LRF-756
[1-5]

RESEARCH ARTICLE Legume Research- An International Journal

Balanced Fertilization for Sustainable Yield and Quality of Peanut (*Arachis hypogaea* L.) in Sandy Soil of Central Vietnam

T.S. Trinh[1], T.T.H. Hoang[1], D.T. Do[1], T.D. Tran[1], T.A.T. Tran[1],
T.M. Vu[1], M. Intizar-ul-Hassan[2], H. Rehman[3]

10.18805/LRF-756

ABSTRACT

Background: Peanut (*Arachis hypogaea* L.) plays an important role in cropping systems under sandy soils of Vietnam. However, studies on imbalanced fertilizer use on peanut cultivation in sandy soil of Binh Dinh province, Central Vietnam are still limited

Methods: The present study was made to compare two different fertilizer combinations *viz*., (T_1) Control (Farmers' practice): 24 kg N (urea) + 74 kg P_2O_5 (Thermophosphate) + 84 kg K_2O (KCl) + 100 kg NPK (16 - 16 - 8 - 13S) ha^{-1} and (T_2) 40 kg N (urea) + 90 kg P_2O_5 (Thermophosphate) + 90 kg K_2O (K_2SO_4) based on 8 tons of cattle manure + 500 kg lime ha^{-1}on peanut yield, quality and physico-chemical properties of sandy soil in Cat Hanh and Cat Hiep communes, Phu Cat district, Binh Dinh province. All treatments were arranged in a completely randomized block design (RCBD) with 3 replications

Result: The results showed that the application of fertilizer in combination including potassium and sulfur increased peanut yield (4.35 - 4.48 tons ha^{-1}), protein content (24.4%), lipid (52.5 - 52.8%), and improved some soil physico-chemical properties (N (9.09%) and P_2O_5 (11.04%). Thus, balanced fertilizer application *i.e*., 8 tons of cattle manure + 40 kg N + 90 kg P_2O_5 + 90 kg K_2O (K_2SO_4) + 500 kg of lime ha^{-1} can be recommended for the best peanut production in sandy soil of Central Vietnam.

Key words: Balanced fertilization, Peanut, Quality, Sandy soil, Soil properties, Yield.

INTRODUCTION

Peanut (*Arachis hypogaea* L.) is a short-term crop with high economic and commercial value, grows best on sandy soils and has capability to improve soil health. In Vietnam, according to Vietnam's soil classification, among 8 main soil groups in Binh Dinh province (South Central Coast Vietnam- SCV), sandy soil covers an area of 13,283 ha and accounts for 9.7% of agricultural production land area (Hoang *et al*., 2015).

The sandy soil in coastal provinces in general and Binh Dinh province in particular is basically sand, with light texture, high fine sand content, with about 2.5 to 12.5%, field moisture capacity, low in total nutrient content, poor in organic matter, hence have low ability to retain water and nutrients (Hoang *et al*., 2016).

The area of peanuts in Binh Dinh in recent years has continuously increased from 8,713 ha (in 2015) to 10,040 ha (in 2018) (Hoang *et al*., 2022). However, peanut cultivation on sandy soil in Binh Dinh province still stagnant due to imbalanced fertilizer use, limited irrigation availability and low soil moisture holding capacity, appropriate varieties for cultivation and low planting distance and density.

Although researches on fertilizer for peanuts cultivation have been increased (Meena *et al.,* 2018; Hoang *et al*., 2015), however, studies on nutrients recommendations especially fertilizers including K and S for peanuts on sandy soil are still limited. Previously, the effects of nutritional deficiencies on peanut yield on sandy soils in South Central Coast (SCC) region showed that without N application, the yield of peanuts decreased from 15.5 to 21.4%, while without K application, it decreased from 15.5 to 21.4% and without S application, yields decreased from 12.71 to 23.35% on sandy soils in Binh Dinh province (Hoang *et al.* 2016). Therefore, the present study was carried out to evaluate the effect of fertilizer combinations involving N, K and S in comparison with farmer's practice to improve productivity and quality, as well as soil properties in peanut production on sandy soil in Binh Dinh province, SCC, Vietnam.

[1]University of Agriculture and Forestry, Hue University, Hue city, Vietnam.
[2]Plant Pathology Research Institute, Ayub Agriculture Research Institute, Faisalabad, Pakistan.
[3]Department of Agronomy, University of Agriculture, Faisalabad, Pakistan.

Corresponding Author: T.T.H. Hoang, University of Agriculture and Forestry, Hue University, Hue city, Vietnam.
Email: htthoa@hueuni.edu.vn

How to cite this article: Trinh, T.S., Hoang, T.T.H., Do, D.T., Tran, T.D., Tran, T.A.T., Vu, T.M., Intizar-ul-Hassan, M. and Rehman, H. (2023). Balanced Fertilization for Sustainable Yield and Quality of Peanut (*Arachis hypogaea* L.) in Sandy Soil of Central Vietnam. Legume Research. doi:10.18805/LRF-756.

Submitted: 06-06-2023 **Accepted:** 14-07-2023 **Online**: 29-07-2023

MATERIALS AND METHODS

The field trial sites were in communes of Cat Hiep (14°03′05″N and 109°99′52″E) and Cat Hanh (14°05′46″N and 109°00′16″E), Binh Dinh province, SCC region. The soils are classified as *Haplic Arenosols* with deep sands, containing >95%. The region has a tropical savannah climate with long dry seasons (January to August) and high evaporation rates (about 100 mm month^{-1}), monsoonal rainfall (average of 1,900 mm), which is concentrated over a short spell (September to December) and mean temperatures between 27 and 35°C. The soil physico-chemical properties before and after experiment at two locations are presented in Table 4.

Peanut (*Arachis hypogea* L.) cv. Ly, a cash crop usually grown on sandy soils in SCC, was sown with two treatments including two different fertilizer schedule (T_1) control (Farmers' practice): 24 kg N (urea) + 74 kg P_2O_5 (Thermophosphate) + 84 kg K_2O (KCl) + 100 kg NPK (16-16-8-13S) ha^{-1} and (T_2) 40 kg N (urea) + 90 kg P_2O_5 (Thermophosphate) + 90 kg K_2O (K_2SO_4) based on 8 tons of cattle manure + 500 kg lime ha^{-1}, in complete randomized block design with three replications during spring season of December 2020 to April 2021 in Cat Hiep and Cat Hanh communes locations, Phu Cat district, Binh Dinh province. A local variety of peanut (cv. Ly) was sown on 26th December 2020 in Cat Hanh commune and 28th December 2020 in Cat Hiep commune.

Each experimental unit had an area of 50 m^2 with total area of 300 m^2 of each trial. Peanut seeds were sown at a distance of 0.3 m between rows and 0.1 m between plants to get a total density of about 3,30,000 plants ha^{-1}. Nitrogen (N), phosphorus (P), potassium (K) and sulfur (S) were used as urea (46% N), thermophosphate (16% P_2O_5), potassium cloride (60% K_2O), potassium sulfate (50% K_2O) and NPK 16-16-8-13S (13% S). Lime ($CaCO_3$-56% CaO) was applied two weeks prior to sowing as a broadcast and incorporated to a soil depth of 20 cm. The required amount of cattle manure (1.12-1.21% N, 0.92-1.14% P_2O_5, 1.41-1.62% K_2O, 0.06-0.08% S), phosphorus and sulphur were applied at sowing by row application. The N and K fertilizers were also dressed following row applications at two stages of plant growth *i.e.,* 12 days after sowing, one third of total at full expansion of the third leaf and and 35 days after sowing, the remaining two third just prior to flowering.

Growth parameters including plant height, number of first branch, number of nodules (pod forming stage), leaf area and biomas were measured from 10 plants plot^{-1} at harvesting stage. The 98 days after sowing at harvesting stage, pod yield at moisture <14% and other yield attributes *viz*., shoot dry matter, pods number and shell weight were assessed from a quadrat measuring 4 m^2. Protein (Kjelhdal method) and lipid (Chromatographic method) contents were determined as peanut quality indicators (AOAC 2000).

Five soil samples were collected from the 0-20 cm layer from each experimental plot and combined to make a composite soil sample before and after experiment. Immediately after collection, the samples were put in plastic bags and brought to the laboratory for treating with removing root debris and the soil samples were air-dried and ground to pass through a sieve of 2 mm size. Soil physio-chemical characteristics were determined by the methods of Page *et al*. (1996).

The collected data was subjected to statistical analysis with mean, SD (standard deviation) and T_{test} by using SPSS version 21.

RESULTS AND DISCUSSION

Effects on peanut growth and yield

The results showed that compared to control (farmers 'practice) (T_1), growth of peanut in T_2 (40 kg N (urea) + 90 kg P_2O_5 (Thermophosphate) + 90 kg K_2O (K_2SO_4) + 8 tons of cattle manure + 500 kg lime ha^{-1}) was improved significantly at two study communes (Table 1). The application of fertilizers in combination increased peanut height by 4.1-4.5%, number of first branches plant^{-1} by 5.0-9.7%, number of nodules at pod forming stage by 13.7-14.8% compared to control. The leaf area index and biomass of peanut with application of fertilizer combinations increased by 2.94-10.68% and 6.37-19.57%, respectively compared with control.

There was a significant difference among yield components of peanut (Table 2). The number of pods per plant was highest in treatment with combined application of

Table 1: Growth parameters of peanut under different treatments.

Parameters	T_1 (Control)	T_2	$P_{\alpha = 0,05}$ (T≤t)
1. Cat Hiep commune			
Plant height (cm)	41.9±2.5^a	43.7±2.6^a	0.317
No. of first branch (branch)	3.9±0.1^b	4.3±0.1^a	0.001
No. of nodule/plant at pod forming stage	185.4±9.8^b	210.9±12.3^a	0.007
Leaf area index at pod forming stage (m^2 leaf m^{-2} soil)	4.49±0.22^b	4.60±0.27^a	0.000
Biomass at harvest stage (t ha^{-1})	10.02±0.53^b	11.39±0.67^a	0.001
2. Cat Hanh commune			
Plant height (cm)	42.5±2.2^a	44.4±1.8^a	0.165
No. of first branch (branch)	4.0±0.2^a	4.2±0.1^a	0.081
No. of nodule / plant at pod forming stage	190.8±13.0^b	219.1±14.6^a	0.012
Leaf area index at pod forming stage (m^2 leaf m^{-2} soil)	4.5±0.17^a	4.7±0.21^a	0.275
Biomass at harvest stage (t ha^{-1})	7.2±0.35^a	7.7±0.37^a	0.077

Values after ±: SD (standard deviation); P≤0,05 significant difference; P>0,05 non-significant difference. Values with a common letter in the same column are not significantly different using LSD at 5% level.

fertilizers with an increase of 15.77-18.32% compared to control. Similarly, number of filled pods increased by 13.47-18.04%, weight of 100 pods by 0.66-0.93 g, weight of 100 seeds increased by 0.36-0.5 g compared with control. Peanut yield ranged from 4.35-4.48 t ha^{-1} with application of fertilizers in combination in Cat Hiep and Cat Hanh communes, which increased by 18.17-19.59% and had a statistical difference compared with control.

Growth and yield of peanut increased with application of fertilizer combination including K and S. Hoang *et al*. (2022) reported that K is an important component in nutritional balance of peanuts in sandy soil. Therefore, K should be balanced at 20-30 kg N and 60 - 90 kg K_2O ha^{-1}. Hoang *et al*. (2021) indicated that an increase of peanut growth and yield with application of 30 kg S ha^{-1} based on 40 kg N + 90 kg P_2O_5 + 60 kg K_2O + 500 kg lime + 8 t of cattle manure ha^{-1} for varieties L14 and SVL1. Milica *et al*. (2013) showed that balanced fertilizer application had a positive effect in improving growth and development, yield and yield components of peanut. Addition of K at 90 kg K_2O ha^{-1}produced the highest peanut yield (Hoang *et al*., 2022). Depending on different types of soil and production conditions, supplementing with S helps peanut to affect growth, development, yield, and its components. Therefore, application of fertilizers combined with K and S fertilizers at appropriate rate gave the highest yield and yield components (Hoang *et al.,* 2022). Hoang *et al*. (2019) also found that the actual pod yield in Cat Hiep and Cat Hanh communes varied from 3.10 to 3.91 t ha^{-1} (2015) and 2.52 to 3.42 t ha^{-1} (2016) with different rates of K application and pod yield increased from 2.67 to 3.86 t ha^{-1} with increase in S rate. Fertilizer application in combination increased biomass, pod and seed yield of peanut. This increase in peanut is evident that potassium fertilization application at the rate of 110 kg of K_2O ha^{-1} increased nutritional status, improving grain production of peanut crop in rotation with sugarcane (Patel *et al*., 2018).

Effects on peanut quality

When supplemented with fertilizers, especially K and S, protein and lipid contents in peanut increased from 24.44-24.61% and 52.56-52.65%, compared with farmer's practice respectively. However, there was no significant difference among treatments (Table 3).

Sulfur (S) is important for peanut nutrition because, along with N, it forms proteins (Wang *et al.,* 2013). As very mobile in soil, S reserves decline, where soils are cropped continuously without application of S-containing fertilizers. Several recent studies have demonstrated the significant contribution of S application to peanut yield and quality (Pratiwi *et al.,* 2016; Solaimalai *et al*., 2020) evident the present study findings. Likely, non-significant effect of fertilizer in combination on protein and lipid contents is validated from) that fertilization treatments did not show any significant effects, neither on the lipid (49.7-52.4%) nor on protein (25.2-27.9%) content in the peanut seeds (Hoang *et al*., 2016).

Soil physico-chemical characteristics

The fertilizer treatments had significant effects on soil properties measured at the end of field experiment (Table 4). The soil acidity decreased with a little of soil pH from 4.76-4.84. Typical to humid tropical regions, soils tend to be very acidic, low in organic matter, and have low cation exchange capacity (CEC) (Hoang *et al.,* 2016). Lime (CaO), which is a cheap base, is commonly used to reduce soil acidity. For peanut, recommended pH range is 5.8-6.2. If pH is less than 5.8, zinc (Zn) toxicity problems could occur (Balota

Table 2: Yield components and yield of peanut under different treatments and locations.

Parameters	Cat hiep commune			Cat hanh commune		
	T_1 (Control)	T_2	$P_{\alpha = 0,05}$ (T≤t)	T_1 (Control)	T_2	$P_{\alpha = 0,05}$ (T≤t)
Total no. of pod $plant^{-1}$	16.92±0.99[b]	20.02±0.94[a]	0.001	17.38±0.87[b]	20.12±1.16[a]	0.003
Total no. of filled pod $plant^{-1}$	15.34±0.83[a]	17.50±0.91[b]	0.004	15.14±0.79 [b]	17.18±0.90[a]	0.005
Weight of 100 pods (g)	125.4±0.18	126.1±1.42	0.446	124.9±1.66 [a]	125.9±1.33[a]	0.356
Weight of 100 seeds (g)	54.17±0.69	54.52±0.85	0.758	53.98±1.10 [a]	54.48±0.63[a]	0.403
Rate of seed (%)	72.58±0.62	72.99±0.66	0.346	72.88±0.78 [a]	73.16±0.75[a]	0.574
Economic yield (t ha^{-1})	3.79±0.24	4.48±0.22	0.001	3.63±0.20 [b]	4.35±0.26[a]	0.001

Values after ±: SD (standard deviation); P≤0.05 significant difference; P>0.05 non-significant difference. Values with a common letter in the same column are not significantly different using LSD at 5% level

Table 3: Effect of fertilizer combinations on lipid and protein contents of peanut seed.

Parameters	Cat hiep commune			Cat hanh commune		
	T_1 (Control)	T_2	$P_{\alpha = 0.05}$ (T≤t)	T_1 (Control)	T_2	$P_{\alpha = 0.05}$ (T≤t)
Lipid (%)	52.43±0.17[a]	52.52±0.40[a]	0.662	52.68±0.24[a]	52.75±0.17[a]	0.650
Protein (%)	24.46±0.11[a]	24.60±0.15[a]	0.140	24.41±0.20[a]	24.62±0.18[a]	0.128

Values after ±: SD (standard deviation); P≤0.05 significant difference; P>0.05 non-significant difference. Values with a common letter in the same column are not significantly different using LSD at 5% level.

Table 4: Soil physio-chemical characteristics before and after the experiment.

Soil parameters	Before experiment	After experiment			
		T_1 (control)		T_2	
		Data	Improvement (%)	Data	Improvement (%)
Cat hiep commune					
pH	4.76	4.78±0.12^a	0.42	4.77±0.15^a	0.21
OM (%)	0.83	0.84±0.02^a	1.20	0.85 ±0.05 ^{a}	2.41
N (%)	0.022	0.023±0.001^a	4.55	0.024±0.002^a	9.09
P_2O_5 (%)	0.026	0.028±0.002 ^{a}	7.69	0.029±0.005^a	11.54
P_2O_5 (mg/100 g)	7.43	7.46±0.25^a	0.40	7.48±0.45^a	0.67
K_2O (%)	0.052	0.053±0.001^a	1.92	0.054±0.004^a	3.85
K_2O (mg/100 g)	5.37	5.41±0.26^a	0.74	5.40±0.31^a	0.56
Texture					
-Sand (%)	94.46	94.42±5.21^a	-0.04	94.39±6.23^a	- 0.07
-Limon (%)	1.37	1.39±0.02^a	1.46	1.40±0.01^a	2.19
-Clay (%)	4.17	4.19±0.13^b	0.48	4.21±0.21^a	0.96
Cat hanh commune					
pH	4.82	4.85±0.15^a	0.62	4.84±0.14^a	0.41
OM (%)	0.91	0.92±0.08^a	1.10	0.91±0.06^a	0
N (%)	0.026	0.028±0.005^a	7.69	0.028±0.003^a	7.69
P_2O_5 (%)	0.025	0.027±0.003^a	8.00	0.026±0.005^a	4.00
P_2O_5 (mg/100 g)	8.27	8.30±0.43^a	0.36	8.29±0.86 ^{a}	0.24
K_2O (%)	0.061	0.062±0.002 ^{a}	1.64	0.061±0.007^a	0
K_2O (mg/100 g)	6.56	6.58±0.32 ^{a}	0.30	6.58±0.45^a	0.30
Texture					
-Sand (%)	91.56	1.60±6,23^a	0.04	58±5.67^a	0.02
-Limon (%)	3.54	93.55±0.06^b	0.28	91.3.64±0.12	2.82
-Clay (%)	4.90	4.85±0.41^b	-1.02	^{a}4.78±0.36^a	-2.45

Values after ±: SD (standard deviation); P≤0.05 significant difference; P>0.05 non-significant difference. Values with a common letter in the same column are not significantly different using LSD at 5% level.

2014). In addition, urea application to acidic soils might further decrease soil pH (Tong and Xu, 2012) and weaken N_2-fixation by leguminous crops (Miller 2016). Appropriate crop nutrition management is crucial, particularly on sandy acidic soils in tropics. The sandy soil (97%) has very low CEC, and low pH (5.1), further reduces its ability to store nutrients. The substantial CaO supplement (500 kg ha^{-1}) used in the present study gave rise to a significant though; there was uneven rise in soil pH (Table 4). The soil organic matter content increased a little in most treatments (0.83-0.85%). Soil N concentration increased, when fertilizer in combination was applied. Available soil P increased from 7.43 to 7.48 mg 100 g^{-1} for all treatments. There was a slight increase in soil available K with fertilizer application in combination. However, sulfur content fluctuated within a narrow range from 0.025-0.028%. Peanut, a leguminous crop, does not require significant N inputs (Balota 2014). Lack of K, led to diminished levels of both soil N and K, which were gradually replenished with rising K application rates. These results indicate that K and S supply are essential for optimum peanut plant development which, in-turn, allows adequate N_2-fixation by the peanut roots, and hence soil enrichment with N as evident from increase in soil N contents of present study.

CONCLUSION

Application of fertilizer (40 kg of N (urea) + 90 kg of P_2O_5 (Thermalphosphate) + 90 kg of K_2O (K_2SO_4) + 500 kg lime ha^{-1}) in a combination of 8 t ha^{-1} of cattle manure for peanut in sandy soil improved biomass by 6.37-19.57%, yield by 18.17%, including quality parameters *viz*., lipid and protein content and soil properties compared to farmers practice. In crux, for better peanut production of high quality in sandy soil, it is recommended to apply the fertilizer in combination with K and S.

ACKNOWLEDGEMENT

This work was partially supported by Hue University under the Core Research Program, Grant No. NCM.DHH.2020.07.

Conflict of interest

None.

REFERENCES

AOAC, (2000). Official Methods of Analysis. The Association of Official Analytical Chemists, Gaithersburg, MD, USA.

Balota, M. (2014). Peanut (*Arachis hypogaea* L.). Nutrition. https://vtechworks.lib.vt.edu/handle/10919/56116.

Hoang, M.T., Do, T.N., Nguyen, T.T., Hoang, V., Hoang, T.T.H., late Chen, W., Nguyen, T.T, Le, D.Q., Mann, S., Bell, R. (2015). Diagnosing Multiple Nutrients Deficiencies That Limit Crop Growth and Yield on Sands in South Central Coast Vietnam. Proceedings of Sustainable and Profitable Crop and Livestock Systems for South-central Coastal Vietnam. ACIAR, Canberra, Australia, p. 62-80.

Hoang, M.T., Duong, M.M., Truong, T.T., Ho, H.C., Phan, V.B. (2016). Agronomic efficiency of Polyhalite application on peanut yield and quality in Vietnam. E-ifc. 47: 3-11.

Hoang, T.T.H., Do, D.T., Do, T.N., Mann, S., Bell. R. (2019). Partial potassium balance under irrigated peanut cropson sands in a tropical monsoonal climate. Nutrient Cycling in Agroecosystems. 114: 71-83.

Hoang, T.T.H., Do, D.T., Nguyen, H.N., Nguyen, V.B., Mann, S., Bell, R. (2021). Sulfur management strategies to improve partial sulfur balance with irrigated peanut production on deep sands. Archives of Agronomy and Soil Science. 67(11): 1465-1478.

Hoang, T.T.H., Do, D.T., Vu, T.M., Do, H.T.P., Bell, R. (2022). Double pot technique for assessing deficiencies of potassium and sulfur on peanut (*Arachis hypogaea*) production in the sands of South-Central coastal Vietnam. Research on Crops. 23(1): 85-91.

Meena, H.N., Yadav, R.S., Debarati, B.A. (2018). Effects of potassium application on growth of peanut (*Arachis hypogaea*) andionic alteration under saline irrigation. Indian Journal of Agronomy. 63(1): 95-103.

Milica, D., Croitoru, M., Drãghici, R. (2013). Research on application of NPK fertilizers in peanuts grown on sandy soils. Scientific Papers. 6: 223-225.

Miller, J.O. (2016). FS 1054: Soil pH and nutrient availability. http://drum.lib.umd.edu/handle/1903/18519.

Page, A.L., Miller, R.L., Keeny, D.R. (1996). Methods of soil analysis. Part 2-Chemical and microbiological properties. ASA, SSSA, CSSA, Madison, p. 624.

Patel, P.K., Viradiya, M.B., Kadivala, V.H., Shinde, R.D. (2018). Effect of potassium and sulphur on yield attributes, yield and quality of summer groundnut under middle gujarat condition. International Journal of Current Microbiology and Applied Sciences. 7(9): 2268-2273.

Pratiwi, H., Aini, N., Soelistyono, R. (2016). Effects of Pseudomonas Fluorescens and sulfur on nutrients uptake, growth and yield of groundnut in an alkaline soil. Journal of Degraded and Mining Lands Management. 3: 507-516.

Tong, D. and Xu, R. (2012). Effects of urea and $(NH_4)_2SO_4$ on nitrification and acidification of Ultisols from Southern China. Journal of Environmental Sciences. 24: 682-689.

Solaimalai, A., Jayakumar, M., Baskar, K., Senthilkumar, M. (2020). Sulphur fertilization in groundnut crop in India: A review. Journal of Oilseeds Research. 37(1): 1-10.

Wang, Y.Y., Zhang, J.L., Zhang, F., Yang, C.T., Gao, F., Wei, T.T., Li, X.D. (2013). Effects of different S fertilizer application on nitrogen metabolism in peanut. Journal of Peanut Science. 1: 002.