield, Integrated nutrient management practices, Exhaustive crop, Summer groundnut

How to cite this paper : Behera, B.K., Patro, H. and Ray, M. (2017). Integrated nutrient management practices in summer groundnut. *Asian J. Bio. Sci.*, **12** (1) : 36-47.**DOI : 10.15740/HAS/AJBS/12.1/36-47.**

INTRODUCTION

Groundnut or peanut (*Arachis hypogaea* L.) is also known as a 'King' of oilseed (Priya *et al.*, 2013) belongs to family Fabaceae. This is also known by various names such as earthnuts, peanuts, goober peas, pindas, jack nuts, pinders, manila nuts, g-nuts and monkey nuts (Annadurai and Palaniappan, 1994). Groundnut crop contributed nearly 40 per cent of the total oilseed production. But the average yield of the crop in India is as low as 900 kg ha^{-1} (Bandopadhya *et al.*, 2011). Among the several constraints, improper nutrient management is important for low productivity. Groundnut being a legume-oilseed crop, its P, S and Ca requirement is quite high. Kanwar *et al.* (1983) reviewed the work done in India on the nutrient and fertilizer response of groundnut and concluded that with balance use of fertilizer for groundnut production can be increased considerably. However, a wide inconsistency in response of groundnut to fertilizer application is noticed (Reddy, 1988) and the conclusive evidences on balance nutrition of groundnut are still meagre and fragmentary in coverage. Here an attempt has been made to review the available research findings in India and abroad for the present investigation integrated nutrient management practices in summer groundnut (*Arachis hypogaea* L.).

Effect of FYM on groundnut production :

Farm yard manure (FYM) is now recognized as an intrinsic and most essential component of a healthy, fertile, living and dynamic soil. FYM is the most commonly used bulky organic manure in India and consists of mixture of animal shed wastes containing dung, urine and the straw (litters). A well decomposed FYM contains 0.5 per cent N, 0.2 per cent P_2O_5 and 0.5 per cent K_2O approximately. The benefit effect of FYM are many fold.

Growth and development :

Growth is irreversible increase in size and weight. Chaithanya *et al*. (2003) observed significant and continuous increase in total dry matter production from 30 DAS to 90 DAS and at harvest due to the application of balanced quality of inorganic fertilizer and organic manure and reported decrease in leaf area, leaf area index (LAI) with omission of specific nutrient from the balanced fertilizer dose.

Moinuddin and Nandan (2014) reported that plant height (37.50cm), number of branches per plant (17.33) and plant dry weight (44.06 g) was observed with the application of 25% RDN through FYM + 25% RDN through vermiompost + 25% RDN through poultry manure + 25% RDN through neem cake which was significantly higher than all the other treatments but among the treatment 50% RDN through vermicompost + 50% RDN through neem cake was found superior.

Baishya *et al*. (2014) reported that the number of nodules per plant were found to be highest in the treatment 100% N through FYM (@ 4 tonnes/ha followed by 50% N through inorganic fertilizer (10 kg N/ha) + 50% N through FYM (2 t/ha).

In rice-groundnut cropping system studied at wetland farm of ANGRAU, Tirupati, Reddy *et al*. (2003) have observed that application of 100 per cent N through FYM to preceding rice crop has resulted in highest dry matter production and increased the nodule weight in *Rabi* groundnut. Application of 10 tonnes of FYM/ha in *Kharif* groundnut improved plant height, plant spread at harvest and primary branches per plant under Junagadh Agro-ecological conditions (Meheta *et al*., 1996).

Yield and yield attributes :

Datta *et al*. (2014) reported that application of FYM @ 10 t/ha recorded the highest haulm yield (3.57t/ha) for NEH Region, Tripura.

Jat and Ahlawat (2010) observed that application of 5 t FYM/ha markedly improved the yield and yield attributed of groundnut over no FYM. The yield of groundnut were increased by FYM application to the tune 25.00 and 27.28 per cent in 2003 and 2004, respectively.

From experiment conducted by Mathukia *et al.* (2015) at Junagadh, the results revealed that the application of FYM and vermicompost recorded significantly higher pod yield (1533 and 1413 kg/ha) and haulm yield (3146 and 3288 kg/ha) of groundnut as compared to RDF.

Abraham and Thenua (2010) observed that application of 13 t FYM along with 75 per cent RDF in root zone as compared to the lower levels of RDF and no FYM and application through broadcasting found to result higher growth and yield in irrigated groundnut in north western plains of India.

In a sandy loam soil of Mainpuri, CSAU, Kanpur, Singh, 2000 observed that in peanut-vegetable pea cropping system application of FYM @ 10 t ha^{-1} + vermiculture @ 60000 ha^{-1} recorded higher number of pods/plant (22.6 no $plant^{-1}$) over other nutrient management practices.

Reddy *et al*., 2005 from UAS, Bangalore reported that application of poultry manure @ 5 t ha^{-1} recorded significantly higher pod and haulm yield over other organic manures.

In a clayey soil under rainfed condition at dry land research farm of Dhari, Gujarat, Akabari *et al*., 2002 have observed that application of FYM @ 10 t ha^{-1} to groundnut, significantly improved the pod and haulm yield.

Effect of organics (*FYM*) *on nutrient content and uptake* :

Jat and Ahlawat (2010) also reported that application of FYM @ 5t/ha significantly increased the total uptake of N, P and K in groundnut. The increase in nutrient uptake by FYM could be attributed to higher yield coupled with slight improvement in nutrient content.

Karmakar *et al*. (2005) have observed that phosphorus, potassium and calcium uptake increased in pod and haulm with application of FYM and other organic matter equivalent to 15 kg N ha^{-1} in the lateritic sandy clay loam soil at IIT, Kharagpur.

Experiments at the wetland farm of ANGRAU Tirupati, Chaithanya *et al*. (2003) have observed that application of FYM @ 8 t ha^{-1} increased the nitrogen, phosphorus, potassium, sulphur, zinc, copper, iron and manganese uptake by groundnut pod and haulm. Increase in nutrient uptake has also been observed by increasing FYM rate from 0 to 5 t ha^{-1} in the lithic ustrothent soil at Punjab Rao Krishi Vidyapith (PKV), Akola by Patil *et al*., 1998.

Baishya *et al*. (2014) observed that 100 per cent N through FYM enhanced the nutrient use efficiency over 50 per cent N through FYM and 50 per cent N through inorganic fertilizer, 75 per cent N through inorganic fertilizers and 25 per cent N through FYM, 100 per cent

N through in-organic fertilizer by 28, 20 and 36 per cent, respectively.

Mathukia *et al*. (2015) reported that application of FYM and vermi compost to groundnut significantly increased uptake of N, P and K. Application of FYM also slightly improved the post-harvest bulk density, organic carbon and availability of N, P and K in soil.

Effect of FYM on oil content and economics :

Reddy *et al*. (2005) at UAS, Bangalore observed that application of poultry manure, sewage sludge and urban garbage compost or farm yard manure resulted in higher oil content and oil yield in groundnut.

Mathukia *et al*. (2015) observed that maximum net return and B:C were obtained of FYM @ 10 t ha^{-1} in groundnut.

***Rhizobium* inoculation :**

Biological nitrogen fixation by legumes offers more flexible management than fertilizer nitrogen because the pool of organic nitrogen becomes slowly available (Dudeja and Duhan, 2005).

Nitrogen fixing micro-organisms are *Rhizobium*, *Azotobacter* and *Azospirillum*. *Rhizobium* is the most widely used inoculants bacteria that fixes atmospheric nitrogen through the process of symbiosis. There are seven *Rhizobium* species so far recognized which are associated with a specific legume crop or a group of leguminous crops those are mutually exchangeable symbioant known as cross inoculation group. Groundnut is associated with *Rhizobium* species in cowpea cross inoculating group (Singh, 1996).

Effect of Rhizobium on growth and development of groundnut :

Patel *et al*. (2002) from ICAR Research Complex, Umiam, Meghalay observed that inoculation of *Rhizobium* increased the plant height, number of branches, dry biomass per plant and root length due to increased nitrogenase activities of nodules.

Patra *et al*. (2008) observed that application of recommended dose of fertilizer along with inoculation of groundnut seeds with *Rhizobium* strain 1GR-6 or NRCG-9 significantly increased nodules/plant and nodule dry weight/plant at 40 and 80 days after sowing (DAS) during both the year (2004 and 2005) over control.

There was significant influence of nitrogen and *Rhizobium* inoculation on enhanced vegetative growth in terms of number of branches. But the correction studies confined negative association between plant height and number of branches (Edna *et al*., 2000).

In sandy loam soils of Mid hill zone of Meghalaya, inoculation with *Rhizobium* culture, resulted in improvement of all the growth attributes of groundnut but higher values were obtained at dual inoculation of *Rhizobium* and phosphate solubilizing bacteria (Panwar *et al*., 2002).

Effect of Rhizobium on yield and yield attributes :

Experiments conducted under medium deep black soils of Maharashtra where farmers practice was supplemented with *Rhizobium* inoculation significant increase dry pod yield was observed not only in the first year but during subsequent years (Karmakar *et al*., 2005).

In sandy loam soils of mid hill zone of Meghalaya, inoculation with *Rhizobium* culture resulted in improvement of pod yield of groundnut but higher values were obtained at dual inoculation of *Rhizobium* and phosphate solubulizing bacteria (Panwar *et al*., 2002). From similar studies at ICAR Research Complex, Union, Meghalaya. Patel *et al*. (2002) reported a significant increase in pod yield, 100 pod weight and shelling per cent due to *Rhizobium* inoculation but as of pods $plant^{-1}$ pod weight $plant^{-1}$ were at par with uninoculated treatment.

Datta *et al*. (2014) carried out an experiment at the ICAR Research complex for NEH region, Lembucherra during *Kharif* season for 3 consecutive year with 10 different combination of nutrient treatments and found that the inoculation of *Rhizobium* culture along with 50 kg $P_2 0_5$ + 50 kg K_2O ha^{-1} showed 45 per cent increment in pod yield (from 1.37 to 1.95 t/ha) over control. From similar studies at ICAR Research Complex Usian, Meghalaya, Patel *et al*. (2002) reported a significant increase in pod yield, 100-pod weight and shelling per cent due to *Rhizobium* inoculation but number of plants, pod weight per plant were at par with uninoculated treatment.

The crop inoculated with biofertilizers (*Rhizobium* + PSB) recorded significantly higher pod (1.74 t/ha) and haulm yields (3.64 t/ha) of groundnut over control in groundnut – rice cropping system at Deodhe, Ratnagiri, (Maharastra), as reported by Chavan *et al*. (2014).

Mohapatra and Dixit (2010) studied that inoculation with *Rhizobium* improved the nodulation that enhanced

N fixation, activation of amino acids for synthesis of carbohydrate and consequently expressed in increase in number of pods/plant, 100 kernel weight and pod yield.

Bandyopadhyay *et al*. (2011) reported that local strain of *Rhizobium* inoculation performed better (*Rabi* 2.22 tons/ha and pre-*Kharif* : 2.50 tons/ha) than foreign strain and control during both the season (2005 and 2006) of crop growth.

Sharma *et al*. (2013) observed that application of *Rhizobium*, being at par with PSB and VAM, significantly increased number of pods per plant, kernels per pod, seed index, pod, haulm and biological yield and shelling per cent over control.

Ram *et al*. (2013) reported that the highest pod and haulm yield was recorded in *Rhizobium* which were 35.5 and 26.1 per cent higher over no inoculation.

Singh *et al*., 2013 observed that maximum seed yield of 1713 kg/ha was recorded with combined inoculation with *Rhizobium* + PSM which was 5.67, 16.60 and 28.60 per cent higher over *Rhizobium*, PSM and inoculated control, respectively.

Patra *et al*. (2008) found that RDF + *Rhizobium* inoculation with IGR -6 strain increased pod yield by 62 per cent over control and 14.2 per cent over RDF.

Effect of Rhizobium inoculation on nutrient uptake :

Chavan *et al*. (2014) marked significant increased in N, P, K uptake by groundnut crop when it is inoculated with biofertilizers.

Bandhyopadhyay *et al*. (2011) reported that the uptake of nitrogen was higher in plots inoculated with local strain of *Rhizobium* in more conducive pre-*Kharif* season during 2005 and 2006 in acidic soil of Terai region of West Bengal.

Sharma *et al*. (2014) observed that the inoculation of *Rhizobium* recorded highest uptake of N, P and K to the tune of 25.5, 23.0 and 18.5 per cent over no inoculation but remained at par with PSB and VAM inoculation during *Kharif* season.

Ola *et al*. (2013) reported that seed inoculation with *Rhizobium* recorded the higher N content and uptake than PSB and found significantly superior to control.

Singh *et al*. (2013) reported that application of *Rhizobium* + PSM increased uptake of N, P, and and Ca significantly over the control during both the years of study. Maximum N, P, K and Ca uptake by pod and haulm was recorded with inoculation of *Rhizobium* + PSM, which was significantly higher than their single inoculation and control treatment.

Effect of Rhizobium inoculation on oil yield and oil content of groundnut :

Sharma *et al*. (2014) recorded that *Rhizobium* inoculation resulted in significantly higher protein and oil content in kernel and oil yield which were 11.3, 13.7 and 41.8 per cent over control, respectively but remained statistically at par with PSB and VAM which also superior over control.

Effect of Rhizobium on economics :

Datta *et al*. (2014) reported that significantly higher total returns (Rs.84, 020/ha), net return (Rs. 58,447/ha) were recorded with inoculation of groundnut seed with *Rhizobium* culture along with soil application of 50 kg P_2O_5+ 50kg K_2O/ha. The highest benefit : cost (3.52) was recorded in the plot inoculated with *Rhizobium* culture for NEH region, Tripura.

Sharma *et al*. (2014) observed that inoculation with biofertilizers significantly increased net returns and the highest (Rs. 43,717/ha) were recorded with *Rhizobium* which was superior over control and VAM but at par with PSB.

Ram *et al*. (2013) reported that maximum net return (Rs. 56,576/-) and B:C (4.17) was found in *Rhizobium* inoculation.

Singh *et al*. (2011) reported that application of *Rhizobium* + PSM recorded the highest net return of Rs. 22, 755/- ha with benefit cost ratio of 1.49 followed by *Rhizobium*.

Singh *et al*. (2013) observed that maximum net return (Rs. 48,920/-) obtained with combined inoculation of *Rhizobium* + PSM, was 7.89 per cent and 24.60 per cent higher over *Rhizobium* and PSM, respectively. The benefit cost ratio of 2.49 was maximum with *Rhizobium* + PSM followed by 2.32 with *Rhizobium*.

Lime :

Calcium maintains cell wall all integrity and membrane permeability. It enhances pollen germination, activities and takes part in protein synthesis and carbohydrate transfer. Calcium requirement is very high during gynophere development and pod filling.

Under similar condition at Jorhat, Dutta *et al*. (2004) observed a significant increase in number of matured pods/plant, dry pod weight/plant, number of kernels/pod and 100 kernel weight with the application of lime @ 25

% LR over no lime. Liming at 25 per cent LR had also a lead over 50 per cent LR which ultimately reflected in yield. It might be due to the fact that calcium requirement of the crop might have been satisfied at 25 per cent LR. Further increment in level upto 50 per cent LR might have disturbed the balance of nutrition affecting yield.

Effect of lime on vegetative growth of groundnut :

In Odisha two third of total area is acidic and there is wide variation of pH within the same group of soils. (Mitra *et al*., 2002). Application of lime at full dose of LR is also not beneficial as the leaching loss becomes very high.

Effect of lime on yield and yield attributes of groundnut :

The critical level of soil Ca is about 250 ppm (1.25 meq/100 g in root zone) and 600 ppm in pod zone. However, soil Ca concentration of more than 2.3 meq/ 100 g in root zone and 1 meq in pod is ideal for groundnut cultivation (Singh *et al*., 2004).

Deka *et al*. (2001) revealed that application of lime @ 25 % LR recorded higher pod yield over control but remained at par with 50 per cent LR in a acid sandy loam soil of Assam.

At Jorhat, Dutta *et al*. (2004) observed a significant increase in number of matured pods/plant, dry pod weight per plant, number of kernels, /pod and 100-kernel weight with the application of lime @ 25 LR over no lime. Liming at 25 per cent LR had also a lead over 50 per cent LR which ultimately reflected in yield. It might be due to the fact that calcium requirement of the crop might have been satisfied at 25 per cent LR. Further, increment in level upto 50 per cent LR might have disturbed the balance of nutrition affecting yield.

Singh *et al*. (2011) reported that application of lime significantly increased pod yield as compared to control. But maximum pod yield was recorded with lime + FYM + 50% NPK which was 6.80 and 13.14 per cent higher over FYM + 50% NPK and 100 per cent NPK, respectively which indicated beneficial effect of lime in improving pod yield of groundnut.

Effect of lime on oil content of groundnut :

Dutta *et al*., 2004 in the sandy loam soil of Assam Agriucltural University, Jorhat observed that by liming upto both 25 per cent lime requirement and 50 per cent lime requirement increase the oil content and oil yield of gorundnut significantly over no liming. The oil content and oil yields were higher in 25 per cent LR over 50 per cent LR.

Effect of lime on nutrient content and uptake :

Studying the effect of liming in acid sandy loam soil of Jorhat, Deka *et al*. (2001) observed that application of lime at 50 per cent LR significantly increased the N content in haulm followed by 25 per cent LR as compared to no liming. Phosphorus content in both kernel and haulm under 25 per cent LR and 50 per cent LR statistically at par due to better ion absorption under limed condition. But K content was higher in haulm than Kernel. The NPK uptake by kernel and haulm were significantly increased due to application of lime at 25 per cent LR than at 50 per cent LR.

Effect of gypsum on groundnut production :

Gypsum supplies sulphur and calcium to crops. Sulphur provides sink strength through development of reproductive structure and production of assimilates to fill sink. Calcium plays an important role in reproductive development of groundnut. In the absence of both xylem and phloem supply of Ca, the penetrating gynophores have modified themselves into aborting organs of calcium from the immediate fruiting.

Sulphur is the integral part of amino acids like cysteine and methionine which are the building blocks of protein and promote oil content in groundnut. Sulphur is involved in the formation of chlorophyll activation of enzymes in the formation of glucocides and glucocinolates. It is a part of Co-enzyme A, Pyrophosphate, vitamins such as biotin thiamine (B_1) (Tandon, 1995).

Soils with available (0.01 m monocalcium phosphate extractable) sulphur, below 10 ppm S is considered as critical level. Most of the soils where groundnut is grown are deficient in sulphur in India (Singh *et al*., 2004) and in Odisha (Mitra *et al*., 2002).

Effect of gypsum on growth and yield of groundnut :

Studies at Ujhani, U.P., where the soil was also sandy loam, application of 45 kg sulphur/ha through gypsum or single super phosphate resulted in tallest plant with highest number of primary branches/plant, more number of pods/ plant, highest pod yield, higher shelling percentage and

100 kernel weight (Chaubey *et al*., 2000).

From the pooled mean pod yield of 3 years (2009-2011), Dash *et al*. (2013) observed that the highest pod yield of 1.80 t/ha was observed with application of 20 kg S/ha for Odisha soil condition.

Jat and Ahlawat (2010), observed that all the three sources of S at both the rates had higher productivity over no S. The differences between 35 and 70 kg S/ha were not marked among the various sources of S. Cosavet at 70 kg S/ha recorded the highest productivity among S treatments, except Cosavet at 35 kg S/ha.

Singh and Mann (2007), studied that application of 20, 40 and 60 kg S/ha increased the pod yield, respectively by 16.5, 22.7 and 22.8 per cent during 2001 and by 19.1, 26.5 and 29.8 per cent during 2002 over the control in Rajasthan. The application of S increased the yield mainly due to early flowering and greater pod setting.

Salke *et al*. (2011) reported that the highest dry pod yield (23.58 q/ha^{-1}) and dry haulm yield (33.01 q/ha^{-1}) was recorded due to application of RDF + gypsum @ 500 kg ha^{-1}.

Effect of gypsum on oil content of groundnut :

In a sandy clay loam soil at Udaipur, gypsum @ 250 kg/ha applied full at sowing or half at sowing and half at 35 DAS recorded higher yield attributing characters and 9 per cent increase in pod yield over control. It resulted in higher number of pods plant^{-1}, 100 kernel weight and percentage of stable mature kernel (Rao and Shekawat, 2002).

Increase in oil content (8 %) due to application of sulphur at 30 kg ha^{-1} either through gypsum or SSP over control has been reported by Bandopadhyay and Samui (2000) from BCKV, Kalyani, West Bengal in summer groundnut.

The oil content in kernel as well as oil yield were the highest at 30 kg S/ha level through gypsum which was due to direct involvement of S in oil biosynthesis as reported by Maity and Giri (2003) in *Kharif* groundnut grown at IARI Farm, New Delhi.

Dash *et al*. (2013) reported that the oil content of the seed showed an increasing trend with increase in sulphur doses from 20 to 60 kg per ha. The mean oil content of three years (2009-2011) was the highest with 60kg S/ha and the increase was 10.80 per cent over control in Odisha condition.

Mohapatra and Dixit (2010) had reported that Gypsum provided S and Ca and recorded 17.9 per cent higher oil content over application of RDF alone.

Effect of gypsum on nutrient uptake :

Application of gypsum @ 250 kg ha^{-1} either in single or split doses to groundnut significantly increased the uptake of N, P, K, S Ca and Mg in plant due to their greater availability in root environment along with extraction and transportation towards plant system (Rao and Shekhawat, 2002).

Mohapatra and Dixit (2010) reported that the higher Ca uptake due to lime and gypsum application was due to increase in its availability in rhizosphere.

Jat and Ahlawat (2010), observed application of 35 and 70 kg S/ha through all the sources significantly increased total uptake of N, P and S in groundnut over no sulphur.

Chemical fertilizers :

Nitrogen requirement and functions :

Nitrogen is an important constituent of protein, chlorophyll, amino acids and nucleic acids and is required for vegetative and reproductive growth. It plays an active role in enzyme reaction and energy metabolism. The N requirement of groundnut is much higher than cereals because of its high protein content. As groundnut takes up about 180 kg N ha^{-1} from the atmosphere through fixation, the demand for mineral nitrogen is low. The nitrogen fixation starts at 25-30 days after sowing. Till that time to give the plant growth an initial boost about 10-30 kg N ha^{-1} has been recommended to be applied basally as a starter dose for different areas (Basu and Dayal, 2003).

Phosphorus requirement and functions :

Phosphorus is present in inorganic form as a component of ATP, RNA, DNA and certain enzymes and proteins and involved in various energy transfer reaction and genetic informations. It limits nodule development N_2 fixation, plant growth, seed development and oil synthesis in groundnut and enhance root production (Singh, 1999).

Potassium requirement and functions :

Potassium is required for translocation of assimilates and involved in maintenance of water content of plants especially the turgor pressure of cells and opening and closing of stomata and increases the availability of metabolic energy for the synthesis of starch and protein. It increases pod formation, growth and filling. Most of

the Indian soils are rich in potassium. In deficient soils 17-34 kg K_2O ha^{-1} may be applied (Basu and Dayal, 2003).

Effect of chemical fertilizer on growth and yield of groundnut :

Mitra *et al*. (2002) observed a significant higher yield (22.75 q/ha) of Rabi groundnut over N, P control (16.42 q ha^{-1}) by applying K @ 60 kg K_2O/ha along with N and P.

Recommended dose of chemical fertilizers (30-50-50) NPK kg/ha recorded the highest pod yield of 28 q ha^{-1}, haulm yield of 56 q ha^{-1}, with highest number of filled pods (21) and 100 pod weight (96.4 g) under Tirupati agroclimatic condition (Chaithanya *et al*., 2003).

Kathamale *et al*. (2000) from K-digraj farm, Sangli, Maharashtra reported that integrated use of FYM @ 2.5t ha^{-1} + 75 % recommended dose of fertilizer produced 2751 kg ha^{-1} haulm yield at harvest which was 55 per cent higher over the control.

Effect of chemical fertilizer on nutrient uptake of groundnut :

Under Tirupati condition application of recommended dose of fertilizer (30-50-50) ensured highest uptake of nutrients such as N, P, K, S, Fe, Zn and Cu by haulms and pods (Chaithanya *et al*., 2003).

Integrated nutrient management (INM) :

According to Prasad (2002) integrated nutrient management involves 'combined use of chemical fertilizers, organic manures and biofertilizers including crop residues and green manures to monitor the pathways of flow of plant nutrients in an agricultural production system in order to maximize profit.

Effect of INM on growth of groundnut :

Rao and Shekawat (2001) in a sandy clay loam soil at Udaipur, Rajasthan observed the highest root dry weight with combined application of FYM @ 10 t ha^{-1}, phosphorus @ 40 kg ha^{-1} and gypsum @ 250 kg ha^{-1}.

Meena *et al*. (2015) recorded highest plant height, more number of branches, maximum plant dry weight, crop growth rate in the treatment in which phosphorus was applied at 40 kg/ha along with seed treatment with VAM, PSB along with application of FYM @ 10t/ha. The yield attributes namely maximum no of pods/plants, kernels/pod and pod yield was also recorded in the aforesaid treatment.

Kausale *et al*. (2009) in an field experiment at Navsari, Gujarat, reported that nodule number, dry matter $plant^{-1}$ of groundnut crop during summer increased with application of 100 per cent RDF (25 kg N + 50 kg P_2O_5 ha^{-1}), 10 t FYM ha^{-1} and *Rhizobium* or PSB seed inoculation.

Baishya *et al*. (2014) studied that application of 75 per cent N through inorganic fertilizers + 25% N through FYM produced maximum shoot length, root length and higher number of branches/plant and pods/plant as compared to other nutrient management treatment.

Effect of INM on yield and yield attributes :

Long term INM trials on rainfed groundnut on red sandy loam soils (Alfisols) of Anantpur, Andhra Pradesh conducted for 18 years revealed that half of the recommended dose of fertilizer (10-8.8-16.5 NPK kg ha^{-1}) along with FYM @ 4 t ha^{-1} recorded the highest mean pod yield of 1041 kg ha^{-1} with sustainability yield index of 0.292 (Balaguravaiah *et al*., 2005).

Karunakaran *et al*. (2010) recorded application of enriched compost along with 125 per cent RDF recorded significantly higher plant height and LAI among all the treatments and also significantly higher dry matter production (6.97 t/ha, mean of 2 years).

A field experiment conducted during three consecutive *Kharif* season of 1993, 1994 and 1995 by Malligawad *et al.* (2000) revealed that the application of FYM @ 4 t/ha +50% RDF (12.5 kg N, 30 kg P_20_5 and 12.5 kg K_20/ha) recorded significantly higher dry pod yield of groundnut (3232 kg/ha) compared to either RDF (25kg N, 75 kg P_20_5 and 25 kg K_20/ha) along (3148 kg/ha) or no application (2742 kg/ha).

Moinuddin *et al*. (2014) revealed that the superiority of yield attributing characters *i.e.* number of pods per plant (29 cm), 100 seed weight (95.50g) pod yield (3110 kg/ha) and haulm yield (3780 kg/ha) was observed with the treatment application of 25% RDN through FYM +25% RDN through vermicompost + 25% RDN through poultry manure + 25% RDN through neem cake which was significantly higher than all the other treatments.

Pattanayak *et al*., 2011 reported that combined application of FYM (2 t ha^{-1}) and lime with 50 per cent of recommended NPK increased groundnut pod yield by 18.4 per cent (2000 kg ha^{-1}) compared to 100 per cent NPK alone (1690 kg ha^{-1}). No significant yield difference was observed between 100 per cent and 50 per cent of

soil test based nutrient application when applied in combination with lime or lime + FYM. This might be related to the issue of balanced nutrition of crops that goes beyond the context of N, P and K. Addition of high rates of N, P and K as part of the treatment may stimulate deficiency of micronutrients, which probably was adequate for the 50 per cent NPK rates (Johnston *et al*., 2009).

Reddy *et al*. (2005) reported that conjunctive use of organics and inorganics *i.e.*,25.75-40 kg N: P_2O_5: K_2O ha^{-1} as per soil test + 10 t FYM ha^{-1} can meet all the nutrient requirement of the groundnut crop and increase pod, haulm and oil yield.

Mohapatra and Dixit, 2010 reported from Berhampur, Odisha that FYM @ 5 t ha^{-1} with 50 per cent RDF of 20-17.4-33.3 kg NPK ha^{-1} + boron 1.0 kg ha^{-1} was optimum for obtaining maximum yield and yield attributes of *Kharif* groundnut grown in alfisols.

Mohapatra and Dixit 2010 reported that application of FYM + 75% RDF + *Rhizobium* + gypsum + boron recorded significantly higher pods/plant, 100 pod weight resulting in higher pod (2.66 t/ha) kernel yield (1.92 t/ha) during *Kharif* season of 2003 and 2004 as loamy sand soil of Berhampur, Odisha.

Patro *et al*. (2012) conducted a field experiment during *Rabi*-summer season of 2009-10 and 2010-11 at Agronomy Main Research Farm, OUAT and the results revealed that application of 100 per cent recommended dose of fertilizer as basal plus 50 per cent recommended dose of fertilizer nitrogen at 30 DAS along with FYM @ 7.5 t/ha recorded the maximum pod yield of 2200 kg/ha which was comparable with 75 per cent recommended dose of fertilizer as basal and 75 per cent recommended dose of fertilizer nitrogen at 30 DAS with or without FYM @ 7.5 t/ha and 100 per cent recommended dose of fertilizer as basal plus 50 per cent recommended dose of fertilizer nitrogen at 30 DAS without FYM @ 7.5 t/ha.

Kausale *et al*. (2009) revealed that in order to obtain higher summer groundnut yield it should be fertilized with 75 per cent RDF (18.75 N, 37.5 P kg/ha along with 10 t FYM and seed treatment of *Rhizobium* or PSB).

Effect of INM on nutrient uptake :

In a clay loam soil at Jhargram, BCKV, West Bengal, Dutta and Mandal (2006) have also observed increased uptake of nitrogen, phosphorus and potassium by application of FYM @ 7.5 t ha^{-1} along with 100 per cent recommended dose of fertilizers (30-60-40 kg NPK ha^{-1}) and 500 kg gypsum ha^{-1} over control.

Karunakaran *et al*. (2010) observed that among the treatments, application of 125 % RDF + EC recorded significantly higher N, P and K uptake than rest of the treatments. This was followed by 125% RDF + FYM and RDF of the treatments. This was followed by 125% RDF+ FYM and RDF + EC and they are at par.

Mohapatra and Dixit (2010) observed higher nutrient uptake of 151.4-17.0-58.6-10.8-0.07 kg N-P-K-S-B ha^{-1} with integrated application of FYM @ 5 t ha^{-1} + 75 % RDF + *Rhizobium* + gypsum + boron and emphasized on synergistic and additive effect of one nutrient on the uptake of other nutrient. They reasoned out highest uptake of nutrients to enhanced microbial root activity under favourable soil physical condition.

Pattanayak *et al*. (2011) in an on farm study under Odisha condition reported that the organic (FYM) and inorganic (PMS) ameliorants either alone or together, created better growing conditions in acid soils which favoured (doubled) the uptake of N, P and K by groundnut.

Effect of INM on oil content and oil yield :

Mohapatra and Dixit (2010) from Berhampur, Odisha reported increase in oil content and oil yield with 50 % RDF + *Rhizobium* + lime 0.25 LR + gypsum @ 250 kg ha^{-1} + boron 1.0 kg ha^{-1} in *Kharif* groundnut grown in Alfisols.

Application of 100 per cent RDF (25-50-0 kg NPK ha^{-1} plus 5 t FYM ha^{-1}) recorded the highest oil content (49.82 %) and oil yield (14.07 q ha^{-1}) in summer groundnut (Thorave and Dhonde, 2011).

In an on farm study under Odisha situation Pattanayak *et al*. (2011) revealed that the oil content of groundnut kernel increased from 43.1 to 45.98 per cent by applying the 100 per cent NPK dose of fertilizer with lime and FYM.

Ola *et al*. (2013) recorded that integrated application of FYM @ 8 t/ha + 50% RDF produced significantly higher yield, oil content, oil yield and protein content as well as N, P content and uptake by groundnut but remained at part with VC @ 3 t/ha + 50% RDF.

Effect of INM on post harvest soil fertility :

Mohapatra and Dixit, 2010 while calculating balance sheet of available Ca, S and B with integrated nutrient management practices *viz.*, 20-40-40 kg NPK ha^{-1} + gypsum 250 kg ha^{-1} + lime 50 % LR + *Rhizobium* opined

that available N, P, K, Ca, S and B after harvest of the crop were 76.1, -0.7, -8.6, + 36.6, -1.2 and -0.99 kg ha^{-1}, respectively. While N and Ca showed positive net gain P, K, S and B showed slightly negative balance.

Babu *et al*. (2008) reported higher organic carbon build up and increase in available P and K with recommended dose of NPK @ 20-40-40 kg ha^{-1} and FYM @ 5 t ha^{-1}.

Patra *et al*. (2011) while doing budgeting of nutrient application in a sandy loam soil to groundnut crop reported that the RDF dose of 20-60-60 kg NPK ha^{-1} exhibited negative balance of N, P and K as compared to RDF + vermicompost 2.5 t ha^{-1} and RDF + phospho compost 2.5 t ha^{-1}.

In a on farm study under Odisha condition, it was reported that lime (PMS) application either alone or with FYM maintained higher pH in the soil by neutralizing the acidity and by buffering action of FYM. Mostly the leaf shedding property of groundnut and treatments of NPK with FYM addition increased organic (status of soils). The available P status in soil declined significantly under farmers practice and 50 per cent NPK treatments where addition was 100, but maintained the P status in 100 per cent NPK treatments (Pattanayak *et al*., 2011).

Choudhary *et al*. (2011) reported that application of 25 kg N + 50kg P_2O_5 + 40 kg K_2O ha^{-1} along with *Rhizobium*, VAM and PSB recorded significantly higher available nitrogen 164.1 kg ha^{-1} and available phosphorus 16.6 kg ha^{-1} whereas minimum were noted with the application of RDF – NPK alone.

Effect of INM on economics :

Mohapatra and Dixit, 2010 reported higher net return and B:C when groundnut was supplemented with FYM + 75 % RDF + *Rhizobium* + Gypsum + B.

Pattanayak *et al*. (2011) at Odisha condition reported that application of 50 per cent of the recommended NPK rate, applied in combination with lime and FYM increased farmer income by about 75 per cent over the farmers practice.

Patro *et al*. (2012) in a field study at OUAT, Bhubaneswar, Odisha reported that application of 100 per cent RDF as basal plus 50 per cent recommended dose of fertilizer N at 30 DAS along with FYM @ 7.5 t ha^{-1} recorded the maximum net return (Rs. 23274 ha^{-1}) and B-C ratio (1.935) which was comparable with 75 per cent RDF as basal plus 75 per cent recommended dose of fertilizer N at 30 DAS with or without FYM and 100 per cent RDF as basal plus 50 per cent RDF N at 30 DAS without FYM.

It can be concluded that adoption of a balanced nutrient management approach will safeguard the higher productivity and returns from money spent.

LITERATURE CITED

Abraham, T. and Thenua, O.V.S. (2010). Influence of organic and inorganic sources of nutrient and their methods of application on growth and yield attributes of groundnut (*Arachis hypogaea* L.). *Indian J. Agric. Res.,* **44** (3) : 216-220.

Akbari, K.N., Sutaria, G.S., Hirapara, D.S., Kunjadia, B.A. and Patel, V.N. (2002). Effect of phosphorus fertilization with and without FYM on groundnut yield and soil fertility under rainfed condition, *Leg. Res.*, **25** (2):117-120.

Babu, M.V., Balaguravaiah, D., Adinarayana, G., Prathap, S. and Reddy, T.Y. (2008). Effect of tillage and nutrient management on rainfed groundnut production and soil properties in Alfisols, *Leg. Res.*, **31** (3) : 192-195.

Baishya, L.K., Ansari, M.A., Singh, R., Deka, B.C., Prakash, N. and Ngachan, S.V. (2014). Response of groundnut (*Arachis hypogaea*) cultivars to integrated nutrient management on productivity, profitability and nutrient uptake in NEH region. *Indian J. Agric. Sci.,* **84** (5): 612-615.

Balaguravaiah, D., Adhinarayana, G., Prathap, S. and Reddy, Y.T. (2005). Influence of long term use of inorganic and organic manures on soil fertility and sustainable productivity of rainfed groundnut in *Alfisols. J. Indian Society Soil Sci.,* **53** (4): 608-611.

Bandopadhya, P. and Samui, R.C. (2000). Response of groundnut cultivars to levels and sources of sulphur in West Bengal, *Indian J. Agron.,* **45**(4): 761-764.

Bandyopadhyay, S., Sharma, L., Roy, A.K. and Gupta, D. (2011). Season wise performance of groundnut (*Arachis hypogaea*) cultivars as influenced by local and foreign strain of Rhizobium inoculation, *Indian J. Agric. Sci.,* **81**(1) : 60-66.

Basu, M.S. and Dayal, D. (2003). *Groundnut production technology for Kharif* (Rainfed). Bulletin NRCG, Junagadh, India, pp.33.

Chaithanya, Devi M., Ramavatharam, N., Naidu, M.V.S. and Reddy, K.S. (2003). Effect of inorganic fertilizers and organic manures on growth, yield and uptake of nutrients by groundnut (*Arachis hypogaea*). *J. Oilseeds Res.*, **20** (1): 126-128.

Chaubey, A.K., Singh, S.S. and Kaushik, M.K. (2000). Response of groundnut (*Arachis hypogaea*) to source and level of sulphur fertilization in mid-western plains of Uttar Pradesh, *Indian J. Agron.*, **45** (1): 166-169.

Chavan, A.P., Jain, N.K. and Mahadkar, U.V. (2014). Direct and residual effects of fertilizers biofertilizers on yield nutrient uptake and economics of groundnut (*Arachis hypogaea*)-rice (*Oryza sativa*) cropping system, *Indian J. Agron.*, **59**(1): 53-58.

Choudhary, S.K., Jat, M.K., Sharma, S.R. and Singh, P. (2011). Effect of INM on soil nutrient and yield in groundnut field of semi-arid area of Rajasthan, *Leg. Res.*, **34** (4) : 283 - 287.

Dash, A.K., Nayak, B.R., Panigrahy, N., Mohapatra, S. and Samanta, P.K. (2013). Performance of groundnut (*Arachis hypogaea*) under different levels of sulphur and irrigation. *Indian J. Agron.*, **58** (4): 578-582.

Datta, M., Yadav, G.S. and Chakraborty, S. (2014) . Integrated nutrient management in groundnut (*Arachis hypogaea*) in sub-tropical humid climate of north-east India. *Indian J. Agron.*, **59** (2) : 322-326.

Deka, N.C., Dutta, R. and Gogoi, P.K. (2001). Effect of lime and nitrogen on nutrient uptake and residual soil fertility in groundnut. *Legume Res.*, **24** (2): 118-120.

Dudeja, S.S. and Duhan, J.S. (2005). Biological nitrogen fixation research in pulses with special reference to mungbean and urdbean. *Indian J. Pulses Res.*, **18**(2): 107-118.

Dutta, D. and Mondal, S.S. (2006). Response of summer groundnut (*Arachis hypogaea*) to moisture stress, organic manure and fertilizer with and without gypsum under lateritic soil of West Bengal. *Indian J. Agron.*, **51** (2): 145-148.

Dutta, R., Gogoi, P.K., Sarma, B.N., Barman, P. and Decka, N.C. (2004). Effect of levels of lime and phosphorus on production of groundnut (*Arachis hypogaea* L.). *Leg. Res.*, **27** (4): 274-277.

Edna, Antony, Doddaman, M.B., Alagavadi, A.R. and Chetti, M.B. (2000). Response of groundnut genotypes to nitrogen level and inoculation, *Ann. Agric. Res.*, **21**(2) : 311-313.

Jat, R.A. and Ahlawat, I.P.S. (2010). Effect of organic manure and sulphur fertilization in pigeonpea (*Cajanus cajan*) + groundnut (*Arachis hypogaea*) intercropping system. *Indian J. Agron.*, **55** (4): 276-281.

Johnston, A.M., Khurana, H.S., Majumdar, K. and Satyanarayana, T. (2009). Site-specific nutrient management - Concept, current research and future challenges in Indian agriculture. *J. Indian Soc. Soil Sci.*, **57**(1): 1-10.

Karmakar, S., Mittra, B.N. and Ghosh, B.C. (2005). Effect of different organic materials with flyash in integrated plant nutrient system for groundnut (*Arachis hypogaea* L.). *Indian J. Agron.*, **50** (2): 152-155.

Karunakaran, V., Rammohan, J., Chellamuthu, V. and Poonghuzhalan, R. (2010). Effect of integrated nutrient management on the growth and yield of groundnut (*Arachis hypogaea*) in coastal region of Karaikal. *Indian J. Agron.*, **55** (2): 128-132.

Kathamale, D.K., Khadtare, S.V., Kamble, M.S. and Patil, R.S. (2000). Integrated nutrient management in groundnut (*Arachis hypogaea* L.)-wheat (*Triticum aestivum*) cropping system on vertisols of Western Maharastra Plains Zone, *Indian J. Agron.*, **45**(2): 248-252.

Kathamale, D.K., Mali, H.N. and Kambale, M.S. (2002). Effect of micronutrients on yield and quality of confectionary groundnut (*Arachis hypogaea*). Extended summaries Vol. **1**, 2nd International Agronomy Congress, New Delhi, India, pp. 282-283.

Kausale, S.P., Shinde, S.B., Patel, L.K. and Borse, N.S. (2009). Effect of integrated nutrient management on nodulation, dry matter accumulation and yield of summer groundnut at South Gujarat conditions, *Leg. Res.*, **32**(3): 227-229.

Maity, S.K. and Giri, G. (2003). Influence of phosphorus and sulphur fertilization on productivity and oil yield of groundnut (*Arachis hypogaea* L.) and sunflower (*Helianthus annus*) in intercropping with simultaneous and staggered planting, *Indian J. Agron.*, **48** (2): 267-270.

Malligawad, L.H., Patil, R.K., Kannur, V. and Giriraj, K. (2000). Effect of fertility management practices in groundnut, *Karnataka J. Agric. Sci.*, **13**(2) : 229-305.

Mathukia, R.K., Sheikh, M.A., Sagarkaand, B.K. and Panara, D.M. (2015). Climate resilient organic farming for groundnut

(*Arachis hypogaea*) – Garlic (*Allium sativum*) crop sequence, *Ann. Agric. Res., New Series*, **36** (1):103-106.

Meena, S., Nagar, T., Choudhary, P. and Dawson, J. (2015). Integrated phosphorus management and its effect on growth and yield of groundnut (*Arachis hypogaea* L.). *Allahabad Farmer*, **70** (2) : 187-188.

Meheta, A.C., Malavia, D.D., Kankeria, B.B. and Khanpara, V.D. (1996). Response of groundnut (*Arachis hypogaea*) to farm yard manure, phosphorus and phosphate-solubulizing microorganism. *Indian J. Agron.*, **41** (1): 172-174.

Mitra, G.N., Misra, U.P. and Sahu, S.L. (2002). Macro and micronutrient status of the soils of Orissa. Technical Report, OUAT, Bhubaneswar, pp.44.

Mohapatra, A.K.B. and Dixit, L. (2010). Integrated nutrient management in rainy season groundnut (*Arachis hypogaea*), *Indian J. Agron.*, **55** (2): 123-127.

Moinuddin, Kaleem M. and Nandan, R. (2014). Effect of different organic sources of nitrogen on growth and yield of groundnut (*Arachis hypogaea* L.) *Allahabad Farmers*, **70** (1) : 301-306.

Ola, B.L., Pareek, B.L., Yadav, R.S., Shivran, A.C. and Sharma, O.P. (2013). Influence of integrated nutrient management on productivity and quality of groundnut in Western Rajasthan, *Ann. Agric. Res. New Series*, **34** (2) : 156-159.

Panwar, A.S., Singh, N.P.S., Saxena, D.C. and Hazarika, V.K. (2002). Nutrient management in groundnut (*Arachis hypogaea*) in mid hills of Meghalaya. *Extended Summaries, 2nd International Agron. Congress.* New Delhi, **1**: 277-278.

Patel, D.P., Munda, G.C. and Singh, N.P. (2002). Response of groundnut (*Arachis hypogaea* L.) to Rhizobium and PSM inoculation in the acid soils of Meghalaya. *J. Oilseeds Res.*, **19**(2): 245-246.

Patil, M.N., Deshmukh, P.W., Nikesar, R.J. and Naphade, K.T. (1998). Response of groundnut to sulphus and farm yard manure on *Lithic ustorthent*. *P.K.V. Res. J.*, **22** (1): 13-15.

Patra, P.S., Singh, A.C. and Mahesh, S.S. (2011). Yield, nutrient uptake and quality of groundnut (*Arachis hypogaea*) kernels as affected by organic sources of nutrient, *Indian J. Agron.*, **56**(3): 237-241.

Patra, R.K., Patra, A.K., Pradhan, K. and Nayak, R.N. (2008). Response of groundnut (*Arachis hypogaea* L.) to *Rhizobium* and phosphobacterium inoculation. *J. Res. Orissa Univ. Agric, Tech.*, **26** (2) : 43-47.

Patro, H., Nanda, S.S., Parida, D., Md Alim, A. and Behera, A.K. (2012). Integrated nutrient management on yield maximization of irrigated groundnut. *Trends Biosciences*, **5** (4) : 287-288.

Pattanayak, S.K., Mishra, U.K., Sarkar, A.K. and Majumdar, K. (2011). Integrated nutrient management for groundnut and red gram on acid soils of Odisha, *Better Crops – South Asia*, **95**(2): 8-10.

Prasad, R. (2002). Sustainable agricultural production and integrated nutrient management. *Souvenir Second International Agronomy Congress on Balanced food and environmental security a continuous challenge*, November 26-30, New Delhi, pp. 57-66.

Ram, C., Singh, H.B., Patel, R.B., Singh, H. and Kumar, G. (2013). Effect of various nutrient sources on productivity and economics of groundnut (*Arachis hypogaea* L.). *Ann. Agric. Res., New series*, **34** (2): 176-178.

Rao, S.S. and Shekawat, , M.S. (2001). Effect of organic manure, phosphorus and gypsum on growth, yield and quality of groundnut ((*Arachis hypogaea* L.), *Indian J. Plant Physiol. New Series*, **6** (3) : 306-311.

Rao, S.S. and Shekawat, M.S. (2002). Effect of organic manure, phosphorus and gypsum on groundnut (*Arachis hypogaea*) production under rainfed condition, *Indian J. Agron.*, **47**(2):234-241.

Reddy, S.M., Reddy, S.D. and Reddy, P.V.R.M. (2003). Dry matter production nodule dry weight and nitrogen uptake of *Rabi* groundnut as influenced by residual fertility of different nitrogen management practices to *Kharif* rice. *J. Oilseeds Res.*, **20**(2): 234-236.

Reddy, S.S., Shivaraj, B. and Reddy, C.V. (2005). Effect of poultry manure, sewage sludge and urban garbage compost on yield, quality and economic of groundnut (*Arachis hypogaea* L.). *J. Oilseed Res.*, **22** (2) : 245-248.

Salke, S.R., Shaikh, A.A. and Dalavi, N.D. (2011). Effect of phosphatic fertilizers, gypsum and sulphur on groundnut (*Arachis hypogaea* L.). *Bioinfolet*, **8** (3): 276 - 277.

Sharma, S., Jat, N.L., Shivran, A.C., Choudhary, S., Puniya, M.M. and Jeetarwal, R.L. (2013). Effect of fertility levels of

biofertilizers on yield and economics of groundnut, *Ann. Agric. Res. New series*, **34** (4): 353-356.

Sharma, S., Jat, N.L., Puniya, M.M., Shivran, A.C. and Choudhury, S. (2014). Fertility levels and biofertilizers on nutrient concentrations, uptake and quality of groundnut. *Ann. Agric. Res. New series*, **35** (1): 71-74.

Singh, A.L., Basu, M.S. and Singh, N.B. (2004). Mineral disorders of groundnut Technical Bulletin, National Research Centre for groundnut. Junagarh, Gujarat, India, pp. 85.

Singh, G.P., Singh, P.L. and Panwar, A.S. (2011). Response of Groundnut (*Arachis hypogaea*) to biofertilizer, organic and inorganic sources of nutrient in North East India. *Leg. Res.*, **34** (3): 196-201.

Singh, G.P., Singh, P.L. and Panwar, A.S. (2013). Seed yield quality and nutrient uptake of groundnut (*Arachis hypogaea*) as affected by integrated nutrient management in mid hill attitude of Meghalaya, India, *Leg. Res.*, **36** (2) : 147-152.

Singh, R.A. (1999). Integrated input management in groundnut (*Arachis hypogaea* L.) – Wheat (*Triticum aestivum*) cropping system under drought prone areas of semiarid region, *Indian J. Agron.*, **44**(4): 673-676.

Singh, R.A. (2000). Feasibility of vermin-farming in (*Arachis hypogaea* L.)- vegetable pea (*Pisum sativum*) cropping system. *Indian J. Agron.*, **45** (2): 257-262.

Singh, S.S. (1996). *Soil fertility and nutrient management.* Kalyani Publishers, Ludhiana (PUNJAB) INDIA.

Singh, Y.P. and Mann, J.S. (2007). Interaction effect of sulphur and zinc in groundnut (*Arachis hypogaea*) and their availability in Tonk district of Rajastan. *Indian J. Agron.*, **52** (1): 70-73.

Tandon, H.L.S. (1995). Sulphur fertilizer for Indian Agriculture-A guide Book Fertilizer Development and Consultation organization, New Delhi, pp.101.

Thorave, D.S. and Dhonde, M.B. (2011). Effect of integrated nutrient management on quality parameters of summer groundnut. Ecology, *Environ. & Conserv.*, **17**(4): 819-822.

12th Year
★★★★★ of Excellence ★★★★★