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A study on effect of various soil amendments [crab shell powder, clam shell powder, green mussel shell powder, coconut shell charcoal and eggshell powder] on the growth of Tomato plants (*Solanum lycopersicum*)

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ABSTRACT

Fertilizers are one of the important components in agriculture which are highly used to balance the essential nutrients in the soil which is required for the plants. The soil amendments can be a waste material of organic origin which can be recycled by using it as an organic fertilizer. In the present study, an attempt has been made to prepare soil amendment using various household waste products namely crab shell, clam shell, green mussel shell, coconut shell charcoal and eggshell in a powder form. The percentage mass of Calcium carbonate(CaCO3) in these shell powders were determined using Acid/ Base Titration. The different proportions of these shell powders (2g,4g,6g,8g,10g) were added to the soil to measure germination percentage, relative germination percentage and mean shoot length of Tomato plants (*Solanum lycopersicum*). The highest seed germination percentage of 100% was observed in 8g clam shell powder pot and it might be because clam shell contains 77.034% of calcium carbonate. The clam shell powder had the highest mean shoot length at the concentration of 2 gm in the pot which was 18.48cm. It was observed that increased concentration of the clam shell decreases the shoot length. The overall mean shoot length of tomato plants grown in 2g,4g and 6g of shell powders were higher than the mean shoot length of control setup which was 9.63cm. The study suggests that clam shell increases the germination of seeds and shoot length of the tomato seeds in the lesser concentrations when compared to other shells. Clam shells also contain a higher concentration of calcium carbonate when compared to other shells.

Keywords: Soil amendments, Organic Fertilizer, *Solanum lycopersicum*, shell waste, germination percentage, relative germination percentage, mean shoot length.

INTRODUCTION

India is the most populous country in the world, occupying 2% of the planet's total land area, and its economy is based primarily on agriculture. United Nations reported, India will have 1.66 billion people by 2050, and agriculture is the prime factor to meet the necessity of the people. Apart from providing food, agriculture is a significant industry that plays a vital role in Indian economy (DESA, 2019). Fertilizer is one of the important components in agriculture which is highly used to balance the essential nutrients in the soil which is required for the plants. Use of fertilizer increases the yield of the product. High use of inorganic fertilizer unfortunately damaged soil not only by physical appearance but many chemical and biological indicators also showed the soil damage. This inappropriate fertilisation techniques may be detrimental to ecosystem services associated with soil health. An unbalanced application of chemical fertilisers can change the pH of the soil, increase pest activity, cause acidification and soil crust, and decrease soil organic carbon and beneficial organisms. This can limit plant growth and yield and potentially cause greenhouse gas emissions (Krasilnikov et al., 2022).

To combat this problem, organic fertilizers has been adopted by many farmers and it has many advantages for instance in potato the dry matter was increased after using organic fertilizers and the pungency in chilli was changed (Mishra et al 2013). Many scientists are recommending for the use of organic fertilizer because of the bad impact created by inorganic fertilizer (Lingga & Marsono, 2013; Brankov et.al., 2020). To improve the crop production and maintain the ecosystem sustainable agriculture will be the need of the hour.

Sustainable agriculture relies on the concept of increasing high quality agricultural products with safe and efficient production which preserves the environment and nurtures the habitat of flora and fauna. It also improves the socioeconomic status of farmers and promote the social justice and financial success (Sukhdev et al., 2013). Organic fertilizers will be prepared by organic material, which helps to improve the physical, chemical, and biological properties of the soil. The soil amendment can be a waste material from an agricultural product which can be recycled by using it as an organic fertilizer. In sustainable agriculture organic fertilizers are prepared using alternative approaches like adding beneficial microorganisms, preparation of compost by adding nutrients etc.

In the present study, an attempt has been made to prepare soil amendment using various household waste products namely crab shell, clam shell, green mussel shell, coconut shell charcoal and eggshell in a powder form**.** Shells are a major waste product in the household thrown away with no economic value. Eggshells contain 2.2 gms of calcium 0.3% phosphorus, magnesium and minute amount of Sodium, Potassium, Zinc, Manganese, Iron and Copper (Anugrah & Safahi, 2021). Like eggshells, Clamshells contain Calcium carbonate along with various minerals like Manganese, Potassium, Iron, Copper, Nickel and Zinc (Hamed et al., 2016). Green mussel shells are one of the major waste products in the coastal areas and they contain 0.6% of the water content and contain several micro and macro nutrients required for the plant growth. The pH of the shell is alkaline (9.8) which can be mixed with the acidified soil to alter the pH of the soil (Kisnawati et al., 2023). Crab shell is another waste product in the coastal areas contains mainly protein, carbohydrates and lipids essential for the plant growth (Mageshwari & Thiripurasundari, 2022). Coconut shell charcoal contains lignin which acts like a carbohydrate source. Studies showed that coconut shell charcoal will increase the nitrogen and phosphorus content of the soil. These agriculture waste products can be used as a soil amendment which helps to repair the soil damaged by extensive agriculture, overuse of inorganic fertilizer and thus improve the agriculture land. The present study focusses on the preparation of soil amendment using different proportions of these shell powders in promoting the growth of plants.

METHODOLOGY

Preparation of soil: Red soil and black soil bags of 10kg were collected from Nursery for conducting the experiment.

Soil pH measurement: 20g of red soil sample was weighed and added to a beaker containing 100 ml of distilled water and stirred it for 1 minute. Allowed it to stand for 30 minutes and with occasional stirring for every 10 minutes. After 30 minutes, soil pH was measured using pH electrode. Three readings were taken for calculating mean pH. Similarly, soil pH of black soil was measured.

Preparation of powders: 1 kg of eggshells were collected from household, washed thoroughly, and dried it in hot sun. After drying eggshells were crushed and made into fine powder in a blender. 1 kg of green mussel shells, clam shells and crab shells were procured from fish shop, washed thoroughly, and dried in hot sun. After drying these shells were crushed using big mortar and pestle and then made into fine powder using a blender. 1 kg of coconut shell charcoal were made into fine powder using a blender.

Figure 1: Shows Green mussel shells, Clam shells, Crab shells, Egg shells and Coconut shell charcoal used in the investigation

Figure 2: Shell powders used in the investigation

Determination of the percentage by mass of Calcium carbonate in the shell powders:

Weigh accurately about 0.6 g of the shell powder into a conical flask. Using a graduated pipette add 20.0 cm^3 of 1.00 mol dm^{-3} hydrochloric acid slowly and swirl the flask to prevent any small amount of liquid escaping from the flask with the carbon dioxide that is produced. Once the reaction has finished, add about 20 cm^3 of distilled water and transfer the contents of the flask to a 100 cm^3 volumetric flask. Use more distilled water to ensure all the contents have been transferred and make the final volume to exactly 100 cm^3. Take 10.0 cm^3 aliquots of this solution and titrate them with standard 0.100 mol dm^{-3} Sodium Hydroxide solution using phenolphthalein as an indicator to determine the percentage by mass of calcium carbonate in each of the shell powders.

Measurement of Germination percentage : Each shell powder weighing 2, 4, 6, 8 and 10g of each shell powder was added to pots containing 1 kg of red soil respectively. Control pot containing, 1 kg red soil without any shell powder was added. In each pot 15 tomato seeds were sown and on 15th day percentage of germination was calculated using formula

$$\text{Germination \%} = \frac{\text{Number of Seeds Germinated}}{\text{Total Number of Seeds}} \text{ X } 100$$

Figure 3: Shows Clam shell setup for measuring Germination percentage.

Measurement of Percentage of Relative Seed Germination: Percentage of Relative seed germination was calculated using below formula on 15th day.

$$RSG\ \% = \frac{\text{Number of seeds germinated in test sample}}{\text{Number of seeds germinated in control}} \times 100$$

Experimental setup for shoot length measurement: Three pots of black soil with two tomato seeds in each were taken for 2g, 4g, 6g, 8g, 10g of each shell powder. For 'control' without any shell powder, three pots with two tomato seeds were taken. The shoot length of six tomato plants from each experimental setup was measured using ruler after 40 days.

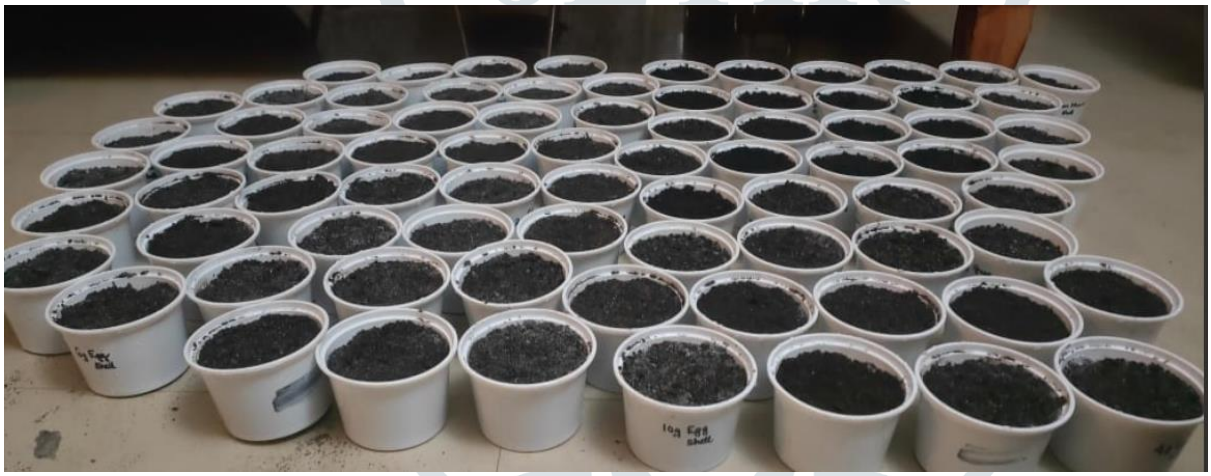

Figure 4: Experimental setup for measuring shoot length.

Statistical analysis: All the experiments were performed in duplicates and the average was calculated. To compare the significant effect between 2 groups, T test was performed. To compare the significance between all the groups one way ANOVA was performed. *P*-value less that 0.005 was considered as statistically significant.

RESULTS AND DISCUSSION:

Soil pH: The mean soil pH of red soil used for experiment to measure Germination percentage was found to be 7.39 and the mean soil pH of black soil used for measuring shoot length of tomato plants was found to be 8.34.

Soil type	Soil pH			Mean Soil pH
	Trial 1	Trial 2	Trial 3	
Red soil	7.52	7.30	7.35	7.39
Black soil	8.49	8.40	8.15	8.34

Table 1: Showing mean soil pH of red and black soil used in this experiment.

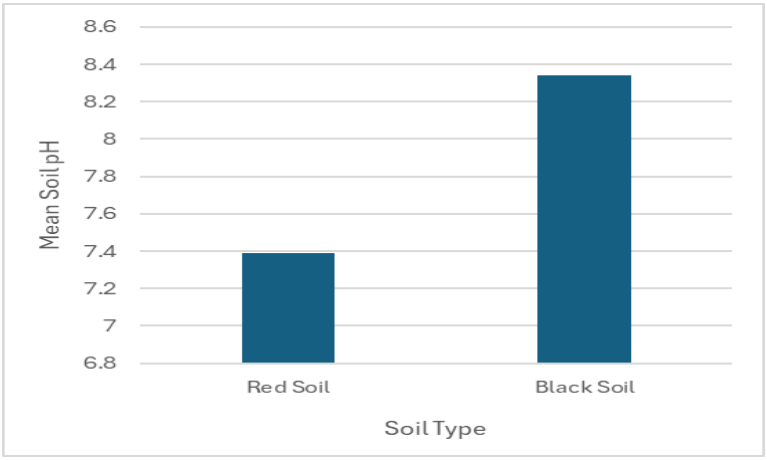

Figure 5: Graph showing mean soil pH of soil used in the experiment.

Mass of CaCO3 and Percentage by mass of Calcium carbonate in each of the shells:

Type of shell powder	Mass of CaCO3 (g)	Percentage by mass of CaCO3 [%]
Clam shell	**0.462**	**77.034**
Crab shell	**0.438**	**73.014**
Green mussel shell	**0.440**	**73.336**
Eggshell	**0.454**	**75.824**
Coconut shell charcoal	**0.428**	**71.405**

Table 2: Showing mass and percentage by mass of Calcium carbonate in various shell powders.

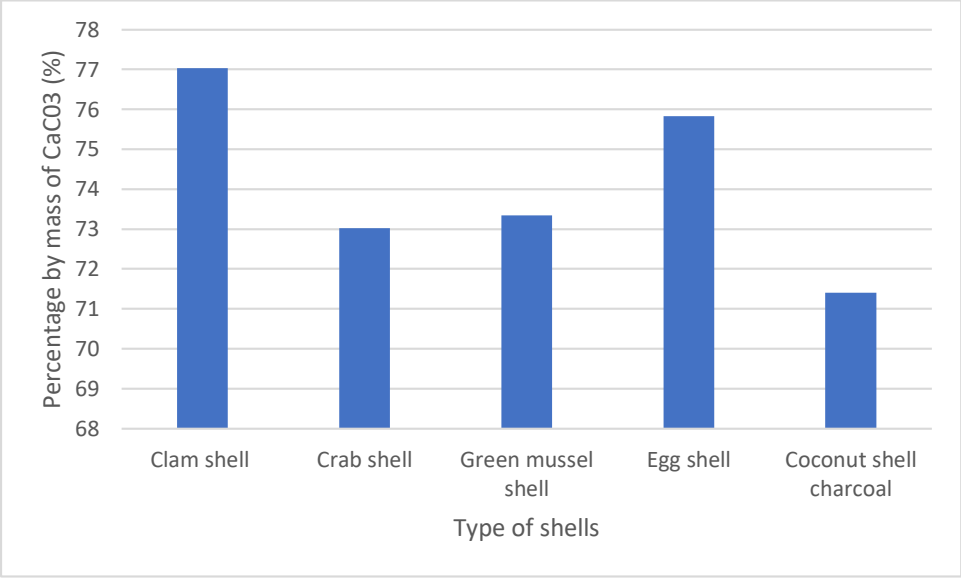

Figure 6: Showing percentage by mass of CaCO3 in different shell powders.

Germination percentage in Red soil:

Type of shell powder	Number of seeds germinated after 15 days				
	2g Pot	4g Pot	6g Pot	8g Pot	10g Pot
Clam shell	**7**	**9**	**6**	**15**	**6**
Crab shell	**4**	**11**	**12**	**8**	**7**
Green mussel shell	**6**	**12**	**10**	**8**	**8**
Eggshell	**7**	**2**	**5**	**8**	**8**
Coconut shell charcoal	**13**	**9**	**8**	**7**	**9**
Control [0g]-7					

Table 3: Shows number of seeds germinated in different concentrations of shell powders.

Figure 7: Shows results for measuring germination percentage after 15 days.

Type of shell powder	Percentage of germination after 15 days				
	2g Pot	4g Pot	6g Pot	8g Pot	10g Pot
Clam shell	47	60	40	100	40
Crab shell	27	73	80	53	47
Green mussel shell	40	80	67	53	53
Eggshell	47	13	33	53	53
Coconut shell charcoal	87	60	53	47	60
Control [0g]-47%					

Table 4: Showing percentage germination after 15 days

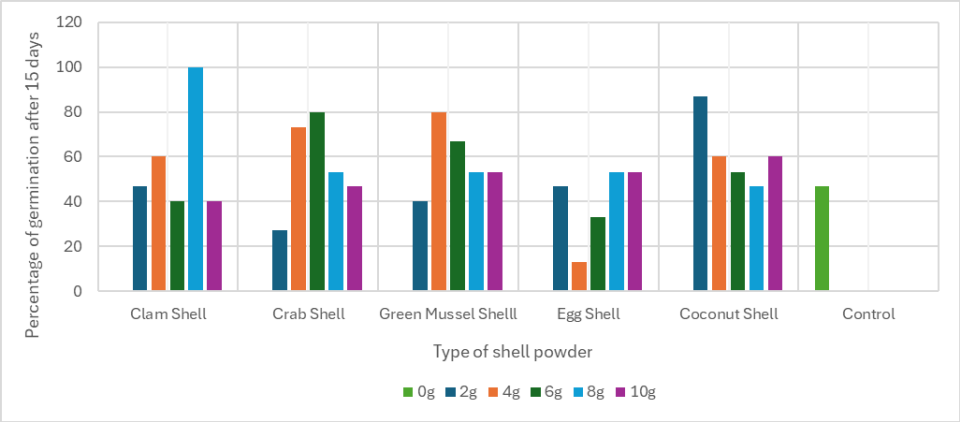

Figure 8: Showing percentage germination after 15 days.

Type of shell powder	Percentage of Relative seed germination after 15 days				
	2g Pot	4g Pot	6g Pot	8g Pot	10g Pot
Clam shell	100	129	86	214	86
Crab shell	57	157	171	114	100
Green mussel shell	86	171	143	114	114
Eggshell	100	29	71	114	114
Coconut shell charcoal	186	129	114	100	129
Control [0g]-7					

Table 5: Showing percentage of Relative seed germination after 15 days

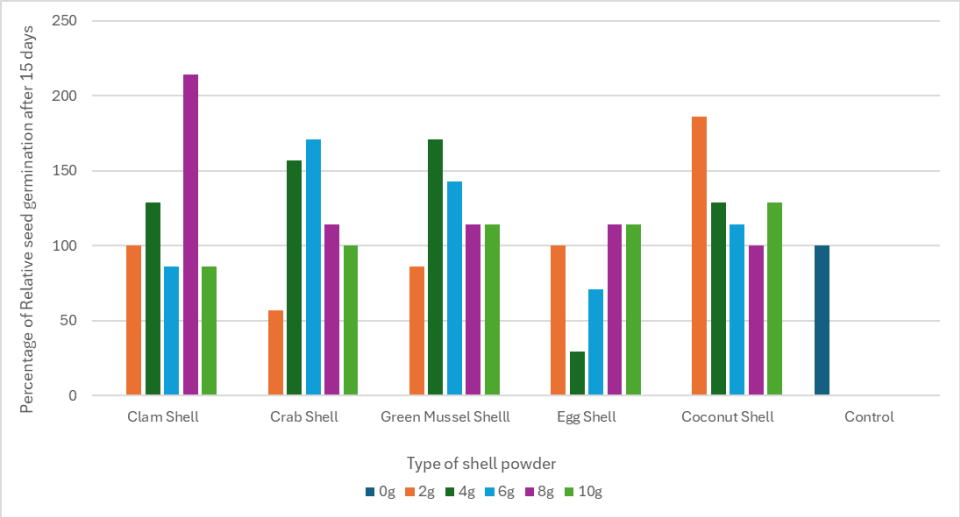

Figure 9: Showing percentage of Relative seed germination after 15 days

Shoot length in Black soil:

Type of shell powder	Mean shoot length (cm)				
	2g	4g	6g	8g	10g
Clam shell	18.48**	17.61	15.30	12.73	11.05
Crab shell	14.88	13.46	12.96	7.98	6.96
Green mussel shell	21.43***	19.65	18.78	17.86	16.66
Eggshell	17.65***	19.73	21.38	20.83	16.26
Coconut shell charcoal	15.35***	17.46	19.01	20.35	18.40

[**Control mean shoot length: 9.63cm**]

Table 6: Showing mean shoot length of tomato plants grown in various concentrations over a period of 40 days. ** denotes *p*-value less than 0.005 and *** denotes p-value less than 0.0005. Apart from crab shell all the other shell powders significantly increased the shoot length.

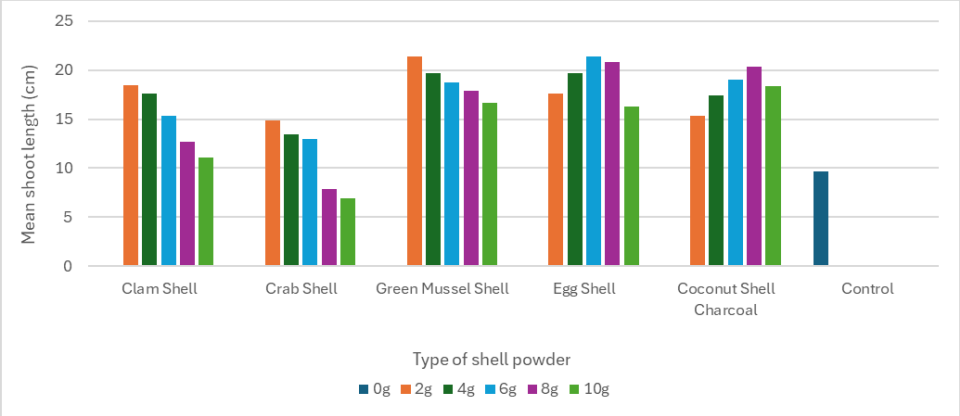

Figure 10: Showing mean shoot length of Tomato plants grown in various concentrations over a period of 40 days.

Figure 11: Showing growth of tomato plants in 20 days.

The present study focused on the effect of various shell powder in increasing the germination of tomato seeds and shoot length. Some aquatic animals and eggs of the birds contains shell mainly to protect the soft nature of the body and the egg yolk respectively (Zhang et al., 2018). Shells are the waste product generated form these food products and the disposal of these waste is the major issue faced by home makers, small to large food processor companies. These waste materials can be used as organic fertilizers. In the present study, soil amendments were prepared using various shells including eggshell, crab shell, clam shell, green mussel shell were used as soil amendments to check the effect in germination of seeds and shoot length. Apart from the animal shell, coconut shell was also evaluated for the effect in increasing the germination of seeds and increasing the shoot length of the plant.

Eggshells are the waste product that has no economic value, meaning that, after the cooking process the removed eggshells are usually thrown away (Lertchunhakiat, Krittiya, et.al., 2016). Without knowing the nutrient content, eggshells are getting wasted. Eggshells contain about 2.2 gms of calcium in the form of calcium carbonate and 0.3% gms of phosphorus and magnesium with the minimal amount of sodium, potassium, zinc, manganese, iron, and copper. The high calcium content has the potential to be used as organic fertilizer for

plants (Butcher & Miles, 2015). Therefore, to reduce the amount of waste that can cause environmental pollution, an environmentally friendly organic fertilizer needs to be produced with natural ingredients, namely eggshells.

In the present study, the highest seed germination percentage of 100% was observed in 8g clam shell powder setup followed by 2g of coconut shell charcoal setup with 87%. The least germination percentage was observed in 4g setup of eggshell (maybe an outlier) followed by 27% of crab shell. The highest seed germination percentage of 100% observed in 8g clam shell powder might be due to presence of calcium carbonate because clam shell contains 77.034% of calcium carbonate. Previous study showed clam shell increases the germination of explant with increased shoot numbers (Ewane et al., 2019). For plants, mineral calcium is a vital nutrient, and it is mostly found in cell organelles including the endoplasmic reticulum and cell wall. This mineral is crucial for controlling the growth and development of plants (Chao et al., 2021). The least Calcium carbonate was found in coconut shell powder of 71.405% but when applied with 2g of coconut shell charcoal powder it gave a second highest germination percentage of 87% which might be due to the presence of various other components in the shell powder.

In the present study the effect of mean shoot length was observed using various shell powder. Clam shell powder had the highest mean shoot length at the concentration of 2 gm in the pot which was 18.48cm followed by green mussel shell 21.43 at the concentration of 2 gms. Increased concentration of shell powders decreases the mean shoot length but at 6gms the mean length of the shoot was significantly increased. When compared to clam shell, green mussel shell increased the shoot length significantly. Green mussel shell can increase the alkalinity of the soil and increase the soil fertility (Kisnawati et al., 2023). Thus, thus the study showed that the shell waste can be used as a soil amendment in increasing the growth of the plant by changing the pH of the soil and increasing the nutrient of the soil.

CONCLUSION:

As population increases, there is more demand for food production which has resulted in the indiscriminate use of chemical fertilisers to boost the yield of crops. This has resulted in various environmental issues such as soil degradation, eutrophication etc and has significant impact on biodiversity and ecosystem functioning. Therefore, use of organic fertiliser is encouraged to improve the crop production and thereby maintaining sustainable agriculture will be the need of the hour. The study concludes that food waste products such as crab shell powder, green mussel shell powder, clam shell powder, egg shell powder and coconut shell charcoal powder can act as soil amendment as well as an organic fertilizer to improve soil fertility when applied in lower concentrations because they contain various minerals that are essential nutrient for plant growth especially calcium. Shells are thus a major by-product, which should not become a waste, but rather a new raw material to be used to the best of their potential.

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