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Effects of inorganic and organic nutrients combindly used on yield and quality of groundnut (*Arachis hypogaea* L.)

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Abstract

This experiment was done to study the effects of combined use of inorganic and organic nutrients on yield and quality of groundnut (*Arachis hypogaea* L.). Treatment were full doses of NPK fertilizers ($N:P_2O_5:K_2O$ @ 16:45:45 kg/ha) alone, Farmyard manure (FYM) @ 15 ton/ha alone and half doses of NPK fertilizers with FYM @ 7.5 ton/ha as basal application with or without N @14 kg/ha as top dressing. The results show that highest seed yield (2558.02 kg/ha) was obtained in NPK @ 22.0:22.5:22.5 kg/ha plus FYM @ 7.5 ton/ha followed by FYM @15 ton/ha with N @ 14 kg/ha (2521.98 kg/ha). The highest protein (29.9 g) and oil (45.6%) contents were recorded in plot treated with FYM alone. It can be concluded that when compared to the standard control, NPK fertilizers @ 22.0:22.5:22.5 kg/ha with FYM @ 7.5 ton/ha gave higher seed yield as well as protein (28.8 g) and oil (38%) contents with less environmental impact.

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Introduction

Groundnut (*Arachis hypogaea* L.) is a leguminous crop and is mostly used for human consumption in Sri Lanka. It is one of the significant oil crops and requires appropriate amount of plant nutrients at correct time for better yield and quality. Low soil fertility generally causes for reduction in crop productivity. As a result, in conventional agriculture, farmers are used chemical fertilizers for increasing crop productivity. On the other hand, the use of NPK fertilizers alone may lead to deplete the soil micronutrients (Veeramani and Subrahmaniyan, 2011) and also excess application of these fertilizers has resulted environmental problem. In addition, the commercial fertilizers are costly to poor farmers involving in groundnut cultivation. Hence, alternative nutrient management is an essential to overcome the constraints prevailing in Eastern part of Sri Lanka where soil is mostly sandy regosol.

Better organic farming system can give high yield and sustainability in groundnut production (Nagaraj *et al*., 2001) and this practice has a marked residual effect on the soil nutrient availability (Veeramani and Subrahmaniyan, 2011). Being leguminous crops, groundnut has also ability to fix atmospheric nitrogen which could add some amount of nitrogen to soil. Organic manure can improve soil fertility, increase water-holding capacity, promote beneficial organisms and improve microbial biomass (Hamza and Abd-Elhady, 2010; Esmaeilian *et al*., 2012). Moreover, organic manure has been used to improve soil physical properties (Busscher *et al*., 2010) especially aggregate stability (Lado and Ben-Hur, 2004) and penetration resistance in loam soils (Alvarez *et al*., 2009). Organic manure increases soil fertility and crop production potential possibly by changing physical and chemical properties of soil (Muhammad and Khattak, 2009) and reduce the environmental pollution.

Livestock is a vital part of mixed farming systems (Maass *et al*., 2012) and in traditional mixed farming, soil fertility of the field is maintained by using available cattle manure (Cox, 2011) which are ecologically safe and friendly. It is a good source of organic matter, an excellent ameliorant to refurbish soil productivity (Miller *et al*., 2009). Although nutrient contents in cattle manure is relatively lower than chemical fertilizers,

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it is an excellent soil amendment and contains remarkable amounts of primary and secondary nutrients. In many regions, cattle manure applies to improve plant nutrition and yield (Miller *et al*., 2009; Obour *et al*., 2010). Application of cow manure biochar to sandy soil is not only beneficial for crop growth, but it also improve soil properties of coarse soil (Uzoma *et al*., 2011) and reduce groundwater contamination caused by leaching of soil nitrogen. However, the effectiveness of cattle manure depends on manure quality, climate, soil type, crop type, extent of soil degradation and management (Sui *et al*., 2009). Cow manure is abundantly available in Sri Lanka and other developing countries. Therefore, this study was aimed to evaluate the effects of integrated use of inorganic and organic nutrients on yield and quality of groundnut (*Arachis hypogaea* L.).

Materials and methods

Field experiments were conducted under irrigation conditions in 2012-2013 at the Agronomy farm of the Eastern University, Sri Lanka which is located at the latitude of 7°43' and longitude of 81°42. During the experimental periods, the average temperatures ranged between 25-35°C. The minimum and maximum rainfalls during growing season were 7 mm and 60 mm respectively. The soil type is sandy regosol.

Experimental design

The experimental design used was a randomized complete block design with three replications. The treatments were different levels of inorganic and organic nutrients applied to soil as shown in Table I. The recommended full doses of

Table I. Total nutrients applied in this experiment

Treatment code	Total nutrients applied to soil
T1 (absolute control)	No fertilizer application
T2	N : P_2O_5 : K_2O @ 16 : 45 : 45 kg/ha
T3 (standard control*)	N : P_2O_5 : K_2O @ 30 : 45 : 45 kg/ha
T4	Farm yard manure (FYM) @15 ton/ha
T5	FYM @15 ton/ha + N @ 14 kg/ha
T6	N : P_2O_5 : K_2O @ 8.0 : 22.5 : 22.5 kg/ha + FYM @7.5 ton/ha
T7	N : P_2O_5 : K_2O @ 22.0 : 22.5 : 22.5 kg/ha + FYM @7.5 ton/ha

*Standard control as recommended by Department of Agriculture, Sri Lanka

N:P_2O_5:K_2O treatment were 30:45:45 kg/ha as a standard control to compare yield and quality of groundnut with other treatments. There was also an absolute control treatment where any kind of fertilizers was not applied.

Soil and manure analysis

Before seeding, soil samples were collected randomly in the experimental area at a depth of 0-15 cm. Likewise air dried Farm yard manure (FYM) was obtained from Dairy farm in the Eastern region of Sri Lanka. The collected samples of soil and FYM were separately mixed thoroughly thereafter physical and chemical analysis was done on dry basis except pH, and electrical conductivity. Available K_2O, Ca, Mg, Cu Fe, Mn and Zn were determined by using atomic absorption spectrometry. Available Nitrogen and P_2O_5 were tested using Kjeldahl and UV visible spectrophotometer respectively. Table II shows the results of the tests obtained.

Table II. Chemical properties of soil and farm yard manure used in this experiment

Chemical properties	Soil at a depth of 0-15 cm	Farm yard manure
Act C.E.C	2.6 meq/100 g	-
pH	6.5	7.8
Organic carbon	0.4 %	22.3 %
Electrical conductivity	32.4 µs cm^{-1}	3.65 µs cm^{-1}
Nitrogen	7 µg g^{-1}	1.12 %
Phosphorus as P_2O_5	35 µg g^{-1}	0.14 %
Potassium as K_2O	0.07 meq/100 g	0.82 %
Calcium	2.0 meq/100 g	0.44 %
Magnesium	0.30 meq/100 g	0.30 %
Sulphur as sulphate	8 µg/g	-
Boron	0.09 µg/g	-
Copper	1.1 µg/g	14 ppm
Iron	33 µg/g	4896 ppm
Manganese	3.5 µg/g	524 ppm
Zinc	2.1 µg/g	76 ppm

Agronomic practices

Land was ploughed to a depth of 15-20 cm, and leveled. Subsequently experimental plots were prepared and each plot size was 2.7 m x 1.8 m (4.86 m^2). Seeds of groundnut cv indi were collected from Seed Production and Processing unit at the Eastern University, Sri Lanka and

treated with captan at a rate of 3 g/kg seeds. The seeds were seeded to maintain one plant per hill at a spacing of 45 cm x 15 cm. The soil was irrigated twice before seeding. Recommended full doses of NPK fertilizers ($N:P_2O_5:K_2O$ @ 16:45:45 kg/ha from urea, triple super phosphate and muriate of potash respectively) alone, FYM @ 15 ton/ha alone and recommended half doses of NPK fertilizers ($N:P_2O_5:K_2O$ @ 8.0:22.5:22.5 kg/ha) with FYM @ 7.5 ton/ha were basally applied where FYM was done on dry weight basis two weeks before seeding and thoroughly incorporated into the soil but NPK fertilizers were applied at seeding. Further, the respective experimental plots were treated with or without N @ 14 kg/ha from urea as top dressing which was applied at flowering stage as indicated in Table I. The plots were regularly irrigated to maintain the field capacity and irrigation ceased during last two weeks to mature pods. Weeds were removed manually and no pesticide was applied.

Agronomic parameters

Mature groundnut plants were uprooted in 110 days after seeding and dried under sunlight for three days. Data were collected on agronomic parameters such as number of pods, number of nodules, leaf area (cm^2), air dry pod and seed weights (g) as well as air dry weights (g) of root and shoot from each tagged plant. Hundred seed weight (g) and plant biomass (g) were recorded. Subsequently shelling %, pod and seed yields (kg/ha), biological yield (kg/ha) and harvest index were calculated. Protein and oil contents in groundnut seeds stored for one year were determined according to AOAC (1990).

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) using Statistical Analysis System (SAS) software (SAS version 9.1, Institute INC., Cary, USA). Treatment means were compared according to Tukey's honestly significant difference test at $\alpha = 0.05$ probability level.

Results and discussion

Pod and nodule numbers

The numbers of pods and nodules per plant were significantly ($P<0.05$) influenced by the fertilizer treatments than those in an absolute control (T1). There was markedly higher number of pods in 14 kg/ha nitrogen treated plants as top dressing (T3-NPK @ 30:45:45 kg/ha; T5- FYM @ 15 ton/ha + N @ 14 kg/ha and T7- NPK @ 22.0:22.5:22.5 kg/ha + FYM @ 7.5 ton/ha) over to without top dressed plants (T2-NPK @ 16:45:45 kg/ha;

Table III. Effect of fertilizer treatments on pod and nodule numbers as well as weights of pods and seeds per groundnut plant

Treatments	Number of pods	Number of nodules	Air dry pod weight (g)	Air dry seed weight (g)
T1	11.00 ± 0.58d	32.33 ± 1.45d	11.43 ± 0.72c	05.86 ± 0.36c
T2	18.00 ± 0.58c	46.67 ± 1.67c	19.93 ± 1.23b	12.68 ± 1.02b
T3	22.67 ± 0.67ab	50.33 ± 1.60c	24.70 ± 1.70ab	16.11 ± 0.80ab
T4	21.33 ± 0.88bc	52.33 ± 1.45abc	23.84 ± 1.53ab	15.80 ± 1.07ab
T5	23.33 ± 0.88a	59.00 ± 0.89a	25.40 ± 1.45a	17.02 ± 1.05a
T6	20.66 ± 0.88bc	57.67 ± 0.88ab	22.31 ± 1.52ab	14.31 ± 0.86b
T7	23.67 ± 0.33a	54.00 ± 2.08bc	25.96 ± 1.11a	17.27 ± 0.89a
F test	**	**	**	**
CV%	6.52	5.62	11.44	11.43

** - $P<0.01$. Values are means± standard error of three replications. Means followed by the same letter are not significantly different from each other according to Tukey's honestly significant difference test at 5% significant level

T4-FYM @ 15 ton/ha and T6-NPK @ 8.0:22.5:22.5 kg/ha + FYM @ 7.5 ton/ha) however, this application did not show remarkable improvement in nodulation compared to the without top dressed plants (Table III). Significantly highest number of pods (23.67) was recorded in T7 followed by T5 (23.33) and T3 (22.67) and those were statically similar with each other. Moreover, pod numbers in T4 and T6 were not significant with T3. Further, it was noted that FYM alone or in combination with reduced level of recommended NPK fertilizers resulted in higher number of nodules compared to the recommended NPK fertilizers (T3).

Pod and seed weights

The fertilizer treatments had considerable ($P<0.05$) effect on mean weights of pods and seeds per plant than an absolute control which gave lower values in both parameters (Table III). The highest weights of pods (25.96 g) and seeds (17.27 g) per plant were obtained in T7 followed by T5 having values of 25.40 g and 17.02 g respectively whereas T3 had 24.7 g of pod weight and 16.11 g of seed weight. Addition of FYM exhibited better result (T7 and T5) which were statically on par with T3. The increasing nitrogen application from 8 kg/ha (T6) to 22 kg/ha (T7) remarkably increased seed weight by 20.7% than that in T6 but seed weight was significantly similar in T4 (15.8 g) and T5 (17.02) though additional 14 kg/ha nitrogen were applied in T5. Seed weight was increased by 7.7% (17.02 g) in T5 and 9.3% (17.27 g) in T7 over to the application of FYM @ 15 ton/ha alone (T4).

100 seed weight and shelling %

Significant effect on hundred seed weight and shelling % were noted by the fertilizer applications (Table IV). Among the treatments, FYM @ 15 ton/ha with 14 N kg/ha (T5) had higher weight (54.77 g) which was on par with the other treatments except T1. In all fertilized plants, 100 seed weight ranged from 49.92 g (T2) to 54.77 g where T3, T4 and T7 had about 53 g meanwhile shelling % in the fertilized plants was between 63.47% (T2) and 66.99% (T5). Significantly lowest value of 51.48% was recorded in T1 among the treatments.

Plant biomass

There were remarkable differences ($P<0.05$) in leaf area, root, and shoot weights and also plant biomass between the treatments (Table IV and V). The fertilized treatments had significantly higher values in these parameters except root weight than those in the absolute control (T1). Highest leaf area (853.36 cm^2) and shoot weight (17.88 g) per plant were recorded in T7 and T5 respectively however there was no significant variation in shoot weight between T7 and T5. Shoot weight and plant biomass ranged from 12.34 g and 34.09 g (T2) to 17.88 g and 48.17 (T5) respectively in the treated plants.

Table IV. Effect of fertilizer treatments on 100 seed weight, shelling %, leaf area and root and shoot of weights of groundnut plant

Treatments	100 Seed weight (g)	Shelling %	Leaf area (cm^2)	Root dry weight (g)	Shoot dry weight (g)
T1	43.80 ± 2.39b	51.48 ± 3.20c	389.04 ± 07.40e	1.79 ± 0.06b	08.44 ± 0.44c
T2	49.92 ± 3.09ab	63.47 ± 1.24b	679.27 ± 17.79cd	1.82 ± 0.03ab	12.34 ± 0.89b
T3	53.91 ± 2.46a	65.40 ± 1.35ab	786.45 ± 18.60ab	1.90 ± 0.06ab	14.90 ± 1.22ab
T4	53.45 ± 2.48a	66.24 ± 1.03ab	627.27 ± 21.43d	1.94 ± 0.02ab	14.81 ± 0.53ab
T5	54.77 ± 2.10a	66.99 ± 0.61a	735.45 ± 10.41bc	2.13 ± 0.09a	17.88 ± 0.95a
T6	51.11 ± 1.96ab	64.24 ± 0.65ab	762.50 ± 15.40bc	1.98 ± 0.02ab	12.99 ± 1.07b
T7	53.52 ± 2.57a	66.48 ± 0.89ab	853.36 ± 30.34a	2.01 ± 0.12ab	16.32 ± 0.88a
F test	*	**	**	*	**
CV%	7.88	4.14	4.68	5.90	12.18

* - $P<0.05$; ** - $P<0.01$. Values are means± standard error of three replications. Means followed by the same letter are not significantly different from each other according to Tukey's honestly significant difference test at 5% significant level

Application of nitrogen fertilizer as top dressing significantly increased plant biomass in T7 than that in T6 (without top dressing) and this cultural practice enhanced plant biomass in other treatments too.

Pod and seed yields

The pod and seed yields were signifi cantly ($P<0.01$) affected by the application of fertilizers. The reduced dose of NPK fertilizers with FYM @ 7.5 ton/ha (T7) was statically on par in pod yield with the other treatments except T1 and T2 (Table V). The average pod yield ranged from 1693.63 kg/ha (absolute control T1) to 3845.43 kg/ha (T7). When nitrogen fertilizer was applied as top dressing it improved the pod and seed yields of groundnut. There was no remarkable difference in average seed yield between FYM @ 15 ton/ha alone (T4) and FYM @ 15 ton/ha with N @ 14 kg/ha (T5) but it was noted that the addition of N @ 14 kg/ha as topdressing in T3 (NPK fertilizers alone) and T7 (NPK fertilizers with FYM) had significant ($P<0.05$) effect on economic yield over the T2 and T6 respectively. Maximum seed yield was obtained in T7 (2558.02 kg/ha) followed by T5 (2521.98 kg/ha) and T3 (2387.16 kg/ha). Moreover, seed yield in the standard control (T3) was relatively similar to that (2340.25 kg/ha) in T4 (FYM alone).

Harvest index

There was significant ($P<0.05$) difference in harvest index between the fertilizer treatment and absolute control however, application of NPK fertilizers or FYM alone or even in combination with FYM had no effect (Table V). Highest value of harvest index (38.96%) was recorded in NPK fertilizers with FYM treatment (T7) followed by the standard control (T3), and FYM alone (T4) whereas absolute control (T1) had lowest value of 27.01% in the present study. Nitrogen application as top dressing increased harvest index in T3 and T7, as compared with T2 and T6 respectively.

Protein and oil contents

The application of FYM alone significantly ($P<0.05$) increased the protein and oil contents in seeds over the standard control or combined use of FYM and NPK fertilizers (Table VI). The highest protein (29.9 g) and oil (45.6%) contents were recorded in plot treated with FYM alone. Further, it was noted that both contents were considerably reduced in treatment T3 and T5 (plants treated with nitrogen as topdressing) than those in T2 and T4 (plants untreated with nitrogen as top dressing) because T3 and T5 gave high seed yield than that in T2 and T4. When compared T6 (NPK @ 8.0:22.5:22.5 kg/ha + FYM @ 7.5 ton/ha) and T7 (NPK @ 22.0:22.5:22.5 kg/ha + FYM @ 7.5 ton/ha), protein content in seed was increased by increasing nitrogen level in T7 whereas oil content was decreased.

Macro and micro nutrients are necessary to enhance the seed production of groundnut. On contrary, farmers in

Table V. Effect of fertilizer treatments on plant biomass, pod and seed yields and also harvest index in groundnut

Treatments	Plant biomass (g)	Pod yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Harvest Index (%)
T1	21.67 ± 1.13c	1693.63 ± 107.38c	868.15 ± 53.03d	27.01 ± 1.42b
T2	34.09 ± 1.06b	2952.59 ± 181.61b	1878.02 ± 120.39c	37.19 ± 2.73a
T3	41.50 ± 2.63ab	3659.75 ± 252.56ab	2387.16 ± 139.03ab	38.90 ± 0.77a
T4	40.59 ± 2.04ab	3532.35 ± 226.47ab	2340.25 ± 148.04ab	38.85 ± 0.73a
T5	48.17 ± 1.19a	3762.96 ± 214.86a	2521.98 ± 146.24a	37.47 ± 1.66a
T6	37.28 ± 0.83b	3304.69 ± 225.46ab	2120.49 ± 118.05bc	38.38 ± 2.04a
T7	44.28 ± 1.76a	3845.43 ± 165.17a	2558.02 ± 132.53a	38.96 ± 0.76a
F test	**	**	**	*
CV%	7.07	11.43	11.43	8.12

* - $P<0.05$; ** - $P<0.01$. Values are means± standard error of three replications. Means followed by the same letter are not significantly different from each other according to Tukey's honestly significant difference test at 5% significant level

most part of the semi-arid region use inadequate and imbalance nutrients which is one of the causes for low yield in groundnut (Veeramani and Subrahmaniyan, 2011). Addition of organic manures improved total N, available P and exchangeable K superior than NPK fertilizer (Adeniyan *et al*., 2011). In the present study, considerably highest number of pods (23.67) as well as pod weight (25.96 g) per plant were recorded in T7 (NPK @ 22.0:22.5:22.5 kg/ha + FYM @ 7.5 ton/ha) followed by T5 (FYM @ 15 ton/ha + N @ 14 kg/ha) over those in the standard control (T3-NPK @ 30:45:45 kg/ha) while remarkably lowest value was recorded in untreated plots (Table III). FYM consists of macro and micro nutrients as a result T7 and T5 exhibited better results which were statically on par with T3. Farm yard manure releases nutrients slowly and it is available to the plants even later stage of plant growth. The nutrient removal by plants depends on soil fertility. The plants tend to absorb more nutrients from the soil and this increases the pod weight of groundnut. This could be attributed to nutrient content in soil treated with FYM.

Nitrogen fertilizer (14 kg nitrogen per ha) applied as top dressing significantly increased plant biomass in T7 (nitrogen treated plants as topdressing) than that in T6 (nitrogen untreated plants). This is in accordance with Aruyi *et al*. (2000) who stated that nitrogen fertilizers applied at high level showed vegetative growth. In the present study, highest seed yield was achieved in T7 (2558.02 kg/ha) followed by T5 (2521.98 kg/ha) and T3 (2387.16 kg/ha). Further, the standard control (T2) was comparatively similar to that (2340.25 kg/ha) in T4 (FYM alone). Organic materials enhanced soil properties to boost plant growth (Tirol-Padre *et al*., 2007; Shakil *et al*., 2012) thus cowdung increases the effectiveness of mineral fertilizers to improve plant yield (Miller *et al*., 2009; Obour *et al*., 2010). Hameed *et al*. (1993) reported that increase in fertilizer level upto 50:75:30 NPK kg/ha improved groundnut seed yield. Cattle manure @ 15 ton/ha with EM can use for better economic yield of groundnut (Seran and Suthamathy, 2013).

The moisture content of groundnut before storage was between 8-9%. The seeds obtained in this experiment were tested for aflatoxin. The result showed that there was no aflatoxin contamination. It might be due to the availability of sulphur content in soil. Addition of FYM alone significantly increased the protein and oil contents in seeds over the standard control or combined use of FYM and NPK fertilizers (Table VI). Ipinmoroti *et al*.

Table VI. Effect of fertilizer treatments on seed protein and oil contents of groundnut

Treatment code	Plant nutrients applied		Protein (g)	Oil (%)
	Basal dressing	Top dressing		
T1	None	None	26.6e	39.3d
T2	N:P_2O_5:K_2O @ 16:45:45 kg/ha	None	28.6b	40.6c
T3	N: P_2O_5:K_2O @ 16:45:45 kg/ha	N @ 14 kg/ha	26.1f	33.4f
T4	*FYM @ 15 ton/ha	None	29.9a	45.6a
T5	*FYM @ 15 ton/ha	N @ 14 kg/ha	27.1d	40.5c
T6	N:P_2O_5:K_2O @ 8.0:22.5:22.5 kg/ha + FYM @ 7.5 ton/ha	None	27.6c	42.2b
T7	N:P_2O_5:K_2O @ 8.0:22.5:22.5 kg/ha + FYM @ 7.5 ton/ha	N @ 14 kg/ha	28.8b	38.4e
	F test		**	**

*FYM-Farm yard manure

Values are means± standard error of three replications. Means followed by the same letter are not significantly different from each other according to Tukey's honestly significant difference test at 5% significant level

(2008) reported that soil fertility in N, P, K, CA and Mg was improved by the application of organic manure than NPK fertilizers. When compared to treatment T6, protein content in groundnut seed was increased by increasing nitrogen level in T7 whereas oil content was decreased (Table VI). Kandil *et al*. (2007) stated that the increasing nitrogen level enhanced pod yield, straw yield and seed protein content. Mohammed *et al*. (2014) indicated that most of the parameters measured were remarkably improved by the organic fertilizers application in groundnut cultivation.

Conclusion

The results reveal that the highest number of pods as well as weights of pods and seeds were achieved in T7 ($N:P_2O_5:K_2O$ @ 22.0:22.5:22.5 kg/ha with FYM @ 7.5 kg/ha) followed by T5 (FYM @ 15 ton/ha with N@ 14 kg/ha). The pod and seed yields were remarkably influenced by the application of fertilizers. Maximum seed yield was recorded in T7 (2558.02 kg/ha) followed by T5 (2521.98 kg/ha) and T3 ($N:P_2O_5:K_2O$ @ 30:45:45 kg/ha (2387.16 kg/ha). The seed yield in the standard control (T3) was comparatively similar to that (2340.25 kg/ha) in T4 (FYM @ 15 ton/ha alone). The plant treated with FYM alone significantly ($P<0.05$) increased the protein and oil contents in seeds over the standard control or combined use of FYM and NPK fertilizers. Based on these results, it could be concluded that highest seed yield with optimal seed protein and oil contents could be obtained by the application of the recommended half doses of NPK fertilizers with farm yard manure @ 7.5 ton/ha as basal dressing and N @ 14 kg/ha as top dressing in groundnut cultivation with lesser impact on human health, and environment as compared to the standard control.

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