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Evaluation of nutrient efficiency of carapace (crab shell) in agriculture sector

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A B S T R A C T

In the coastal region, crab cultivators are concerned about the wastage produced by crab moulting and polluting soil health for pisciculture. Farmers have recently been using different bio-compost, produced after decomposing as vegetable wastage, cow dung, Trico-compost and vermin-compost. The nutritional composition of carapace based on dry matter has been approximately analysed and indicates DM-97.33%, Moisture-2.67%, Crude protein, CP-0.02%, Ether extract, Lipid-2.12%, Crude fiber, CF-5.57% and Ash, Minerals-20.25%. After decomposing, the crab shell was used for BARI hybrid summer tomato production in a field trial to observe the plant vegetative and yield performance. In the field, trial has been set five (5) treatments with six (6) replications for each treatment as T1= control treatment, T2= Soil (50%) + vermin-compost (50%), T3= vermin-compost (100%), T4= Crab Shell compost (100%), T5=Soil (50%) + Crab Shell compost (25%) + Vermin-compost (25%). Crab shell compost has a significant relation to vermin compost for enhancing the leaf length of the plant. T4 was more significant than T2 and T5 for enhancing the leaf width of plants and average fruit weight. Crab shell compost is non-significance for increased tiller number, inflorescence number and plant height. T5 have a more significant relation than vermin-compost for increasing the tiller number of plant. After the field trial, the soil nutrient analysis report showed that alkalinity is on the optimum label for crop production. Decomposed crab shell-treated soil also increases Organic matter, Nitrogen, Potassium, Boron, Zinc, and salinity but reduces phosphorous compared to the control treatment. Therefore, the decomposed crab shell is a nutrient source for agricultural production.

Keywords: DAT= Days after treatment, Crab shell compost, Vermin-compost= bio-compost produced by vermin

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Introduction

Now farmers are using different organic fertilizers such as bio-compost, vermin-compost, and trico-compost for organic vegetable production. In the coastal region of Bangladesh, major farmers are included in shrimp culture and craft cultivation. However, it has become a great panic for the farmer because farmers have no stable market for selling the molted shell. Therefore, the molted shell decomposes in a gher/pond, increases ammonium gas in water, and grows different bacterial diseases in fish. The carapace is the shell on the back of the crab made of a hard bone called chitin. Chitin contained in crab shells may help rhizobial multiplication by biologically controlling root pathogenic organisms; as a result, multiplication by biologically controlling root pathogenic organisms might increase symbiotic nitrogen fixation. Other relevant advantages of crab shell application to agricultural soil include supplementing or replacing costly inorganic fertilizers. Therefore, crab shells can be a useful organic material for environmental conservation in sustainable agriculture (Muhammad *et al.*, 1998). This craft shell was recently used in Poultry feed and aesthetic ornamental production. Fertilizer made of shellfish is composed of the shells of crustaceans such as crabs, shrimp, or even lobsters and is called shrimp or crab meal.

The shells, rich in nitrogen, are mixed with a coarse carbon-rich material such as wood shavings or chips, leaves, branches, and bark. Romano *et al.* (2007) show that the leading composites of the shell are calcium carbonate and inorganic minerals. Crab shells had a deleterious effect on soybean root nodulation and nitrogen fixation at an early growth stage. However, low concentrations of chitin had a stimulatory impact at a later growth stage (Ali *et al.*, 1997). Deleterious effects of undecomposed lobster shells and stimulatory effects of well-decomposed lobster shells on the growth of buckwheat have been reported (Michiyama, 1994; Michiyama, 1995). It is safe to use near water systems since the nitrogen does not leach out of the soil and into water runoff. Chen *et al.* (2013) observed that when shellfish fertilizer is tilled or dug in well, it helps plants fight off root rot, blight, and powdery mildew.

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In contrast, they are encouraging healthy populations of microorganisms and earthworms. In addition, because the muscle proteins in shellfish, which cause allergies, are eaten by microorganisms as they compost down, there is no danger to people with shellfish allergies (https://www.gardeningknowhow.com). Hence, essential plant elements have present there. Cornwall (2014) found out that shells, especially crab shells, can be used as an ingredient in compost, which farmers and gardeners use as an organic fertilizer. The awareness of environmental and food safety issues has been responsible for developing organic farming in recent years (Worthington, 1998; Masarirambi *et al*., 2010).

On the other hand, vermin-compost is a proven organic fertilizer for crop production. Vermin-compost enhances the fertility, porosity, composition and water-absorbing capacity of soil. After decomposing the animal part, vegetable wastage becomes a good nutrient source and increases soil fertility. This organic fertilizer does not burn plants like other fertilizers because it is slow-release. Mahmoud and Soliman (2017) pointed out that a mixture of organic fertilizers (cattle manure and humic substances) and soil amendments (zeolite and magnetite) led to a significant increment in morphological growth (plant height, number of branches, number of leaves, leaves area, leaves fresh weight and leaves dry weight), floral characteristics (number of flower, number of capsules, seed yield as well as health index) and chemical composition symbolized in plant. Wazir *et al.* (2018) found that among the different organic treatments, eggshell powder, banana peel and used tea waste were found to be best as an organic fertilizer source for vegetables. Therefore, the key objective is to identify the nutrient composition of craft shells as organic fertilizer in vegetable production. Therefore, this study will determine what will result in vegetable production use of craft shell compost.

Materials and Methods

Study area

The study was conducted in Shyamnagar Upazilla, a coastal region of Bangladesh. Shyamnagar Upazilla is the nearest area of Sundarban and is prone to saline problems. An approximate analysis of nutritional composition was conducted in the animal and poultry science laboratory of Khulna University. Soil health was also tested at the laboratory of Soil Resource Development Institute (SRDI) of Khulna.

Data collection and analysis

The nutritional composition was from the dry powder of carapace based on dry matter. The approximate analysis uses three (3) replication, and the average result is the optimum result. The test was conducted in the Poultry Science Laboratory of Khulna University. In the field, the trial has been set for five (5) treatments as T1= Control treatment, T2= Soil (50%) + vermin-compost (50%), T3= Vermin-compost (100%), T4= Crab shell compost (100%), T5=Soil (50%) + crab shell compost (25%) + vermin-compost (25%). Each treatment has six (6) replication. For every replication, six (6) response variables (plant height, leaf number, leaf length, leaf width, inflorescence number, tiller number) data were collected at four DAT (days after treatment) in the vegetable stage of BARI hybrid summer tomato-8. The vegetative data was collected in centimeters (cm), and fruit weight was contained in grams (g). In the pick period of harvesting, total fruit was harvested, and data was collected for three variables: total fruit number, total fruit weight and average fruit weight. Data analysis was conducted in STAR version 2013 software in CRD (Completely Randomized Design) to analyse the variation of significance among applied treatments. After the field trial, the carapace in vegetable (summer tomato) production the soil health was also tested at Soil Resource Development Institute (SRDI) of Khulna. The test has been taken for four samples (T1, T2, T4, T5). Vermin-compost is scientifically approved for crop production; for this reason, laboratory tests have not been conducted for T3 treatment.

Results

Laboratory-based analysis

A study on the materials of the carapace was done by a chemist, Romano *et al.* (2007) shows that the leading composites of the shell are calcium carbonate and inorganic minerals. Table 1 shows the nutrient composition of the carapace.

Table 1. The compositions of the crab's carapace.

Material/wt% sample	H_2O	Organic matrix	Total mineral content	$CaCO_3$	H_2O from apatite
Crab carapace	11.8	16.6	71.6	27.3	0.7

The study showed that organic matter contains 16.6%, Calcium carbonate 27.3% and mineral content 71.6% based on the weight percentage of the carapace material. Another approximate nutritional analysis was conducted in the Animal and Poultry Science Laboratory of Khulna University. The nutritional composition gets from the dry powder of the carapace based on dry matter. This result is shown in Table 2.

Table 2. Nutritional composition of Crab shell powder.

DM (%)	Moisture (%)	Crude protein (%)	Ether extract (%)	Crude fiber (%)	Ash (%)
97.33	2.67	0.02	2.12	5.57	20.25

Approximate nutritional composition of Crab shell based on Dry matter (DM) – 97.33%, Moisture - 2.67%, Crude protein (CP) - 0.02%, Ether extract (lipid) - 2.12%, Crude fiber (CF) - 5.57% and Ash, minerals - 20.25%. The dry crab shell has 20.25% Ash and mineral, which can be used as an essential plant element. The main constituents of the ash are calcium, iron, magnesium, aluminium, potassium, sodium, silicon and titanium (Kim *et al.*, 2011). Thus, the ideal soil composition needs a significant amount of dry matter. The crab shell increases soil organic matter content, improves soil physical properties, and supplies essential plant nutrients, particularly N and P (Date, 1989). Organic sources of nutrients become available after decomposition and in an ionic form for plant uptake. As an experimental confirmation, the different treatments used of the carapace in the tomato plant as an experiment and harvested large of tomato. After using the carapace in soil, the soil health was also tested at Soil Resource Development Institute of Khulna. After one season utilizing vegetable (summer tomato) production, the nutrient composition is shown in Table 3.

Table 3. Soil nutrient composition after cultivation of tomato.

Treatment	PH	Salinity (ds/ml)	Organic matter (%)	Nitrogen (%)	Phosphorous (microgram/g)	Potassium (ppt/100g	Sulpher (microgram/g)	Zinc (microgram/g)	Boron (microgram/g)
T1	8.3 Alkaline	4.4 Lower	1.42 Small	0.083 Less	180.08 Surplus	0.65 Surplus	10.56 Lower	1.11 Medium	0.42 Medium
T2	8.4 Alkaline	2.6 Less	2.10 Medium	0.122 Lower	169.25 Surplus	0.80 Surplus	7.88 Lower	1.94 Surplus	1.85 Surplus
T4	8.4 Alkaline	4.6 Lower	1.63 Small	0.094 Lower	172.60 Surplus	0.67 Surplus	6.73 Lower	1.14 Medium	1.70 Surplus
T5	8.3 Alkaline	4.3 Lower	1.80 Medium	0.106 Lower	175.37 Surplus	0.89 Surplus	7.57 Lower	1.60 Sufficient	0.78 Surplus

The crab is cultivated in the coastal region, so the carapace contains salty ions, which increases in a less amount of soil salinity and alkalinity of the soil. T2 reduces salinity compared to the control treatment. T4 has increased a little bit more salinity compared to the control treatment (T1). Crab shell is a by-product of marine organisms (Muhammad *et al.*, 1998). Vermin-compost reduces salinity in T2 and T5. However, the alkalinity is on the optimum label for crop production. After combining vermin-compost and carapace, the soil increases Organic matter, Nitrogen, Phosphorous, Potassium, Boron, and Zinc but reduces Sulphur and salinity compared to the control treatment. Only carapace-treated soil also increases Organic matter, Nitrogen, Potassium, Boron, Zinc, and salinity but reduces Phosphorous compared to the control treatment. Therefore, the result shows carapace has some essential elements of plants, which can be in soluble form for plant update. Thus, the carapace is a nutrient source for agricultural production.

Field trial-based analysis

Efficiency of carapace in the vegetative stage of plant

The vegetative growth data was analysed after using carapace in BARI hybrid summer tomato plant to see the efficiency of the other treatment. Table 4 shows the comparative plant height at different stages (DAT-1 = 17-08-2021, DAT-2 = 24-08-2021, DAT-3 = 01-09-2021, DAT-4 = 22-09-2021) of the life cycle. Data has been analyzed for five specific treatments those are:

T1= Control treatment
T2= Vermin-compost treated soil
T3= Vermin-compost
T4= Crab shell compost
T5= Crab shell compost and vermin-compost treated soil

Table 4. Comparative plant height at different stages of the life cycle in specific treatment.

Treatment	DAT=1	DAT=2	DAT=3	DAT=4	Mean
1	9.16 bc	15.167 b	22.83 d	54.33 c	29.09
2	13.00 ab	17.50 b	27.16 a	58.50 b	
3	14.00 a	21.83 a	38.16 a	70.83 a	
4	8.83 c	10.00 c	15.16 e	50.67 c	
5	13.50 a	18.50 ab	32.67 b	70.00 a	

**Means with the same letter are not significantly different.*

The mean value is 29.09, achieved in DAT-3 by Vermin-compost and Crab shell with vermin-compost treated soil. On the other hand, the control treatment, vermin-compost treated soil, and crab shell compost treated soil are not significantly different for plant height. Vermin-compost (T3) is the best treatment for plant height in the whole life cycle compared to other treatments. T5 is the nearest result for plant height to T3. In T4 treatment, plant height was less compared to the control treatment T1. For analysis, the significance of leaf number for all treatments has shown in Table 5.

Table 5. The significance of plant leaf number at different treatments.

Treatment	DAT=1	DAT=2	DAT=3	DAT=4	Mean
1	4.16 ab	5.50 bc	7.83 bc	11.83 c	9.12
2	5.33 ab	7.00 ab	8.67 ab	14.33 b	
3	6.00 a	7.50 a	10.50 a	18.00 a	
4	4.00 b	4.33 c	6.67 c	18.83 a	
5	6.00 a	6.66 ab	10.33 a	18.83 a	

Means with the same letter are not significantly different.

Growing leaf numbers have a significant relation in vermin-compost and carapace-treated soil. Crab shell compost has the same significant relation as vermin-compost with crab shell-treated soil. T3, T4 and T5 are highly significant for leaf number of the plant. T4-treated plants bear more leaves compared to T3. However, vermin-compost-treated plants achieved the highest height. T4 treated plant has less height but the highest leaf number. For analysis, the significance of enhancing leaf length for all treatment has shown in Table 6.

Table 6. Analysis of significance for specific treatment in plant leaf length.

Treatment	DAT=1	DAT=2	DAT=3	DAT=4	Mean
1	4.83 ab	10.16 c	14.83 d	19.00 c	15.32
2	5.33 ab	11.33 bc	19.00 c	31.16 a	
3	5.83 a	13.67 a	27.50 a	28.33 b	
4	3.33 b	5.50d	8.16 e	27.16 b	
5	6.16 a	12.50 ab	23.83 b	28.83 b	

Means with the same letter are not significantly different.

All treatments have significant relation for enhanced leaf length, but vermin-compost treated soil (T2) is more significant than others. Crab shell compost (T4) has the nearest significant relation as vermin-compost for enhancing the leaf length of the plant. Leaf length measured from axile to the tip of the leaf in centimetre (cm). For analysis, the significance of enhancing leaf width for all treatment has shown in Table 7.

Table 7. Analysis of significance for specific treatment in plant leaf width.

Treatment	DAT=1	DAT=2	DAT=3	DAT=4	Mean
1	3.15 ab	6.83 b	9.81 c	13.10 c	9.72
2	3.53 ab	7.56 b	12.95 b	16.36 b	
3	3.41 ab	9.81 a	17.41 a	20.81 a	
4	1.81 b	2.61 c	5.36 d	16.98 b	
5	4.23 a	8.46 ab	14.51 b	15.66 b	

Means with the same letter are not significantly different.

All treatments have significant relation for enhanced leaf width, but vermin-compost is more significant than others. Vermin-compost has a more significant relation than vermin-compost treated soil (T2) and vermin-compost (T3) for enhancing the leaf width of plants. It is observed that carapace (T4 & T5) have non-significant relation to leaf width. For analysis, the significance of the tiller number for all treatment has shown in Table 8.

Table 8. Analysis of significance for specific treatment in increasing the tiller number.

Treatment	DAT=1	DAT=2	DAT=3	DAT=4	Mean
1	0.0 a	1.33 b	1.66 a	4.33 c	2.35
2	0.0 a	2.00 ab	2.00 a	6.67 b	
3	0.0 a	2.33 a	2.16 a	8.16 a	
4	0.0 a	0.00 c	0.00 b	3.33 d	
5	0.0 a	2.00 ab	2.00 a	9.00 a	

Means with the same letter are not significantly different.

Crab shell compost (T4) is non-significance for increased tiller number, but vermin-compost is more significant than others. Crab shell compost with vermin-treated soil has a more significant relation than vermin-compost for increasing the tiller number of plant. For analysis, the significance of the inflorescence number for all treatment has shown in Table 9.

Table 9. Analysis of significance for specific treatment in inflorescence number.

Treatment	DAT=1	DAT=2	DAT=3	DAT=4	Mean
1	0.0 a	0.0 a	0.33 a	4.50 c	1.84
2	0.0 a	0.0 a	0.50 a	6.83 b	
3	0.0 a	0.0 a	1.00 a	8.83 a	
4	0.0 a	0.0 a	0.33 a	3.50 c	
5	0.0 a	0.0 a	0.83 a	10.16 a	

DAT= Days after treatment, CV= Coefficient of variation

**Means with the same letter are not significantly different.*

For increased inflorescence number crab shell compost is non-significance, but vermin-compost with carapace-treated soil more significant than others. Vermin-compost with carapace-treated soil has a more significant relation than vermin-compost for increasing the inflorescence number of plants.

Efficiency of carapace in fruit production of plant

After the fruit set, total fruit number and weight were measured in DAT-5 (days after treatment) for all treated replication. In the Excel sheet, the average fruit weight has been calculated and shown in Figure 1 to see the differences among all treatments.

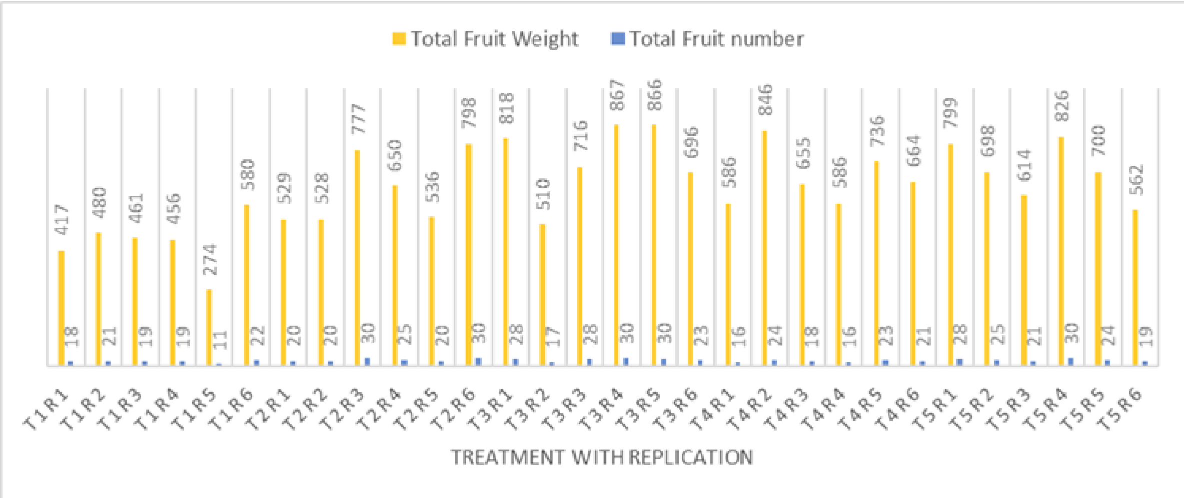

Figure 1. Total fruit number and weight showed for specifically treated replication.

The fruit setting range observed 11 to 30 numbers, and the weight range was 274 g to 867 g. In control, the highest fruit bearing was 22 number and fruit weight was 580 g. Crab shell compost has the highest fruit bearing 24 numbers and the highest fruit weight 846 g. For vermin-compost, fruit-bearing and fruit were highest compared to all treatments. Yield means total fruit bearing with average fruit weight shown in Table 10.

Table 10. Yield performance for specific treatment.

Treatment	Total fruit number	Total fruit Weight	Average fruit Weight
T1	108	2668.0	24.70
T2	145	3817.5	26.32
T3	155	4473.2	28.71
T4	117	4073.8	34.78
T5	146	4198.6	28.64

Fruit average weight was nearest for vermin-compost-treated plants and carapace with vermin-compost-treated soil, but fruit-bearing was highest in vermin-compost. In Table 10 observed that the highest average fruit weight was achieved in carapace-treated plants, but the fruit number was less than in other treatments. Table 11 shows the significance analysis for specific treatment to total fruit number.

Table 11. The analysis of significance for specific treatment to total fruit number.

Treatment	Means	N group	Mean for fruit number
1	18.33	6.0 c	22.53
2	24.17	6.0 ab	
3	26.00	6.0 a	
4	19.67	6.0 bc	
5	24.50	6.0 ab	

**Means with the same letter are not significantly different.*

The total fruit number analysis showed that the vermin-compost treated plant was mostly significant for increasing fruit number. Alternatively, vermin-compost (T3), vermin-compost treated soil (T2), and carapace with vermin-compost treated soil (T5) are significant for fruit number increase. However, carapace was non-significant for bearing the total fruit number compared to the mean value of 22.53. Adverse effects of soluble salts have been reported to reduce yield potential and nodulation of legumes such as chickpeas (Lauter *et al*., 1981), beans (Yousef and Sprent, 1983), cowpea, mung bean (Balasubramanian and Sinha, 1976), Lucerne (Lakshmi *et al*., 1974), and soybean (Elsheik and Wood, 1995; Singleton and Bohlool, 1984; Tu, 1981; Wilson, 1970). Table 12 shows the significance of fruit weight in specific treatments.

Table 12. The analysis of significance for specific treatment to total fruit weight.

Treatment	Means	N group	Mean for fruit weight
1	444.67	6.0 b	641.03
2	636.33	6.0 a	
3	745.50	6.0 a	
4	678.83	6.0 a	
5	699.83	6.0 a	

**Means with the same letter are not significantly different.*

It is observed that the mean fruit weight is 641.03 g, whereas carapace, vermin-compost and carapace with vermin-compost treated soil are significant for fruit weight increase. The highest fruit weight 745.5 g is achieved in the vermin compost. Total fruit weight measured in gram scale. T4 and T5 also significant in the fruit weight. Table 13 shows the significance of fruit weight in specific treatments.

Table 13. Significance for specific treatment to total average fruit weight.

Treatment	Means	N group	Mean for average fruit weight
1	24.77	6.0 c	28.76
2	26.37	6.0 c	
3	28.88	6.0 b	
4	35.05	6.0 a	
5	28.76	6.0 b	

**Means with the same letter are not significantly different.*

It is observed that the mean fruit weight is 28.76 g, where carapace, vermin-compost and carapace with vermin-compost treated soil are significant for average fruit weight increase. The result shows that T4 is more significant than other treatments. Carapace treated non-significant fruit number, but total fruit weight and average fruit weight were more significant than other treatments. The result shows that mean fruit weight is more in carapace than in other treatments.

Conclusion

Crab shell (carapace) has H2O, Organic matrix, mineral content and CaCO3 in its appetite. After decomposing, the approximate nutritional composition of crab shell based on Dry matter 97.33%, Moisture-2.67%, Crude protein, -0.02%, Ether extract (lipid)- 2.12%, Crude fiber - 5.57% and Ash, minerals-20.25%. The dry crab shell has 20.25% Ash and mineral, which can be used as plant essential elements. Therefore, the result shows carapace has some essential elements of plants and can be in soluble form for plant update. Crab shell compost has a significant relation to vermin compost for enhancing the leaf length of plants. Crab shell compost is more significant than vermin-compost treated soil and vermin-compost with carapace treated soil for enhanced leaf width of plant and average fruit weight. The highest average fruit weight was achieved in carapace-treated plants, but the fruit number was less than other treatments. Crab shell compost is non-significance for increased tiller number, inflorescence number, total fruit number and plant height. Crab shell compost with vermin-treated soil has a more significant relation than vermin-compost for increasing the tiller number of plants. After the field trial, the soil nutrient analysis report showed that alkalinity is on the optimum label for crop production. Decomposed crab shell-treated soil also increases Organic matter, Nitrogen, Potassium, Boron, Zinc, and salinity but reduces phosphorous compared to the control treatment. Therefore, the decomposed crab shell is a nutrient source for agricultural production.

References

Ali, M., Horiuchi, T. and Miyagawa, S. 1997. Nodulation, nitrogen flxation and growth of soybean plants (*Glycine max* Merr.) in soil supplemented with chitin or chitosan. *Japanese J. Crop Sci.* 64: 100-107. https://doi.org/10.1626/jcs.66.100

Balasubramanian, V. and Sinha, S.K. 1976. Effects of salt stress on growth, nodulation, and nitrogen fixation in cowpea and mung bean plants. *Physiol. Planta.* 36: 197-200. https://doi.org/10.1111/j.1399-3054.1976.tb03935.x

Chen, B., Yin, D., Chen, X., Yuan, Q. and Zhiling, Z. 2013 Nanostructural Mechanism of Toughness of Crab Carapace. *J. Comput. Theor. Nanosci.* 10(6): 1436-1440. https://doi.org/10.1166/jctn.2013.2867

Cornwall, J. 2014. Edible Crab Measuring Guide**.** https://www.cornwallgoodseafoodguide.org.uk/fish-guide/crab-brown-edible.php

Date, N. 1989. Soil amendment materials. In N. Date ed. Hiryo Binran. Rural Culture Assoc, Tokyo. pp. 295-314.

Elsheik, E.A.E. and Wood, M. 1995. Nodulation and N_2 fixation by soybean inoculated with salt-tolerant rhizobia or salt-sensitive Bradyrhizobia in saline soil. *Soil Biol. Biochem.* 27: 657-661. https://doi.org/10.1016/0038-0717(95)98645-5

Kim, M.K., Shah, M.D., Islam, A., Yun, M.G., Kim, J.M. and Cho, J.J. 2011. Use of bottom ash of waste coal as an effective microbial carrier. *Biosci. Biotech. Biochem.* 75: 2264-2268. https://doi.org/10.1271/bbb.110495

Lakshmi, K.M., Singh, C.S. and Subba Rao, N.S. 1974. Root hair infection and nodulation of lucerne (*Medicago sativa* L.) as influenced by salinity and alkalinity. *Plant and Soil* 40: 261- 268. https://doi.org/10.1007/bf00011509

Lauter, D.J., Munns, D.N. and Clarkin, K.K. 1981. Salt response of chickpea as influenced by N supply. *Agron. J.* 73: 961-966. https://doi.org/10.2134/agronj1981.00021962007300060013x

Mahmoud, A.M. and Soliman, A.S. 2017. Comparative study on the influence of organic fertilizer and soil amendments on evening primrose (*Oenothera biennis* L.). *Int. J. Agric. Res.* 12(2): 52-63. https://doi.org/10.3923/ijar.2017.52.63

Masarirambi, M.T., Mduduzi, M.H., Olusegun, T.O. and Thokozile, E.S. 2010. Effects of organic fertilizers on growth, yield, quality and sensory evaluation of red lettuce (*Lactuca sativa* L.) "Veneza Roxa". *Agric. Biol. J. North America* 1: 1319-1324. https://doi.org/10.5251/abjna.2010.1.6.1319.1324

Michiyama, H. 1994. Effect of Ca·chitin and lobster shell on buckwheat growth. In: A. Hara ed., Res. Rep. on general use of chitin and its related materials. Fac. Agric. Meijo Univ, Nagoya. pp. 2-7. https://cir.nii.ac.jp/crid/1571417124923106176

Michiyama, H. 1995. Effect of decomposed lobster shell on buckwheat growth. In: A. Hara ed., Res. Rep. on General Use of Chitin and its Related Materials. Fac. Agric. Meijo Univ, Nagoya. pp. 2-10. https://cir.nii.ac.jp/crid/1573668924736788608

Muhammad, A., Horiuchi, T. and Miyagawa, S. 1998. Effects of soil amendment with crab shell on the growth and nodulation of soybean plants (*Glycine max* Merr.). *Plant Prod. Sci.* 1(2): 119-125. https://doi.org/10.1626/pps.1.119

Romano, P., Fabritius, H., Raabe, D. and Epple, M. 2007. The composition of the exoskeletons of large arthropods: example of two crustaceans: The American lobster *Homarus americanus* and the edible crab *Cancer pagurus*. *Thermochimica Acta.* 463(1-2): 65-68. https://doi.org/10.1016/j.tca.2007.07.018

Singleton, P.W. and BoWool, B.B. 1984. Effect of salinity on nodule formation by soybean. *Plant Physiol.* 74: 72-76. https://doi.org/10.1104/pp.74.1.72

Tu, J.C. 1981. Effect of salinity on Rhizobium-root hair interaction, nodulation and growth of soybean. *Canadian J. Plant Sci.* 61: 231 -239. https://doi.org/10.4141/cjps81-035

Wazir, A., Gul, Z. and Hussain, M. 2018. Comparative Study of various organic fertilizers effect on growth and yield of two economically important crops, potato and pea. *Agril. Sci.* 9: 703-717. https://doi.org/10.4236/as.2018.96049

Wilson, R. 1970. Response to salinity in Glycine. Some effects of a range of short-term salt stress on the growth, nodulation, and nitrogen fixation of *Glycine wightii*. *Aust. J. Agric. Res.* 21: 571 -582. https://doi.org/10.1071/ar9700571

Worthington, V. 1998. Effect of Agricultural Methods on Nutritional Quality: A Comparison of Organic with Conventional Crops. *Alter. Therap. Health Med.* 4: 58-69. https://pubmed.ncbi.nlm.nih.gov/9439021

Yousef, A.N. and Sprent, J.I. 1983. Effects of NaCl on growth, nitrogen incorporation and chemical composition of inoculated and NH4 -No3 fertilized *Vicia faba* (L.) plants. *J. Exptl. Bot.* 34(8): 941-950. https://doi.org/10.1093/jxb/34.8.941