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Postharvest Quality and Productivity Improvement of Eggplant (*Solanum melongena L.*): Through Calcium Application Derived from Organic and Inorganic Source

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ABSTRACT— Postharvest quality of eggplant fruit diminishes rapidly after harvest especially if placed or displayed in inappropriate storages which is very evident in local markets of Samar. Calcium as major element needed by plants, it is reported to promote postharvest qualities of vegetables. A study was arranged in Randomized Complete Block Design (RCBD) to evaluate the effects of calcium derived from organic source (eggshell and "kohol" shell) and chemical fertilizer (calcium nitrate) on the postharvest qualities, horticultural characteristics and yield components of eggplant. Results showed that yield components and growth parameters in terms of height was enhanced applied with different source of calcium (calcium nitrate, eggshell, "kohol" shell) compared to control while the days to flower initiation, number of flowers and leaves were not significantly different. Postharvest qualities of fruits were improved in plants treated with calcium. Weight loss was minimal in plants applied with calcium nitrate. Carbon dioxide percentage and respiration rate were also minimal in plants applied with calcium wherein calcium nitrate had the least CO^2 production (0.37 to 0.13 %) and respiration rate (0.0275 to 0.0148 %). Visual quality appearance and firmness of fruits was prolonged with application of calcium both organic and inorganic compared. Results suggests that calcium application could improve the growth, yield, postharvest qualities of fruits and eventually the storage/shelf life.

KEYWORDS: Eggplant, calcium amendments, postharvest quality, prolonged storage, yield.

1. INTRODUCTION

The quality of harvested crops depends not only on postharvest practices in terms of extending or maintaining the marketability but it also depends on the pre-harvest handling management. Postharvest losses can be minimized through the application of technologies that can improve the crops and prevent various factors that cause damages. Biological factors (pathological, entomological, animal); physiological factors (physiological disorders, nutritional imbalances, maturity); environmental/cultural factors (e.g. climate, weather, soils, water relations, light intensity); mechanical damage; extraneous matter (growing medium, vegetable matter, chemical residues); and genetic variation and aberrations [7], hormonal or combinations of these are some factors in which can modulate the harvested crops. The agricultural sectors in most of the localities in Samar is faced with challenges in utilizing technologies for producing high quality crops; significant manipulation of light, nutrients, water and plants is possible only when plant responses to environmental conditions are understood by local farmers. Genetic engineering and modification can produce plants with desirable characteristics, but society is not yet convinced that benefits gained outweigh risks [5] and can be a limiting factor to persuade farmers and consumers to adopt. However, plant's postharvest quality, marketability and palatability can also be improved in terms of nutritional aspects and proper pre-harvest handling or practices. Various studies revealed that the application of calcium as fertilizer or in combination of other fertilizer exhibited a positive effect on the prevention of some postharvest diseases [1], whilst calcium can minimize the reduction of fruit firmness during ripening, increases the resistance to bacterial wilt caused by (Ralstonia solanacearum) [12], and postharvest calcium application can also have a positive storage effect in calcium deficient harvested fruits [3]. Calcium is an important element to plant cell walls and membranes. High soil calcium are associated with other postharvest benefits, including increased vitamin C content, extended storage life, delayed ripening, increased firmness, and reduced respiration and ethylene production [10]. Thus, in this study the effects and benefits of calcium application on the quality of eggplant are being evaluated. Comparison of commercial fertilizers and other organic based sources of calcium applied as pre-harvest treatments are investigated.

2. Material and Methods

2.1 Seedling Preparation to Planting of Grown Seedlings

Eggplant seeds (Morena var.) were sowed in seedling tray with 1-1 ratio of garden soil and vermi compost. Grown seedlings were transplanted after 4 weeks for desirable characteristics and to attained high survival percentage of seedlings. Conventional practices of care and maintenance were applied using the recommended rates of nutrient solution (complete fertilizer 2 grams/ liter of water) to prevent toxicity. The seedlings were hardened in 2 days before transplanting to minimized mortality. Polyethylene pots with a 7 litre capacity were used. It was filled with medium 1-1-1 ratio of garden soil, carbonized rice hull, and vermicompost. The garden soil was sterilized using the simplified methods of heating practiced by the local farmers. Grown seedlings were planted in each pot individually in an open field. Water, pest management and weeding were done if necessary.

2.2 Experimental Design and Treatments

The study was set up in a Randomized Complete Block Design (RCBD) single factor replicated three (3) times with 100 sample plants. T0 (control)- Conventional methods of growing eggplant wherein sampled plants were fertilized with urea (60-0-0) at seedling to vegetative stage and complete (14-14-14) from vegetative to reproductive stage following recommended rates. Treatment 1- Control plus the addition of commercial fertilizer that contains calcium (calcium nitrate). Treatment 2- Control plus the addition of powdered eggshells incorporated within soil medium. Treatment 3- dried powdered golden snails shell incorporated within soil medium. The treatments were applied on the experimental plants 5 days after transplanting to allow recovery of the sampled plants and the succeeding application of treatments were made following the recommended application interval practiced by local farmers.

2.3 Horticultural Characteristics Evaluation

The plant height was measured from the ground base to the tip of the highest shoot until at the period were the sampled plants bears first recognizable fruit. The number of flowers and leaves were counted in the period of two weeks. The days to flower initiation was recorded by counting the days from transplanting until it initiates flower or floral opening regardless with the size or shape.

2.4 Harvesting and Fruit Sampling

Eggplants were harvested at physiological maturity either at15-35 days after floral expansion (anthesis) or 75-90 days after transplanting. Marketable fruits with desirable morphological appearance were used as samples subjected to postharvest quality evaluation.

2.5 Yield components

The number of fruits per plant was counted within the period of two weeks then the weight of each fruit was measured in grams. The fruit length was measured in cm by the use of tape measure and the diameter in mm by vernier caliper.

2.6 Post Harvest Quality Evaluation

Weight loss was measured by subtracting the newly weight to initial weight in every other 2 days until the 5th session of weighing. Digital weighing scale was used in measurements.

Fruit firmness was evaluated by the feel method rating.
1 to 1.5 (Firm and Hard)
1.6 to 2.5 (1-10% surface softening)
2.6 to 3.5 (11-30% surface softening)
3.6 to 4 (31-50% surface softening)

The CO^2 percentage and rate was measured by the used of gas analyzer and computation with the given equation below:

$$\text{Respiration rate} = \frac{C1-C0}{100} \times V \times \frac{1}{(t)(W)} \times 1.83$$

C1= % CO2 after a time interval
C2= %CO2 at zero
V= Head space
ml= Vol. of respiration jar-vol. of commodity
t= time interval (hour)
W=weight of commodity

The visual quality rating (VQR) was evaluated using the ranking below:
9- excellent, field fresh, no defect
7- good, minor defects
5- fair defect, moderate limit of marketability
3- poor defect serious limit of edibility
1- non edible under normal condition

3. Results and Discussion

3.1 Horticultural Characteristics of Eggplant

Plant height was significantly different at early weeks from 1st to 3rd week after application of different calcium sources and at the 4th to 5th week it showed no significant difference (Figure 1). Eggplant showed a visible response to calcium at the initial vegetative stage and were less reactive on the phase towards reproductive stage. The use of calcium nitrate stimulates the increase in height compared to eggshell and "kohol" Shell. Similar trends on the study of [6] where the application of 6% of commercial calcium showed significant increase in plant height as compared to 0% of calcium. There was no significant difference on the application of eggshell and "kohol" Shell and was comparable to control. This might due to the characteristic of organic source of nutrients or fertilizer as slow release during decomposition [11] or mineralization occurs in longer days in contrast to chemical fertilizer in which immediate nutrient is available [4].

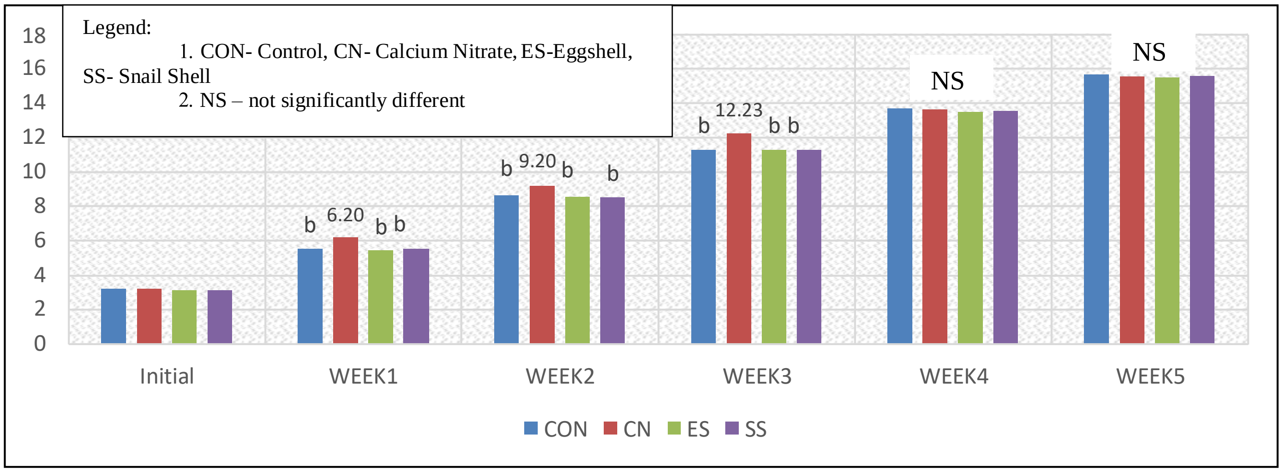

Figure 1. Plant Height (inch) as affected by different calcium sources.

The application of different source of calcium as fertilizer to eggplant did not affect the number of flowers, leaves as well as the days to produce flowers (Table 1) wherein no significant differences among treatments were observed. The result might due to the use of cultural practices of growing eggplant in which the sample plants were given with the same fertilizers (Urea and Complete 14-14-14), maintenance and management practiced by the farmers in the locality. Thus, the sample plants were still capable of growing to its optimum as evident that the control was comparable to different calcium sources.

Table 1. Days to flower initiation after transplanting, number of flowers and leaves of eggplant as affected by different calcium sources as pre-harvest treatments.

Treatments	Days to flower initiation after transplanting	In 2 weeks	
		No. of Flowers	**No. of Leaves**
T0-Control	24.93	14.67	23.37
T1-Calcium Nitrate	24.6	15.2	23.8
T2-Eggshell	24.73	14.83	24.23
T3- “Kohol” shell	24.8	14.73	24.13
CV (%)	1.75	4.22	3.58

Means with the same or without letter designation are not significantly different at 5% level of significance, (LSD)

The yield and its components were significantly different among treatments (Table 2). It showed that the number of fruits harvested applied with calcium either organic or inorganic were numerous compared to control. Similar results were observed in the study of [9] in which total fruit yield was increased in plants sprayed with calcium as compared with the control plants. The fruits were heavier in weight if treated with calcium nitrate and were less heavy if organic source were applied (eggshells and “kohol” Shells). Calcium nitrate also initiates the longest fruit length and widest fruit diameter as compared to control and organic source. In organic sources of calcium, there were no significant differences in terms of fruit weight, length and diameter observed.

Table 2. Yield components of eggplant as affected by different calcium sources as pre-harvest treatments

Treatments	No. of Fruits/Plant	Fruit Weight (g)	Fruit Length (cm)	Fruit Diameter (mm)
T0-Control	3.08 b	142.44 c	21.87 c	37.22 c
T1-Calcium Nitrate	4.28 a	177.67 a	26.10 a	44.07 a
T2-Eggshells	3.81 a	155.55 b	24.40 b	43.77 b
T3- “Kohol” Shell	3.67 ab	154.00 b	24.73 b	43.47 b
CV(%)	9.37	4.16	2.65	4.57

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3.2 Postharvest Quality Evaluation

The weight loss of eggplant fruits treated with calcium nitrate was slower compared to sample fruits without additional calcium fertilizer. Organic sources of calcium both eggshell and "kohol" Shell showed no significant difference in loss of weight. In first few days after harvest the loss of weight was gradual and on succeeding days after harvest the weight loss increases (Table 3.). The loss of weight was in accordance with the percent of carbon dioxide produced by the fruits (Table 4.) wherein the higher CO_2 production of commodity is accompanied by the increase in weight loss of commodity. The result showed that the calcium application contributed a significant effect in maintaining the quality of harvested eggplant. The use of different organic source showed no significant differences and fruits without additional calcium fertilizers degrade at lesser period of time.

Table 3. Weight loss (g) of eggplant in 5 weighing phase as affected by different calcium sources as pre-harvest treatments

	Weight Loss (g) in every other two days				
Treatments	**2 DAYS**	**4 DAYS**	**6 DAYS**	**8 DAYS**	**10 DAYS**
T0-Control	3.33 a	4.73 a	9.87 a	15.60 a	29.80 a
T1-Calcium Nitrate	1.67 c	2.53 b	7.33 c	13.20 c	24.00 c
T2-Eggshells	2.15 b	2.67 b	8.33 b	14.73 b	27.87 b
T3- "Kohol" Shell	2.24 b	2.53 b	8.20 b	14.53 b	27.93 b
CV (%)	16.76	15.16	4.31	2.56	2.37

Means with the same letter designation are not significantly different at 5% level of significance, (LSD

The respiration rate of eggplant was also different among treatments in which fruits applied with calcium nitrate has the lowest respiration rate compared to other treatments. Sampled fruits without calcium amendments has the highest respiration rate while between organic source (eggshell and "kohol" Shell) showed no significant difference. The results suggest that calcium has significant effects in respiration activity of harvested eggplant in which the lower or higher results of CO_2 percentage and the respiration rate accord with calcium application. It also showed that in both treatments the respiration rate and CO_2 percentage declines as the fruit undergoes softening to senescence.

Table 4. Carbon Dioxide percentage (%) of harvested eggplant as affected by different calcium sources as pre- harvest treatment.

Treatments	**RATE 1 (3 hours after harvest)**	**RATE 2 (3 days after harvest)**	**RATE 3 (6 days after harvest)**
T0-Control	1.27 a	0.73 a	0.53 a
T1-Calcium Nitrate	0.37 b	0.22 c	0.13 c
T2-Eggshells	0.52 b	0.35 b	0.23 bc
T3- "Kohol" Shell	0.42 b	0.34 bc	0.25 b
CV (%)	15.25	14.25	18.53

Means with the same letter designation are not significantly different at 5% level of significance, (LSD)

Table 5. Respiration rate (%) of harvested eggplant as affected by different calcium sources as pre-harvest treatment.

Treatments	RATE 1 (3 hours after harvest)	RATE 2 (3 days after harvest)	RATE 3 (6 days after harvest)

T0-Control	0.1218 a	0.0706 a	0.0507 a
T1-Calcium Nitrate	0.0275 c	0.0183 c	0.0148 c
T2-Eggshells	0.0562 b	0.0375 b	0.0249 bc
T3- “Kohol” Shell	0.0532 b	0.0372 b	0.0274 b
CV (%)	16.01	15.66	19.31

Means with the same letter designation are not significantly different at 5% level of significance, (LSD)

The visual appearance of harvested eggplant showed minimal defects on the 8th day onwards but were still marketable and palatable. Harvested eggplants without calcium amendments, the quality of fruit in terms of appearance declines at short period of time and on the 6th day it showed that fair defects were already visible compared to calcium treated plants. On the 12th day harvested eggplants without calcium application appeared to be non- edible under normal condition (Table 6 and Figure 2). This result could be attributed to its lesser reduction of firmness, low respiration rate and less CO_2 production percentage in calcium treated plants.

Table 6. Visual Quality Rating (VQR) of harvested eggplant as affected by different calcium sources as pre-harvest treatment.

Treatments	Rating in every other 2 days						
	INITIAL	2nd Day	4th Day	6th Day	8th Day	10th Day	12th Day
T0-Control	9	7.72	6.62 b	5.00 c	4.07 b	3.07 c	1.07 b
T1-Calcium Nitrate	9	7.89	7.80 a	7.33 a	6.1 a	5.67 a	4.50 a
T2-Eggshells	9	7.87	7.76 a	6.78 b	5.43 a	4.57 b	3.33 b
T3- “Kohol” Shell	9	7.76	7.71 a	6.78 b	5.39 a	4.62 b	3.67 b
CV (%)	constant	2.54	1.09	3.16	7.09	9.94	20.23

Means with the same or without letter designation are not significantly different at 5% level of significance, (LSD)

In terms of firmness, the application of calcium as fertilizer improves the hardness and exhibited less shrinkage compared to control plant samples. Calcium application also retains the firmness of the fruit (Table 7) at longer period of time. Similar results obtained in the study of [8] that calcium treated eggplant fruits skin firmness and flesh was higher when compared to the control plant's fruits skin and flesh firmness. The improved firmness of eggplant due to calcium can be attributed to its efficacy against degradative enzymatic activities responsible for softening [2].

Table 7. Firmness of harvested eggplant as affected by different calcium sources as pre-harvest treatment.

	Days after harvest					
Treatments	2 DAYS	4 DAYS	6 DAYS	8 DAYS	10 DAYS	12 DAYS
T0-Control	2.17 a	3.50 a	3.75 a	3.85 a	4.00 a	4.00 a
T1-Calcium Nitrate	1.00 c	1.32 c	2.03 c	2.20 c	2.66 c	2.73 c
T2-Eggshells	1.52 b	2.42 b	2.58 b	2.67 b	3.28 b	3.72 b
T3- “Kohol” Shell	1.45 bc	2.42 b	2.58 b	2.70 b	3.28 b	3.77 b
CV (%)	15.65	5.77	6.17	4.32	2.05	1.5

Means with the same letter designation are not significantly different at 5% level of significance, (LSD)

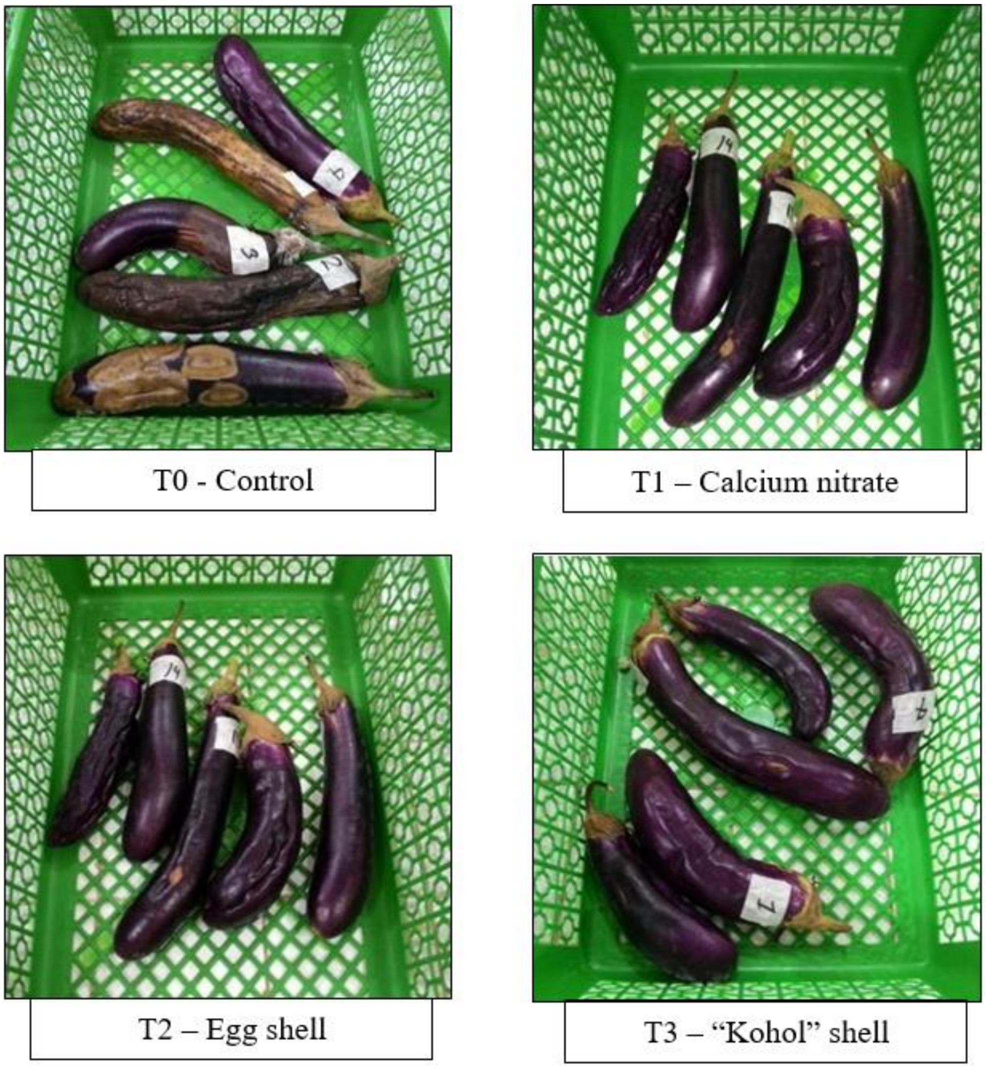

Figure 2. Visual appearance of sampled eggplants on the 12th day of observation

4. Conclusion

Based on the results of the study, pre-harvest application of different source of calcium either inorganic or organic can improve the growth (plant height), yield (number of fruits) and postharvest qualities (prolonged shelf life, minimized weight loss, delay reduction of fruit firmness and visual quality rating) of eggplant. Chemical fertilizer (calcium nitrate) improves most of the parameters compared to organic source of calcium (eggshell and "kohol" Shell).

5. Acknowledgement

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