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Influence of calcium from different seashells on growth and yield of Khon Kaen 6 peanut cultivar

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Abstract Application of all calcium sources increased biomass and crop growth rate of peanut. Significantly increasing in biomass was found in the crop threated with gypsum. The crop growth rate was significantly increased in the crop treated with gypsum, mussel and clams. Application of calcium sources was not significantly affected on yield and yield components of peanut. The possibility to used seashells as an alternative calcium source for peanut production.

Keywords: *Arachis hypogea*, Pod yield, Mussel, Eggshells

Introduction

Peanut (*Arachis hypogea* L.) is a leguminous crop native to central South America, and it is commonly planted in most parts of Thailand. Peanut grows well in sandy loam soil with good drainage. Because peanuts are not resistant to waterlogging, growth and yield reduce greatly under water logging condition (Khon Kaen Field Crops Research Center, 2021).

Peanut is a multi-purpose crop. Peanut seed is used as food and feed peanut, and peanut stover is used as green manure. Peanut meal after oil extraction is a source of protein of animal feed. According to FAO (2021), world production area harvested of peanuts was estimated at 32.7 million ha with production of 16.4 million tons. As two-thirds of the total production area of peanuts is in the rainfed areas, where drought is a recurring problem, drought is a main problem of yield reduction of peanut (Vorasoot *et al*., 2003). Peanut requires 500-700 mm of water throughout the growing season (Soni *et al*., 2016). Insufficient water supply reduces crop growth, pod yield and seed quality of peanut.

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As peanut is grown in sandy and infertile soils, nutrient deficiency and imbalance of nutrients also cause severe yield reduction of peanut. Calcium deficiency is an important problem for peanut production in most peanut production areas (Kadirimangalam *et al*., 2022). According to Kabir *et al*. (2013), peanut required high demand of calcium and sulfur during flowering and calcium deficiency resulted in reduction in pod yield and seed quality. Application of gypsum provides both calcium and sulfur to the crop. Pod yield and calcium content in peanut seeds for the crop applied with gypsum were higher than that without gypsum (Yang *et al*., 2022).

Synthetic calcium sources such as gypsum, flue gas desulfurization, and lignite power generation are generally used in agriculture (American Coal Ash Association, 2015). However, many natural sources of calcium such as eggshells and seashells also contain a large amount of calcium and can be used in agriculture. According to Phakamas *et al*. (2023), application of eggshells of some bird species such as duck, chicken and quail could increase seed yield of peanut.

Seashells of various mollusk species are considered as waste from households, restaurants and fishery industry. These seashells contain high percentage of calcium, and they are promising for use as an alternative source of calcium in peanut production. According to Olivia *et al*. (2017), seashells contained calcium carbonate ($CaCO_3$) of 95-98%. Application of seashells as a source of calcium in peanut production can reduce waste. The information on the application of seashells as a source of calcium in peanut production is still lacking. The objective was to compare the effects seashells from different mollusk species on growth and yield of peanut cultivar Khon Kaen 6.

Materials and methods

Location and experimental design

The experiment was conducted in the farmer field at Ban Non-Sang, Huai Jot sub-district, Kranaun district, Khon Kaen province (16°40'04.4"N 102°59'48.0" E) during December 2022 to April 2023. Topsoil at the depth of 0-30 cm was collected and analysed for physicochemical properties. KK 6 peanut variety was used in this experiment. Seven treatments consisting of un-treated control, eggshell, gypsum, mussel, oyster, clam and scallop were assigned in a randomized completely block design with four replications. All types of seashells were finely ground into powder and the texture was similar to that of gypsum.

Soil preparation and planting

The soil was ploughed twice and left follow for two weeks. Twenty-eight raised-bed plots of 2 × 3 m were constructed between the allays of 1 m. The seed was inoculated with rhizobium at the rate of 200 g per 10 - 15 kg for nitrogen fixation and treated with 3% ethephon at the rate of 9.5 ml per 1 L water to overcome seed dormancy.

Sprinkler system was installed for irrigation, and water was supplied to the raised beds at field capacity. Peanut seed was planted on the raised beds at the rate of 3-4 seeds per hill at the spacing of 40 cm between rows and 20 cm between hills within rows.

Non-germinated hills were replanted at 7 days after planting (DAP) and the seedlings were thinned to obtained 1 plant per hill at 14 DAP. All calcium sources were applied to the pre-determined treatments at the rate of 312.5 kg ha^{-1} at flowering. No calcium source was applied to un-treated control. Weed was controlled manually until flowering.

Data collection

The peanut was harvested at 130 days after planting (DAP). Days to harvested was determined by 60% of mature pods, and the inner shell of the pods changed to brown color. Because of difficulty to get access to the experimental site, two plants were sampled from each plot. Data were recorded for stem dry weight, leaf dry weight, pod dry weight, biomass, percentage of filled seeds, percentage of un-filled seeds, shelling percentage and seed yield. The samples were oven-dried at 80 ^{o}C for 48 hours or until dry weights were constant, and the dry weights of the samples were recorded. The data were derived for crop growth rate (CGR), leaf area index (LAI), specific leaf area (SLA) and harvest index (HI).

Crop growth rate (CGR) was calculated as follows;

$$\text{CGR} = \frac{1}{\text{GA}} \times \frac{\text{W1-W2}}{\text{T2-T1}}$$

Where, W1 is total dry matter production at previous sampling date, W2 is total dry matter production at current sampling date, T1 is date of previous sampling, T2 is date of current sampling and GA is ground area (m^2).

Leaf area index (LAI) was calculated as follows;

$$\text{LAI} = \frac{\text{Leaf per plant}}{\text{Ground coverage per plant}}$$

Specific leaf area (SLA) was calculated as follows;

$$\text{SLA} = \frac{\text{Leaf per plant}}{\text{Leaf dry weight}}$$

Harvest index (HI) was calculated as follows;

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}}$$

Where, economic yield is seed yield and biological yield is biomass

Data analysis

Data for all parameters were statistically analysed according to a randomized complete block design. Means were separated by Duncan's multiple range test (DMRT) at 0.05 probability level. All calculations were accomplished by using M-STATC software (Bricker, 1989).

Results

Stem dry weight, leaf dry weight, pod dry weight and biomass

Differences among sources of calcium were not significant for stem dry weight, leaf dry weight and pod dry weight, but the differences were significant ($P \leq 0.01$) for biomass (Table 1). The range of stem dry weight was between 2,962.5 kg ha^{-1} for scallops to 6,193.1 kg ha^{-1} for gypsum. The range of leaf dry weight was between 3,435.6 kg ha^{-1} for eggshells and 5,732.5 kg ha^{-1} for mussel, whereas the range of pod dry weight was between 2,560.0 kg ha^{-1} and 4,650.0 kg ha^{-1} for mussel.

Values of biomass were in a range between 9,938.8 kg ha^{-1} for untreated control and 15,776.9 kg ha^{-1} for gypsum. However, only gypsum was significantly higher than untreated control, whereas the others were similar to untreated control.

Crop growth rate, leaf area index and specific leaf area

The treatments were significantly different ($P \leq 0.05$) for crop growth rate, but they were not significantly different for leaf area index and specific leaf area (Table 2). Crop growth rates ranged between 8.3 and 13.2 g m^{-2} d^{-1}. Untreated control was lowest and gypsum was highest. Gypsum, mussel and clams were significantly higher than untreated control, whereas eggshells and scallops were not significantly different from untreated control.

Differences in calcium sources did not have significant effects on leaf area index and specific leaf area. The range of leaf area index was between 5.2 for eggshells and 8.9 for mussel, whereas the range of specific leaf area was between 169.0 cm^2 g^{-1} for gypsum and 200.8 cm^2 g^{-1} for oysters.

Table 1. Means for stem dry weight, leaf dry weight, pod dry weight and biomass of Khon Kaen 6 as affected by different sources of calcium

Treatment	**Dry weight (kg ha^{-1})**			
	Stem	leaf	Pod	Biomass
Untreated control	3,754.4	3,624.4	2,560.0	9,938.8^{b}
Eggshells	3,620.6	3,435.6	2,967.5	10,023.8^{ab}
Gypsum	6,193.1	5,387.5	4,195.6	15,776.9^{a}
Mussel	4,835.0	5,732.5	4,650.0	15,217.5^{ab}
Oysters	5,610.0	4,409.4	3,127.5	13,146.9^{ab}
Clams	6,026.3	5,070.0	4,571.9	15,668.2^{ab}
Scallops	2,962.5	3,746.3	3,520.6	10,229.4^{ab}
F-test	ns	ns	ns	**
C.V (%)	37.85	29.11	29.66	22.09

ns, ** = nonsignificant and significant at 0.01 probability level, means within the same column followed by the same letter are not significantly different by DMRT.

Table 2. Means for crop growth rate, leaf area index and specific leaf area of Khon Kaen 6 as affected by different sources of calcium

Treatment	**CGR (g m^{-2} d^{-1})**	**LAI**	**SLA (cm^{2} g^{-1})**
Untreated control	8.3^{b}	5.8	176.8
Eggshells	8.4^{b}	5.2	172.5
Gypsum	13.2^{a}	8.0	169.0
Mussel	12.7^{a}	8.9	176.4
Oysters	11.0^{ab}	7.1	200.8
Clams	13.0^{a}	8.1	199.2
Scallops	8.5^{b}	5.7	181.1
F-test	*	ns	ns
C.V (%)	22.1	27.93	12.77

ns, * = nonsignificant and significant at 0.05 probability level, means within the same column followed by the same letter are not significantly different by DMRT

Yield and yield components

Differences among the treatments for % filled seed, % unfilled seed, shelling percentage, seed yield, harvest index and 100-seed weight were not significant (Table 3). Percentage of filled seed ranged from 88.6 to 98.9%. Mussel was highest for % Filled seed (98.9%), whereas gypsum was lowest (88.6%). Percentage of unfilled seed ranged from 1.1% to 11.4%. Mussel was lowest for % unfilled seed (1.1%), whereas gypsum was highest (11.4%).

The range of shelling percentage was between 38.2% and 46.4%. Mussel was highest (46.4%), and eggshells was lowest (38.2%). Seed yields ranged between 2,240.2 kg ha^{-1} and 1,130.5 kg ha^{-1}. Mussel was highest (2,240.2 kg ha^{-1}) and untreated control was lowest (1,130.5 kg ha^{-1}).

Harvest indexes were in a range between 0.25 and 0.40. Oysters had the lowest harvest index (0.25), whereas mussel and scallops had the highest harvest index (0.40). Weights of 100-seeds were in a range between 74.1 g and 108.4 g. Eggshells had the smallest seed size (74.1 g), and Mussel had the largest seed size (108.4 g). It is interesting to note here that application of mussel provided the best characters of seed yield and yield components as indicated by the highest % filled seed, shelling percentage, seed yield, harvest index and 100-seed weight and the lowest % unfilled seed.

Table 3. Means for % filled seed, % unfilled seed, shelling percentage, seed yield, harvest index and 100-seed weight of Khon Kaen 6 as affected by different sources of calcium

Treatment	**% Filled seed**	**% Un-filled seed**	**Shelling percentage**	**Seed yield (kg ha^{-1})**	**HI**	**100-seed weight (g)**
Untreated control	97.1	2.9	45.3	1,130.5	0.29	80.1
Eggshells	92.9	7.1	38.2	1,134.2	0.29	74.1
Gypsum	88.6	11.4	44.0	1,670.8	0.26	97.6
Mussel	98.9	1.1	46.4	2,240.2	0.40	108.4
Oysters	97.5	2.5	41.4	1,303.3	0.25	101.5
Clams	96.4	3.6	44.7	1,973.3	0.33	85.1
Scallops	95.0	5.0	46.2	1,602.5	0.40	91.4
F-test	ns	ns	ns	ns	ns	ns
C.V (%)	7.2	142	19.9	29.7	48.3	31.1

ns = nonsignificant, means within the same column followed by the same letter are not significantly different by DMRT.

Discussion

Calcium is important for peanut production as it is important for pod growth and seed filling (Singh, 1994). Calcium deficiency in peanut is indicated by hollow-heart symptom of the seed (Cox and Reid, 1964). As peanut takes up calcium by pod surface rather than by root, calcium is usually applied to the crop at flowering in pod zone (Schenk, 1961).

Shells of various mollusk species are considered as waste from fishery industry. The shells contain high percentages of calcium, and they can be use as an alternative fertilizer in agriculture. In this study, four types of mollusk shells (mussel, oysters, clams and scallops), eggshells and commercial gypsum were compared with untreated control.

The results in this study indicated that the effects of calcium from different sources on growth and yield of peanut were not large as significant effects were found for biomass and crop growth rate only, whereas application calcium from different sources did not have significant effects on stem dry weight, leaf dry weight, pod dry weight, leaf area index, specific leaf area, % filled seed, % un-filled seed, shelling percentage, seed yield, harvest index and 100-seed weight. For biomass, only mussel was significantly higher than untreated control. For crop growth rate, mussel, gypsum and clams were significantly higher than untreated control.

In previous study, Inban *et al*. (2022) reported that application of commercial gypsum, phosphogypsum, FGD gypsum and chicken eggshells could increase biomass, crop growth rate and seed yield of peanut. Kabir *et al*. (2013) application of calcium could increase crop growth rates and leaf area index. Application eggshells, duckshells and quailshells resulted in higher growth and yield of peanut compared to commercial gypsum (Phakamas *et al*., 2023). Application eggshells powder containing of 88.08% calcium carbonate at planting could increase shoot weight, root weight nodules and pod yield of L27 peanut (Vu *et al*., 2022). According to Kamara *et al*. (2017), application of calcium from oyster shells at the rate of 100 kg ha^{-1} had the highest yield and seed germination of peanut. Application of calcium in combination with potassium resulted in the increases in pod yield, seed yield and oil content of peanut (Gashti *et al*., 2012).

Most studies reported so far have supported the application of calcium from various sources to increase peanut productivity. However, there were still differences among the studies in the details.

The results in this study pointed out that the effects of calcium on growth and yield of peanut was rather low. Low effects of calcium would be mainly due to three reasons. The first reason is that calcium is not classified as macronutrients such as nitrogen, phosphorus and potassium, which are generally deficient in most soils (Singh, 1994). The second reason is that calcium deficiency in the soil of the experimental site would not be severe as hollow-heart symptom was not found in the control treatment. Soil analysis might verify this assumption. The third reason is that calcium sources have slow release and the residual effects can last for few years after application.

In this study, calcium contributed to the accumulation of biomass rather than pod yield and seed yield as indicated by significant higher biomass and crop growth rate of calcium sources compared to untreated control, whereas the treatments were not significantly different for seed yield and yield components. The reasons for larger contribution to biomass rather than pod yield and seed yield would be due to indeterminate growth of peanut for some extent.

Unlike most cereal crops, which stop vegetative growth after flowering, peanuts especially spreading type still grow continuously after flowering, and, therefore, assimilates were still partitioned to biomass. Competition for assimilates between vegetative growth and pod growth might cause low effects of calcium on pod yield and seed yield.

Mussel was the best source of calcium for peanut growth and yield as indicated by the highest biomass and the highest crop growth rate, and it also provided the highest yield although the differences were not significant. Gypsum and clams were also promising. However, gypsum gave the highest unfilled seeds and the lowest filled seeds.

Because of low effect of calcium on pod yield and seed yield, the results of this study were still not conclusive for the merit of calcium to improve peanut productivity, and further investigations through experiments are still required.

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References

American Coal Ash Association (2015). Coal combustion products production and use statistics. Available: https://www.usgs.gov

Bricker, A. A. (1989). MSTAT-C User's Guide. Michigan State University, East Lansing, MI.

Cox, F. R. and Reid P. H. (1964). Calcium-boron nutrition as related to concealed damage in peanuts. Agronomy Journal, 56:173-176.

FAO (2021). FAOSTAT. Retrieved from https://www.fao.org/

Gashti, A. H., Vishekaei, M. N. S., Vishekaei, S. and Hosseinzadeh, M. H. (2012). Effect of potassium and calcium application on yield components and qualitative characteristics of peanut (*Arachis hypogaea* L.) in Guilan Province, Iran. World Applied Sciences Journal, 16:540-546.

Inban, N., Somchit, P. and Phakamas, N. (2022). Effects of calcium sources on physiological traits related to pod and seed yield of peanut. International Journal of Agricultural Technology, 18:503-518.

Kabir, R., Yeasmin, S., Islam, M. and Sarkar, A. (2013). Effect of phosphorus, calcium and boron on the growth and yield of groundnut (*Arachis hypogaea* L.). International Journal of Bio-Science and Bio Technology, 5:51-60.

Kadirimangalam, S. R., Sawargaonkar, G. and Choudhari, P. (2022). Morphological and molecular insights of calcium in peanut pod development. Journal of Agriculture and Food Research, 9:100320. https://doi.org/10.1016/j.jafr.2022.100320

Kamara, E. G., Olympio, N. S., Asibuo, J. Y., Kabbia, M. K., Yila, K. M. and Conteh, A. R. (2017). Effect of calcium and phosphorus fertilizer on seed yield and nutritional quality of groundnut (*Arachis hypogaea* L.). International Research Journal of Agricultural and Forestry, 7:129-133.

Khon Kaen Field Crops Research Center (2021). Peanut production technology properly appropriate. Rattana publishers. Khon Kaen. 51 p.

Olivia, M., Oktaviani, R. and Ismeddiyanto (2017). Properties of concrete containing ground waste cockle and clam seashells. Procedia Engineering, 171:658-663.

Phakamas, N., Gatewit, P., Kongsamret, M., Somchit, P. and Aninbon, C. (2023). Effect of eggshell wastes from different bird species on growth and yield of peanut. Current Applied Science and Technology, 23:2023. DOI: https://doi.org/10.55003/cast.2022.03.23.001

Schenk, R. U. (1961). Respiration of the developing peanut fruit. Crop Science, 1:103-106.

Singh, A. L. (1994). Micronutrient nutrition and crop productivity in groundnut. In Plant productivity under environment stress. Karan Singh and Purohit, S. S. (edit.). Argo-Botanical publishers. Bikaner, India., pp.67-72.

Soni, J., Kumar, K. A., Kumar, V., Rani, S. and Banerjee, A. (2016). Response of groundnut under micro irrigation. Progressive Research – An International Journal, 11:4455-4459.

Vorasoot, N., Songsri, P., Akkasaeng, C., Jogloy, S. and Patanothai, A. (2003). Effect of water stress on yield and agronomic characters of peanut (*Arachis hypogaea* L.). Songklanakarin Journal of Science and Technology, 25:283-288.

Vu, N. T., Dinh, T. H., Le. T. T. C., Vu. T. T. H., Nguyen, T. T. T., Pham, T. A., Vu, N. L., Koji, S., Hama, S., Kim, I. S., Jang, D. C., Kim, D. H. and Tran, A. T. (2022). Eggshell powder as calcium source on growth and yield of groundnut (*Arachis hypogaea* L.). Plant Production Science, 25:413-420.

Yang, R., Howe, J. A., Harris, G. H. and Balkcom, K. B. (2022). Uptake and timing of calcium in runner peanut (*Arachis hypogaea* L.). Field crops research, 277:108429. https://doi.org/10.1016/j.fcr.2021.108429

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