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Growth and yield response of peanut, (*Arachis hypogaea* L.) and soil characteristics with application of inorganic and organic fertilizer and dolomite addition

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Key words: Peanut, Growth and yield, Chicken manure, Soil properties, Dolomite.

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Abstract

Peanut is one of affordable nutrition rich leguminous crops. This experimental study evaluated the response of peanut, *Arachis hypogaea* and soil properties to the application of ten (10) treatments with three replication such as T_1-unfertilization, 10 t ha^{-1} of CM-chicken manure (T_2), CM-Biochar(T_3), GM-Goat manure(T_4), NPK -60-60-60 kg ha^{-1} (T_5), dolomite -1 t ha^{-1} (T_6), and T_7 (T_2 + dolomite), T_8 (T_3 + dolomite), T_9 (T_4 + dolomite) and T_{10} (T_5 + dolomite) in RCB design. Comparison of means revealed there is no significant difference on plant height, number of leaves, girth size diameter and no. of pods and weight of nodules but there is significant difference in the weight of pods, number of nodules, dry weight of roots and shoot provide by ANOVA test. However, there is an increase inplant height, number of leaves, girth size diameter observed treatments with either chicken manure or biochar with dolomite. Further, chicken manure increase in number and weight of pods and weight of nodules while number of nodules, dry matter of shoot and root observed higher in chicken manure biochar alone and/or with dolomite and also improve soil characteristics. Furthermore, soil analysis revealed heavy soil texture, 0.6-0.7 % SOM, Soil pH range 5.3-6.2 i.e. moderately to slightly acidic, P low to medium, K is low amount but relatively improve than initial. Furthermore, soil amended with chicken manure increases growth and yield of peanut *Arachis hypogaea* L.

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Introduction

The cultivated peanut or groundnut (*Arachis hypogaea* L.) is one of the important leguminous crop worldwide as well as in the local. Peanut is an annual oil seed belonging to the Leguminosae family originated in South America and is now grown in tropical and warm temperate regions of the world (Putnam *et al.*, 1991; Sharma and Mathur, 2006; Bertioli *et al.*, 2011). Utilize worldwide for its nutrition, protein and energy-rich to address the nutritional needs in developing countries. Currently, consider as good heart-healthy diet and value in phytonutrient such as resveratrol, isoflavonoids, phenolic acids, and phytosterols, which may enhance health and wellness (Isanga and Zhang, 2007; Francisco and Resurreccion, 2008; Akhtar *et al.*, 2014; Toomer, 2018).

Peanut is the second most important food legume in the Philippines (Altoveros and Boromeo, 2007). However, peanut farmers got only 47% production of 0.9 t/ha to the potential output of 2 t/ha indicating a low yield performance due to operating capital, farm size, and total labor (Huelgas *et al.*, 1989).

The production remains low and erratic in the year 1990-1996 (Palomar, 1998) and in 2012 (Sicat and Buño, 2014). Further, the national peanut production as of first quarter of 2019 at 12.25 thousand metric tons it was 0.5 percent lower than its 2018 level of 12.30 thousand metric tons (Perez and Bautista, 2019). Inadequate and imbalance use of nutrient, poor soil health and drought stress, high levels of aflatoxin contamination in harvested kernels are the common problem worldwide in peanut production (Singh, 1999; Pitt *et al.*, 2013; Njoroge *et al.*, 2017).

According to relevant studies peanut can be grown considering the important macronutrients, (N, P, K, Ca, S and Mg) and micro-nutrients (Fe, Mn, Zn, Cu, B, Mo and Cl). In addition nickel (Ni) and cobalt (Co) are also beneficial for groundnut and some other legume crop including pH requirements (Singh and Chaudhari, 2006; Balota, M 2014; Rajitha *et al.*, 2018). Increase supplementation of Phosphorous significant effect on groundnut yield and pod yield (Mupangwa and Tagwira, 2005; Kamara *et al.*, 2011). Furthermore, soil amended with poultry manure recorded the best growth and yield of peanut enhance soil quality and improve peanut productivity and/or sustain peanut production in marginal lands with continuous cultivation and flat tilled soil (Ewulo *et al.*, 2008; Amanullah *et al.*, 2010; Aipa and Michael 2018, Uko *et al.*, 2018). Goat manure increases yield production in maize grains (Law-Ogbomo *et al.*, 2017) increased pod weight, Soil Organic Matter, pH, soil N, P, K and Mg contents in okra (Awodun, 2007) and in pepper (Awudon *et al.*, 2007). Goat manure better quality when applied to the field than cattle manure for the macronutrient N, P and K in the field area/soil (Wuta and Nyamugafata, 2012). Biochar-chicken manure co-compost could substantially reduce soil N2O emissions, soil organic C stabilization and the activities of microbial functional groups, especially bacterial denitrifiers (Yuan *et al.*, 2017)

The yield increases in radish can be attributed largely to the ability of these biochars to increase N availability (Chan *et al.*, 2008). Results indicated that initial high P release from manure can be mitigated by converting the manure into biochar (Liang *et al.*, 2014). The biochar is good for soil amendments, potential for improving crop production and environmental management (Antal and Gronli, 2003; Major, 2010).

Moreover, liming can help to maintain soil pH and Calcium availability. Dolomitic is superior high Calcium lime and widely used that increase soil pH and soil calcium levels (Rogers, 1948; Sullivan *et al.*, 1974; Yang, 2015). Soil molybdenum availability, as indicated by plant leaf analysis, increased significantly when lime (dolomitic) was applied (Quaggio 2004). The improvement in peanut yield and the decrease in aflatoxin concentrations in kernels can be attributed to the improvement in soil moisture retention capacity and soil microbial activity arising from manure amendments (Chalwe *et al.*, 2019). Organic manures are known to be rich sources of both macro and micro nutrients of the crop

(Soremi *et al.*, 2017).

This experimental study attempted to evaluate the effects of chicken manure, Chicken manure biochar, goat manure and/or liming (dolomite) addition to the growth and yield of peanut, *Arachis hypogaea* L. and soil characteristics and infer its yield to the application of chemical fertilizer. This provides information relevant to farmers which of the organic manure equivalence or better to NPK Chemical fertilizer application of peanut production and soil condition.

Methodology

The experiment was conducted at CSU Greenhouse, Ampayon, Butuan City on January 26- April 27, 2019. The experiment was laid out in Random Complete Block (RCB) Design with a single factor having 10 treatments with three replications. There were a total number of 30 pots for the test crop which is peanut (variety is UPL Pn-2 and was readily available from CSU Soils Lab) and each pot has 3 kg air-dried soil based on fresh weight basis.

Soil collection and analysis

The soil samples that was used for raising the peanut seeds was taken from the surface (0-15cm), then was air-dried and sieved to 0.5mm for soil pH, soil organic matter, P and K. Samples was analyzed at the Regional Soils Laboratory, Department of Agriculture CARAGA Region located at Barangay Taguibo, Butuan City. The same process was done after the experiment.

Collection of organic materials and dolomite

All organic materials and dolomite was obtained from the Soil Laboratory of the College of Agriculture and Agri-Industries in Caraga State University, Ampayon, Butuan City.

Pot experiment

The soil that was used in the experiment was weighed to 3kg based on fresh weight basis. There are 4 treatments that was assigned in the experiment, namely: The treatments were:T_1-Control, T_2-Chicken Manure (CM) @ 10 t/ha, T_3-Chicken Manure Biochar (CMB) @ 10 t/ha, T_4-Goat Manure (GM) @ 10 t/ha, T_5-60-60-60 kg NPK/ha, T_6-1 t/ha lime (dolomite), T_7-CM @ 10 t/ha + 1 t/ha (dolomite), T_8-CMB @ 10 t/ha + 1 t/ha (dolomite), T_9-GM @ 10 t/ha + 1 t/ha (dolomite) and T_{10}-60-60-60 kg NPK/ha + 1 t/ha (dolomite). The treatment was replicated 3 times and was arranged in Randomized Complete Block Design. The dimension of pot that was used in the experiment was 5"x5"x8½". Prior to sowing, T2, T3, T4, T7, T8 and T9 was amended with 16g, 15g and 14g of chicken manure, chicken manure biochar, goat manure respectively, and then watered with 500ml of water. Three seeds were sown on each pot, and when the true leaves were visible, thinning process was done to avoid competition of nutrients. Complete fertilizer was dissolved in 100ml of water and was applied 15 days after seedling emergence in T5 and T10 in 0.56g. Dolomite was applied 1.3g on T7, T8, T9 and T10.

Data gathering

Measurements of the plant height and number of leaf was taken 1 week after sowing while the number of pods, weight of pods, number of nodules, weight of nodules, weight of grains, weight of oven dried roots and weight of oven dried shoot was taken after termination of study.

Statistical analysis

The data was statistically analyzed using Statistical Tool for Agricultural Research (STAR) Version: 2.0.1. Means was compared using Tukey's Honest Significant Difference (HSD) test at 0.05 level of probability, when the F-values was significant.

Results and discussion

Plant Height, Number of Leaf and Girth Diameter

In Table 1 showed the growth response of the peanut *Arachis hypogaea* L. to the different treatments applied. The highest plant height 21 days after emergence observed in this order of the treatments $T_{10}>T_8> T_6> T_9> T_3> T_2 \& T_5> T_7> T_4> T_1$. However, during termination final plant height recorded higher in this order; $T_7> T_9> T_3> T_8>T_2 \& T_5> T_{10}> T_4> T_6> T_1$.Plant height after 14 days emergence chemical fertilizer NPK plus dolomite provide higher growth response of the shoot but after the period of cropping the increment of height was changed and observed higher in the all manure added with dolomite.

Further, plant leaf in final stage observed higher number of leaves in Chicken Manure Biochar alone and dolomite addition. Furthermore, comparison on the calculated mean between treatments revealed no significant difference in all plant parameters such as initial and final; height and no. of leaves and size of girth diameter between treatments with p value >0.05.

Table 1. The ANOVA and DMRT of the mean of Plant Height, No. of Leaf and Girth size of *A. hypogaea*.

Treatment' name	Parameters				
	Plant Height (cm)		No. of Leaf (pcs)		Girth size diameter (mm)
	Initial	*Final*	*initial*	*final*	
T_1-Unfertilized	18.83	35.00	11.33	24.00	3.20
T_2–CM	20.67	39.67	10.33	30.67	3.20
T_3–CMB	21.67	41.67	12.00	31.67	2.90
T_4–GM	19.67	38.03	10.00	23.33	2.97
T_5–NPK	20.67	39.67	9.33	26.00	2.83
T_6–LIME (Dolomite)	22.17	36.83	9.67	17.67	3.10
T_7- (T_2 + dolomite)	20.30	44.33	8.00	23.33	3.03
T_8 -(T_3 + dolomite)	22.67	40.97	11.00	31.67	3.57
T_9 -(T_4 + dolomite)	21.83	42.97	9.00	27.00	2.97
T_{10} -(T_5 + dolomite)	23.80	39.07	11.00	17.67	3.50
**p-value*	0.6122	0.6104	0.1798	0.2015	0.0968

Note: * significance @ Alpha <0.05.

T_1-unfertilized, T_2-10 t ha^{-1} of CM-chicken manure, T_3 -10 t ha^{-1}CM-Biochar, T_4 -10 t ha^{-1}GM-Goat manure, T_5 - NPK -60-60-60 kg ha^{-1}, T_6-Dolomite -1 t $ha^{-1}$and T_7(T_2 + dolomite), T_8 (T_3 + dolomite), T_9 (T_4 + dolomite) and T_{10} (T_5 + dolomite).

This indicates that the treatment that provide readily absorb nutrients from the soil especially the synthetic NPK with lime (dolomite) will provide immediate nutrient during emergence and early stage of *A. hypogaea* growth patterns compare to the treatment organic fertilizer that needs to undergo decomposition until it becomes available to the plants providing higher shoot growth in the final termination.

Plant Yield Parameters

Furthermore, number and weight of pods and nodules weight observed highest in chicken manure alone with significant difference to control, dolomite alone and NPK chemical fertilizer application provided by Tukeys' HSD post hoc test (Table 2).

It was also observed in the result that in all treatment with mixture of chicken manure (chicken manure biochar alone or with dolomite addition and, chicken manure with liming (dolomite) is higher number and weight of pods and dry matter of shoot and root of peanut . Also highest in nodulation together with chicken manure alone with significant difference to control, dolomite alone and NPK application revealed by Tukeys' HSD post hoc test.

Moreover, the comparison of the calculated means of Weight of Pods, number of Nodules, Dry weight of Roots and Shoot revealed high significant difference among groups with p value <0.05 and only no. of pods and weight of nodules does not give significant difference (p>0.05) provide by ANOVA test.

The highest yield of peanut grown on OxisolKaranganyar was 1.01 t/ha, and it obtained by applying 100 kg rock-phosphate + 500 kg dolomite + 5 t chicken manure/ha (Taufiq, 2002). But Chicken manure gives higher yields in terms of weight of pods that is in contrast to the study of Singh *et al.* (2011) integration of lime to farm yard manure and NPK could give best yield for groundnuts.

Table 2. The results of ANOVA and Tukey's HSD post hoc test of the mean of selected parameters of *A. hypogaea*.

Treatment' name	Parameters					
	No of Pods (pcs)	Weight of Pods (g)	No. of Nodules (pcs)	Weight of Nodules (g)	Roots Dry weight (g)	Shoot Dry Weight (g)
T_1-Unfertilized	6.0	4.47 ^{c}	12.67 ^{c}	0.02	0.86 ^{ab}	2.8 ^{c}
T_2-CM	14.33	21.57 ^{a}	155.67 ^{a}	3.22	1.21 ^{ab}	7.87 ^{a}
T_3-CMB	12.33	19.45 ^{ab}	121.00^{ab}	0.85	1.34 ^{a}	8.48 ^{a}
T_4-GM	9.00	14.75 ^{abc}	95.00 ^{abc}	0.59	1.16 ^{ab}	6.69 ^{ab}
T_5-NPK	10.33	9.99 ^{bc}	29.00 ^{bc}	0.10	0.82 ^{ab}	3.54 ^{c}
T_6–LIME (Dolomite)	3.67	5.14 ^{c}	5.33 ^{c}	0.01	0.52 ^{b}	2.06 ^{c}
T_7- (T_2 + dolomite)	10.67	17.48 ^{ab}	158.67 ^{a}	0.83	1.38 ^{a}	7.77 ^{a}
T_8 -(T_3 + dolomite)	12.00	19.11 ^{ab}	163.67 ^{a}	0.82	1.21 ^{ab}	7.29 ^{a}
T_9 -(T_4 + dolomite)	8.00	11.47 ^{abc}	104.00 ^{abc}	0.43	1.20 ^{ab}	6.69 ^{ab}
T_{10} -(T_5 + dolomite)	9.00	14.48 ^{abc}	69.00 ^{abc}	0.35	1.03 ^{ab}	4.47 ^{bc}
**p-value*	0.826^{ns}	0.0002*	0.0001*	0.2597^{ns}	0.0098*	0.0001*

Note: * significance @ Alpha <0.05, ns- no significant difference, Mean with the same letters has no significant difference.

T_1-unfertilized, T_2-10 t ha^{-1} of CM-chicken manure, T_3 -10 t ha^{-1} CM-Biochar, T_4 -10 t ha^{-1} GM-Goat manure, T_5 -NPK -60-60-60 kg ha^{-1}, T_6-Dolomite -1 t $ha^{-1}$and T_7(T_2 + dolomite), T_8 (T_3 + dolomite), T_9 (T_4 + dolomite) and T_{10} (T_5 + dolomite).

These yields trend also to explain that liming alone cannot serve to achieve the maximum potential of an acid soil, thus suggesting that the soils are more depleted of N and K, which clearly influence crop performance as, was observed when these amendments (lime and P fertilizer) were applied in combination with manure (Farag and Zahran, 2014). The rate of dolomite plus that was higher than 2,500 kg ha-1 could decrease the yield (Sutriadi and Setyorini, 2012). Organic sources such as farm yard manure, ice husk ash, paper factory sludge along with chemical fertilizers improved the yield and quality of peanut kernels in a better and comparable way than lime (Basu *et al.*, 2007).

Furthermore, as cited by Nelson and Janke (2007) Poultry manure both compost and manure have high P values compare to others. Application of60 kg p 105 ha-l significantly increased growth, yield and quality parameters compared to 20 kg p 105 ha-l of *A. hypogaea* (Rao 2001). Results revealed that poultry manure 2.5 t/ha + neem cake 2.5 t/ha + vermicompost 2.5 t/ha + phosphocompost 2.5 t/ha gave 2.08 tonne pod yield/ha, which was 9.47% higher over recommended dose of chemical fertilizer (Patra *et al.*, 2011). Groundnut, *A. hypogaea* can be organically produced, provided adequate phosphorus is applied as phosphocompost.

The highest yield of groundnut obtained with combination of phosphocompost, poultry manure, neem cake and vermicompost (Patra and Sinha 2012). Poultry litter gave a greater yield than fertilizer when both increased yield above the control (Balkcom *et al.*, 2003). In 2002, Productivity of peanuts and green pea crop with chicken manure higher than with cow and sheep manure and higher to the national productivity in Japan (Sukartaatmaja *et al.*, 2002).

Soil characteristics

Soil health is the foundation of productive farming practices. Fertile soil provides essential nutrients to plants (Kime, 2012). Soil analysis determines the nutrients available, physical, and chemical and soil properties (Folnovic, 2019). Table 3 showed the texture, pH, P and K. properties of soil media used in *A. hypogaea* is in poor condition. By comparing the pH to the soil analysis before (Table 3) after treatment (Table 4) pH range from 4.80 increase to least of 5.3 in CM and 6.2 in CM Biochar. Planting *A. hypogaea* a leguminous help increase pH **as** observed in control without fertilizer.

Table 3. The initial result of soil analysis used in A. hypogaea soil media.

		Soil Characteristics		
Texture	pH	SOM (%)	Phosphorous (ppm)	Potassium (ppm)
Heavy	4.80 *strongly acidic*	0.40 *low*	4.00 *low*	72 *low*

Note: (pH; Strongly acidic <5.1, Moderately acidic 5.2–6.0, Slightly acidic 6.1–6.5, Neutral 6.6–7.3, Moderately alkaline 7.4–8.4, Strongly alkaline >8.5), (Phosphorous ; Low <10, Medium 10–25, High 25–50 Excessive >50), (Potassium; Low <150 ppm, Medium 150–250 ppm , High 250–800 ppm , Excessive >800 ppm (Horneck *et al.*, 2011).

The soil composition analysis after the cropping period will help to determine how much nutrient where available and needed for the next production. The soil characteristics obtained after experimental utilization of peanuts in this study. The soil parameters included the texture, pH, Organic matter percentage, Phosphorous and Potassium tabulated in Table 4. All of the soil parameters have no significant difference among all treatments with the p value >0.05.

Table 4. The mean and interpretation and ANOVA of soil properties parameter after cropping of peanuts.

Treatment Name	Soil Characteristics**				
	Texture	pH	SOM- Soil organic matter (%)	Phosphorous (P) ppm	Potassium (K) ppm
T_1-Unfertilized	Heavy	5.8 moderately acidic	0.7 low	15.3 medium	68.3 low
T_2–CM	Heavy	5.3 moderately acidic	0.6 low	3.0 low	62.0 low
T_3–CMB	Heavy	6.2 slightly acidic	0.7 low	12.3 medium	87.7 low
T_4–GM	Heavy	5.6 moderately acidic	0.6 low	15.3 medium	52.3 low
T_5 –NPK	Heavy	5.6 moderately acidic	0.7 low	7.7 low	81.0 low
T_6–LIME (Dolomite)	Heavy	6.1 slightly acidic	0.6 low	11.3 medium	68.7 low
T_7- (T_2 + dolomite)	Heavy	5.4 moderately acidic	0.6 low	2.0 low	62.0 low
T_8 -(T_3 + dolomite)	Heavy	5.5 moderately acidic	0.7 low	13.0 medium	91.0 low
T_9 -(T_4 + dolomite)	Heavy	5.9 moderate acidic	0.6 low	7.0 low	45.7 low
T_{10} -(T_5 + dolomite)	Heavy	5.9 moderately acidic	0.7 low	6.0 low	78.0 low
*p-value	-	0.483^{ns}	0.858^{ns}	0.402^{ns}	0.385^{ns}

Note:* *significance @ alpha <0.05, ns-no significant difference*

T_1-unfertilized, **T_2**-10 t ha^{-1} of CM-chicken manure, **T_3** -10 t ha^{-1} CM-Biochar, T_4 -10 t ha^{-1} GM-Goat manure, **T_5** –NPK 60-60-60 kg ha^{-1}, **T_6**-Dolomite -1 t ha^{-1}and **T_7**(T_2 + dolomite), **T_8** (T_3 + dolomite), **T_9** (T_4 + dolomite) and **T_{10}** (T_5 +dolomite)

Methods and Interpretation: Texture- feel method, SOM-Walkley-Black, pH -Potentiometric, Phosporous- Olsen method, Potassium – exchangeable K (Cold sulphuric Acid Method). (pH**; *Strongly acidic <5.1, Moderately acidic 5.2–6.0, Slightly acidic 6.1–6.5, Neutral 6.6–7.3, Moderately alkaline 7.4–8.4, Strongly alkaline >8.5), (**Phosphorous** ;* Low <10, Medium 10–25, High 25–50 Excessive >50), ***(Potassium;*** *Low <150 ppm, Medium 150–250 ppm , High 250–800 ppm , Excessive >800 ppm),. DA Caraga RSL; Horneck et al 2011*]

The soil texture and Soil Organic matter classified as heavy and low SOM % respectively provide by DA Caraga, RSL- Regional Soil Laboratory. The pH, P and K interpretation utilized the guide from Horneck *et al*, (2011). Soil pH was moderately to slightly acidic condition, P content described as low to medium and then K is low amount after the termination. Some soil characteristics resulted to better values after treatment and planting but not as much.

According to Spargo *et al*, (2013), "pH range of 6.0 to 7.0 desired by most crops but acidity reduced availability of nitrogen, phosphorus, and potassium. P deficiency of this nutrient can lead to impaired vegetative growth; weak root systems, poor fruit and seed quality, and low yield. Plants deficient in potassium are unable to utilize nitrogen and water efficiently and are more susceptible to disease" .The soils that are low to moderate in fertility require quite reasonable management (Belachew and Abera, 2010). Soil organic matter is on-site biological decomposition affects the soil structure and porosity, water infiltration rate, moisture, diversity and biological activity of soil organisms and nutrient availability (Bot and Benitez 2005). Soil texture influences soil fertility and the way air and water move through the soil **(**Macie, 2013)

Conclusion

The present study concluded that there are no significant differences on plant height, number of leaves, girth size diameter and no. of pods and weight of nodules but there is significant difference in the weight of pods, number of nodules, dry weight of roots and shoot provide by ANOVA test. There is an increase in plant height, number of leaves, girth size diameter observed treatments with either chicken manure or biochar with dolomite. Further, chicken manure increase in number and weight of pods and weight of nodules while number of nodules, dry matter of shoot and root observed higher in chicken manure biochar alone and/or with dolomite and also improve soil characteristics. Furthermore, soil amended with chicken manure increases growth and yield of peanut *Arachis hypogaea* L.

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