Proceedings of the 11th International Conference on Agriculture, Vol. 9, Issue 1, 2024, pp. 57-68

ISSN 2682-7018 online
DOI: https://doi.org/10.17501/26827018.2024.9105

THE INFLUENCE OF CALCIUM NITRATE AT DIFFERENT CONCENRATIONS ON PLANT GROWTH, YIELD AND FRUIT STORABILITY OF CUCUMBER "Cucumis sativus L." VAR. PIPINITO

Ravelo SM

College of Agriculture, Agusan del Sur State College of Agriculture and Technology, Bunawan, Agusan del Sur, Philippines

Abstract: Cucumber plants var. pipinito (*Cucumis sativus L.*) were grown in an open field and treated with different levels of calcium nitrate (75g, 150g, and 225g) to assess its performance with different characters for pre-harvest study. The objective of the study was to evaluate the effects of calcium nitrate at different concentrations on plant growth, yield and fruit storability at room temperature storage. The fruits from the same grown plants were then used for the postharvest losses assessment using different level of calcium nitrate (9.36g/2L, 18.75g/2L, 28.125g/2L) by dipping the fruits for 20 minutes on the prepared solution. Calcium nitrate application at 150g (T3) resulted to higher yield and has positive effect in most of characters studied. Also, treatment of calcium nitrate on fruits after harvest was beneficial in controlling fruit weight loss and maintaining TSS at higher level during storage. Postharvest application of calcium nitrate to cucumber fruits in this study extend storage shelf life, decrease fresh weight loss, decrease leakage of electrolytes and ascorbic acid content and ethylene production. Moreover, the storability and quality of cucumber fruits was prolonged due to the positive effect of calcium nitrate application.

Keywords: *Cucumis sativus L.*, Pepinito, Calcium Nitrate

Introduction

Cucumber (*Cucumis sativus* L.) is one of the vegetable crops which are often grown under covers. Plant growth regulators play an important role in increasing growth and yield of many horticultural crops (Davies, 1995). Many synthetic growth regulators such as gibberellins and auxins have been used to increase fruit set, vegetative growth and total fruits and seeds yield (Sinha and Mandal, 2000; Chaudhaiy et al, 2006; Akter et al, 2007; El-al and Faten, 2009).

Relation between nutrition status of plant and fruit yield has been studied in different cucumber cultivars under different growth conditions (Jilani et al., 2009; Gomez et al., 2003). Calcium is involved in cell membrane stability and permeability in addition to its involvement in cell division and elongation (Marschner, 1995; Ashraf, 2004). It was found that the increase of calcium concentration in cucumber growth medium alleviated the reduction of growth and photosynthetic rate due to salinity. Application of supplemental Ca decreased the Na content in plant parts and increased the K content (Dabuxilatu, 2005). Akinci and Simsek (2004) reported that root and shoot growth of cucumber embryos was improved by supplemental potassium nitrate at 10 mM and calcium nitrate at 20 mM. Geetha and Shelly (2002) found that treating seeds of highly susceptible cucumber cultivars with 90 mM of CaCl improved plant resistance to diseases. In addition, calcium ions were found to increase the osmoticants contents in green gram seedlings exposed to salinity (Misra and Gupta, 2006).

*Corresponding Author's Email: *sarahravelo072208@gmail.com

It is necessary to extend the shelf life and keeps at best quality of the fruits and vegetables during postharvest. In developing countries, losses of fruits and vegetables during post-harvest fluctuate between 20-50% (Okezie, 1998). Storage of cucumber fruits at 24°C compare to 10°C decreased storage life, fresh weight, ascorbic acid content and firmness (Homin and Kuenwwoo, 1999). Postharvest application of Calcium Nitrate to cucumber fruits stored at 20 or 13°C extend storage shelf life, decrease fresh weight loss, decrease leakage of electrolytes and ascorbic acid content and ethylene production from fruits (Kwon et at, 1999). Also, Khalifa et al. (2009) concluded that foliar spray with calcium chloride significantly increased yield and improved physical and chemical quality of Anna apple (Mains domestica cv. Borkh). The objective of this study was to evaluate the effects of calcium nitrate at different concentrations on plant growth, yield and fruit storability at room temperature storage.

Methodology

Experimental Design and Field Layout

The experiment was arranged in randomized complete block design (RCBD) with three (3) replications and with ten (10) samples in each replication.

The study was conducted to evaluate the effect of calcium nitrate fertilization on growth, yield and post-harvest losses of cucumber var. pipinito (Cucumis sativus L.). The planting distance was 0.5m between pots and 0.5m between rows. An alleyway was provided between replication to facilitate farm operation and management as well as data gathering. The treatments are the following:

T1 – Control

T2 – 75 grams (g) Calcium Nitrate ($Ca(NO_3)_2$

T3 – 150g $Ca(NO_3)_2$

T4 –225 g ($Ca(NO_3)_2$

Cultural Management

Soil mixture consisting of carbonized rice hull, garden soil, and vermicompost in a ratio of 6:2:1 was used in the experiment. Pipinito seeds was sown in a seedling tray using vermicompost as a medium. The seedling tray was then placed in a screen house for protection against environmental conditions.

The seedlings was transplanted ten (10) days after sowing in the 8x8x16cm polyethylene bags filled with mixed soil media. For basal fertilizer application, 10g/pot of complete (14-14-14) fertilizer was applied at planting. Drenching was done weekly by mixing 16 liters of water per week. One hundred fifty (150) ml of the solution was applied per plant.

Watering was done early in the morning when the soil is dry. The plants was monitored for any pest invasion and appropriate measure will be taken using IPM.

Postharvest Processing and Treatment

Selected fruit of uniform size, color, and physical integrity from the control treatment was washed in running water. This was used for the separate postharvest experiment. The fruits were washed with distilled water to remove any dirt and dip for twenty minutes in the following concentrations of Calcium Nitrate:

T1 - control

T2 - 9.36g/2Liters (L) $Ca(NO_3)_2$ solution

T3 - 18.75g/2L $Ca(NO_3)_2$ solution

T4 - 28.125g/2L $Ca(NO_3)_2$ solution

The study was carried out in completely randomized design. Each treatment included fifteen fruits and were replicated three times. Five (5) fruits per replication were studied and stored at room temperature for almost 3 weeks. A sample of randomly selected 5 fruits at day one and weekly intervals was collected from each replication in a treatment during the storage period. All experiments was carried out in triplicate.

Data Gathered

Number of leaves per plant- The number of leaves per plant were counted and recorded their means by taken five randomly plants from each sub-plot and calculated their average.

Plant height (cm)-The data pertaining to plant height was recorded in centimeters from transplanting and termination by measuring the plant from soil surface to the tip of the main stem by taking five randomly plants from each of sub-plot and after their means will be calculated.

Days from Transplanting to Harvesting-This were determined by counting the days from transplanting to harvesting.

Fruit Size (cm^3)-At least five fruits was randomly taken from each treatment and their volume were recorded with the displacement of water (ml) as 1ml = $1cm^3$ and calculated their average.

Fruit weight (g)-The average weight of the individual fruit were measured with the help of electronic balance in grams by weighting five randomly taken pepinito fruits from each treatment and the means were calculated.

Number of Marketable and Non-marketable Fruits-This were determined by counting the marketable fruits and non-marketable fruits harvested that are free from any damage either caused by insect or mechanical damage.

Weight of Marketable and Non-marketable Fruits (g)-This was determined by weighing the marketable and non- marketable harvested fruits.

Percentage of Survival (%)-This was determined by counting the number of dead plants per plot divided by the total number of plants in every plot times 100.

Yield (t ha^{-1})-All the pipinito fruit was weighed at each harvest and the total yield were calculated in tons per hectare.

Weight loss percentage-To evaluate weight loss, samples in 3 replicates of each treatments were used. The same samples were evaluated for weight loss each time at 4 days intervals until the end of experiment. Weight loss was determined by the following formula:

Weight loss (%) = [(A−B)/A] x 100

Where A indicates the fruit weight at the time of harvest and B indicates the fruit weight after storage intervals.

Firmness-The fruit firmness were recorded using the feel method. For this purpose, 5 fruits per replication from each treatment were taken and graded using the following rating:

1-Firm and hard;

2-1-10% surface softening;

3-11-130% surface softening;

4- 31-50% surface softening; and

5-Extensive softening/ripe soft.

12. Visual Quality Rating (VQR)

This was determined using the following rating:

9 – Excellent, field fresh, no defect;

7 – Good, Minor defect;

5 – Fair, defect moderate, limit of marketability;

3 – Poor, defect serious, limit of edibility; and

1 – Non-edible, under usual condition

(Fan, X. and Mattheis J.P. 2011)

Marketable (Shelf life)-The shelf life of the pipinito fruit was calculated by counting the days required for them to attain the last stage acceptable for consumer or up to the stage when they remained still acceptable for marketing.

Vitamin C-This were determined by using the 2, 6- Dichloroindophenol Titrimetric method and the results reported as mg/100g of Pipinito fruit.

Fruit juice pH-Pipinito fruits from each treatment was randomly taken and juice were extracted with juice extractor and the pH was recorded with the use of electronic pH meter.

Total Soluble Solid-Total soluble solids (TSS) was measured by the method described by Dong et al., (2001). TSS in Brix% was measured with the use of hand refractometer. Seyoum, et al., 2009

Titratable acidity-The juice of Pipinito fruit (50g) were extracted using the juice extractor. Two drops of phenolphthalein were added in this juice. A 5 ml aliquot were taken in a titration flask and titrated against 0.1N NaOH till permanent light pink color appeared. Percent acidity was calculated by using the following formula:

%TA = (ml NaOH used) (Normality of NaOH) (Equivalent wt. of cetric acid) x 100

(vol. of aliquot taken)

Headspace gas composition -CO_2 composition of pipinito fruits were determined using a CO_2 gas analyzer. Gas analysis was done by inserting a needle attached to the gas analyzer through a rubber septum on the jar. Gas sampling was done before opening the package to remove the fruits.

Data Analysis

For the pre harvest experiment it was laid out in Randomized Complete Block Design with 3 replications and Completely Randomized Design with four treatments and three replications for postharvest experiment. The data were analyzed by Analysis of Variance using Statistical Tool for Agricultural Research (STAR) software developed by International Rice Research Institute (IRRI) and treatment means will be separated by the Least Significant Difference (LSD) at a 0.05% level of significance.

Results and Discussion

Growth characteristics

Table 1 shows the growth characteristics of cucumber var. pipinito in terms of plant height, number of leaves and number of days from transplanting to last harvest. The growth characteristics were not significantly affected by the different concentration of calcium nitrate applied to the crop. Numerically, plants treated with 150g Calcium Nitrate (T3) produces higher standing crop (186.63 cm) at seven weeks after transplanting followed by T1 (186.60 cm), T4 (185.14cm) and the T2 (184.60cm). The increased in plant height was attributed to increased cell division and cell elongation induced by the interaction of calcium nitrate and auxin. Auxin cause an increase in plant height due to stimulation of cell extension and softens the cell wall by increasing plasticity (Davies, 1995). Moreover, due to the presence of nitrogen in calcium nitrate which enhanced the growth attributes as nitrogen is said to be a key component in the plant structure made up of amino acids, serving as the building blocks of protein and needed in growth and development of plants (Leghari et al., 2016).

In terms of the number of leaves, the plants treated with 150g of calcium nitrate (T3) produces more leaves (22.97) at seven weeks after transplanting but not comparable to other treated plants. The number of days from transplanting up to the last harvest recorded up to 50.67 days.

Table 1. Growth characteristics of Cucumber var.pipinito (Cucumis sativus L.) as influenced by different level of Calcium Nitrate application on its growth, yield and post-harvest losses

Treatment	Days from trans-planting to last harvest	Plant Height (cm)			Number of leaves		
		Weeks after Transplanting (WAT)					
		2 WAT	4WAT	7WAT	2 WAT	4WAT	7WAT
T1-Control	50.67	7.44	98.93	186.60	4.04	11.47	23.50
T2- 75g $Ca(NO_3)_2$	50.67	7.50	92.40	184.60	4.02	11.73	22.30
T3-150g $Ca(NO_3)_2$	50.67	8.33	92.03	186.63	4.63	11.93	22.97
T4- 225 g $Ca(NO_3)_2$	50.67	7.16	94.60	185.14	3.84	11.99	22.10
CV(%)	1.14	11.29	4.10	2.65	9.35	6.94	3.83

Yield Characteristics

The yield performance of the cucumber var. pepinito is shown in table 2 in terms of percent survival, the total yield at the end of harvest, the fruit size, weight and the number of fruits produced. Plants treated with 75g Calcium nitrate (T2) had 100% survival but not significantly different compared to other treatments (T1, T3 and T4) which has 96.67 % survival.

On the yield of plant those treated with 150g calcium nitrate (T3) produces higher yield (1,1957kg) compared to other treated plants, while the control had the lowest yield. Likewise, the fruit size is much bigger in plants treated with 150g (T3) calcium nitrate followed by T4 (149.67), T1 (146.60) and T2 (134.13).

On the other hand, the plants that were treated with 150g (T3) calcium nitrate had the most number of marketable fruits produced (77) and much heavier in weight (8559.33g) as recorded until the last harvest. The untreated plants produces the lowest marketable fruit weight compared to the treated ones. The plants that were treated with 150 g calcium nitrate is statistically comparable to plants treated with 225g calcium nitrate.

Table 2. Yield characteristics of Cucumber var.pipinito (Cucumis sativus L.) as influenced by different level of Calcium Nitrate application on its growth, yield and post-harvest losses

Treatments	% survival	Yield	Fruit	Fruit weight (g)	Number of fruits

			Size (ml)	M	NM	M	NM
T1 (Control)	96.67	8365.67 b	146.60	5137.33 b	3228.33	45.67 b	30.00
T2 (75g Ca(NO3)2)	100.00	10371.67 ab	134.13	5937.00 b	3258.00	58.67 ab	27.00
T3 (150g Ca(NO3)2)	96.67	11957.00 a	151.53	8559.33 a	2802.00	77.00 a	28.67
T4 (225 g Ca(NO3)2)	96.67	9334.33 b	149.67	6576.67 ab	2309.33	62.00 ab	28.67
CV (%)	5.13	12.47*	6.53	17.18*	26.38	17.10*	18.23

Means in column with the same letter are not significantly different at 5% level LSD

** Significant   M-marketable   NM-Non marketable*

Calcium is a critical part of the cell wall that produces strong structural rigidity by cross linking acidic residues (Hepler, 2005). Cell wall strength and thickness are increased by calcium addition. In rapid plant growth, the structural rigidity of stems is strongly coupled to calcium availability (Eastwood, 2002). The importance of Ca as a component of Chlorophyll molecule as well as the role of Ca in cell division and pollen grain germination may illustrate the effect of the tested macronutrients in improving the yield a fruit physical character (Morsey et al., 2008). Calcium is regulating the activity of enzymes and photosynthesis (Mignani et al., 2005).

Moreover, the mobilization of minerals and photo-assimilates from other regions of the plant to growing fruits, as well as engagement in cell growth and division, which resulted in increased fruit weight in treated plants. Fruit set, cell division, and cell growth are all aided by auxin. Both of these developmental processes use calcium as a secondary messenger and impact calcium distribution patterns. The application of calcium nitrate resulted in enhanced fruit weight by maintaining a lower level of auxins in various areas of the fruit, which aided in fruit growth (Zaman et al., 2019 as cited by Pandya et al., 2023).

Physical and Chemical Analysis

Table 3. Weight loss and marketable shelf life of Cucumber var.pipinito (Cucumis sativus L.) as influenced by different level of Calcium Nitrate application

Treatment	Untreated pipinito fruits					Treated pipinito fruits w/ calcium nitrate					
	% Weight loss Days Interval				Marketable Shelf Life (DFS)	% Weight loss Days Interval					Marketable Shelf Life (DFS)
	4DAS	8DAS	12DAS	16DAS		4DAS	8DAS	12DAS	16DAS	20DAS	
T1 – Control	7.41	11.73	14.72	15.33	13.63	3.00	5.80b	7.55	9.79	11.06b	22.67
T2 - 75g; 9.36g/2L $(CaNO_3)_2$	7.18	11.04	14.07	15.10	16.30	4.33	7.57a	9.50	12.56	13.25a	22.33
T3 - 150g; 18.75g/2L $(CaNO_3)_2$	8.17	12.25	15.44	16.50	15.55	4.39	7.82a	9.81	12.17	13.65a	21.67
T4 - 225 g; 28.12g/2L $(CaNO_3)_2$	7.27	11.05	14.60	15.60	15.73	4.21	7.29a	9.12	11.27	12.90a	23.50
CV(%)	14.51	10.36	25.33	25.08	9.38	14.72	7.39**	10.45	10.94	6.15**	5.45

Means in column with the same letter are not significantly different at 5% level LSD
***Highly significant*

DAS-Days after storage

Table 3 shows the percent weight loss and marketable shelf life both in treated and untreated fruits of cucumber var. pipinito. The percent weight loss of untreated fruits were not significantly affected by the different level of calcium nitrate at four days interval until termination but the percent weight loss of fruits treated with calcium nitrate after harvest significantly differed among treatments at eight days interval until termination. Numerically, fruits treated with 18.75g/2L (T3) of calcium nitrate after harvest had higher percentage weight loss of 7.82 and 13.65 at eight days and 20 days after storage respectively.

On the other hand, the marketable shelf life did not significantly differ among treatments and is longer on fruits that were treated with calcium nitrate ranging 22 to 23 days after storage as compared to those fruits that remain untreated with calcium ranging 13 to 16 days only after storage. The result was so evident in this study that calcium nitrate application will help prolong the shelf life of the produce if applied after harvest to improve storability and quality of fruits and vegetables like cucumber var. pipinito.

The decrease in shelf life may have reflected degradation and solubilization of cell wall polyuronides and hemicelluloses associated with fruit softening (Huber, 1984).

Table 4. Visual quality rating and firmness of Cucumber var.pipinito (Cucumis sativus L.) as influenced by different level of Calcium Nitrate application

Treatment	Untreated iepinito fruits								Treated pipinito fruits w/ calcium nitrate							
	VQR				Firmness				VQR				Firmness			
	Days After Storage (DAS)								Days After Storage (DAS)							
	4	**8**	**12**	**16**	**4**	**8**	**12**	**16**	**6**	**12**	**18**	**24**	**6**	**12**	**18**	**24**
T1	6.77	7.00	5.77	5.00	2.07	2.33	2.39ab	2.00	8.60	7.80	6.47	5.53	1.20	1.93	2.27ab	2.80
T2	7.00	7.00	6.17	5.17	2.00	2.00	2.67a	2.00	8.60	7.13	6.33	5.40	1.07	1.53	1.93b	2.67
T3	7.00	6.83	5.83	5.17	2.00	2.00	2.17b	2.17	8.73	7.00	6.33	5.40	1.20	1.73	2.47a	2.67
T4	7.00	6.87	5.33	5.00	2.00	2.00	2.25b	2.00	8.87	7.27	6.20	5.67	1.27	1.60	2.53a	2.73
CV(%)	2.91	2.67	9.83	4.02	2.86	13.86	7.12*	7.07	1.88	9.36	6.32	2.97	13.80	13.15	9.05*	3.68

Means in column with the same letter are not significantly different at 5% level LSD
**Significant*

DAS-Days after storage

The Visual Quality Rating (VQR) and firmness were presented in table 4. Both parameters were gathered using the rating mostly used in the laboratories. The firmness were performed using the feel method. Among untreated pepinito fruits T2 significantly differ to other treatments in terms of firmness but was comparable to T3 and T4. Moreover, among treated fruits T4 (2.53) was significantly firm at 18 days after storage but was comparable also to T3. The result might be attributed due to the effect of calcium nitrate application to fruits after harvest to improve the quality in terms of firmness and prolong the shelf life of cucumber var. pepinito. However, the effect was not so significant with VQR because the limit marketability of cucumber for consumers depend on the firmness of the fruit and not on the color. Mitra (1997) found that fertilization with nitrogen and calcium play an important role in reducing fruit cracking phenomenon, improved fruit growth and create a state of water balance between epicarp and inside fruit tissues, as well as maintains cell walls elasticity and firmness.

Postharvest losses of cucumber in terms of TA, TSS, pH, Vit.C and CO2 are presented in tables 5 and 6 for both untreated and treated fruits. For the untreated fruits (Table 5), the total acid and soluble solids significantly differ among treatments but was comparable to the control which has higher TA and TSS compared to the plants with calcium nitrate application. While for the treated fruits (Table 6), the total soluble acids has significant effect among treatments. Fruits that were treated with 9.36g/2L (T2) of calcium nitrate has higher TSS compared to other treatments (T3, T4 and T1). The pH and Vit.C content of the fruits for both treated and untreated has no significant effect among treatments. Numerically, T3 (150g calcium nitrate) has high pH (6.7) for the untreated fruits while T4 (28.125g/2L calcium nitrate) has high pH (6.6) for the treated fruits during initial and final reading compared to other treatments. Salamat et al. (2013) stated that, as fruit maturity progresses and sugar content increases, total soluble solids will also increase. The increase in soluble contents may be due to hydrolysis of sucrose to invert sugars as reported by Bhatti (1975). Changes in TSS at the storage period are due to respiration, inversion of insoluble compounds to soluble forms and moisture loss by evaporation (Miaruddin et al., 2011). Application of calcium nitrate showed significant effect on TSS it might be due to greater chlorophyll leads in the leaves. Greater chlorophyll and nutrient levels in the leaves may have resulted in increase metabolite synthesis and translocation to the fruits, resulting in higher total soluble solids content in the fruits (Kumar et al., 2021). In addition, calcium composites lower titratable acidity by increasing sturdy nobs in cell walls. The creation of fractious connections between the carboxyl groups of polyuronide chains located in the middle lamella of the cell wall might explain this action (Young-sik et al., 2022).

On the other hand, the percent CO2 has significant effect among treatments for both treated and untreated fruits of cucumber var. pepinito. The final reading of both is high in T3 (0.28 and 0.25 %) but was comparable to T2 and T4. The result was attributed to respiration activity which happen from the time of harvest until the last stage of storage.

Table 5. Postharvest losses of untreated Cucumber var.pipinito (Cucumis sativus L.) as influenced by different level of Calcium Nitrate application

Treatments	Untreated fruits									
	TA		TSS		pH		Vit. C		% CO2	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
T1 (Control)	0.1700a	0.1900	4.93a	5.20	6.70	6.83	0.8067	0.7107	0.0200b	0.2500a
T2 (75g Calcium Nitrate)	0.0667b	0.1500	4.00b	4.40	6.63	6.73	0.7467	0.6500	0.0600a	0.2200ab
T3 (150g Calcium Nitrate)	0.0933b	0.1700	4.53ab	4.40	6.77	6.73	0.8267	0.5746	0.0200b	0.2800a
T4 (225 g Calcium Nitrate)	0.0767b	0.1333	3.87	4.33	6.73	6.80	0.8300	0.8667	0.0467a	0.1800b
CV(%)	35.46*	26.80	8.32*	10.76	1.49	0.73	47.86	35.59	31.49*	14.90*

Means in column with the same letter are not significantly different at 5% level LSD
**Significant*

Table 6. Postharvest losses of treated Cucumber var.pepinito (Cucumis sativus L.) as influenced by different level of Calcium Nitrate application

Treatments	Treated fruits									
	TA		TSS		pH		Vit. C		% CO2	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
T1 (Control)	0.0800	0.1133	4.67b	4.03b	6.63	5.90	0.8067	0.92	0.0233b	0.2233b
T2 (9.36g/2L Calcium Nitrate)	0.1033	0.1300	5.87a	4.40a	6.57	5.77	0.7467	0.99	0.0233b	0.2133b
T3 (18.75g/2L Calcium Nitrate)	0.0733	0.1233	5.67a	4.13b	6.60	5.70	0.8267	1.21	0.0433a	0.2533a
T4 (28.125g/2L Calcium Nitrate)	0.0833	0.1600	5.67a	4.00b	6.63	5.90	0.8300	1.05	0.0133b	0.2233b
CV(%)	25.64	47.53	4.95**	3.12**	0.7566	1.79	47.86	15.14	22.35**	2.53**

Means in column with the same letter are not significantly different at 5% level LSD
***Highly Significant*

Conclusion

In conclusion based on the result from the study conducted, the application of calcium nitrate at 150g (T3) resulted to higher yield and has positive effect in most of characters studied. Also, treatment of calcium nitrate on fruits after harvest was beneficial in controlling fruit weight loss and maintaining TSS at higher level during storage. Moreover, the storability and quality of cucumber fruits was prolonged due to the positive effect of calcium nitrate application. A follow up study on storability of cucumber under different storage temperature must be done to further justify the effect of calcium nitrate on postharvest losses of cucumber.

References

Akinci, I.E. and M. Simsek (2004). Ameliorative effect of potassium and calcium on the salinity stress in embryo culture of cucumber. *J. Biological Sci., 4*:361-365.

Akter, A., Ali E., M.MZ. Islam, Karim, R., Razzaque, A.H. (2007). Effect of GA3 on growth and yield of mustard. *Int. J. Sustain. Crop Prod., 2*:16-20

Ashraf, M. (2004). Some important physiological selection criteria for salt tolerance in plants. *Flora, 199*:361-376.

Bhatti, M.S. (1975). Studies on some ripening changes in mangoes during storage. (M.Sc. Thesis), Dept. Food technol., University of Agriculture, Faisalabad, Pakistan, pp. 32-48.

Chaudhary, B.R., Sharma, M.D., Shakya, S.M., Gautan, D.M. (2006). Effect of plant regulators on growth, yield and quality of chili (*Capsicum annum* L.) at Pampur, Chitwan. *J. Inst.Agric.Sci., 27*:65-68.

Dabuxilatu, I.M. (2005). Interactive effect of salinity and supplemental calcium application on growth and ionic concentration of soybean and cucumber plants. *Soil Sci. Plant Nutr., 51*:549-555.

Davies, P.J. (1995). Plant hormones: Physiology, Biochemistry and Molecular Biology. Dordrecht, Kluwer, pp:319.

Eastwood (2000). Calcium's role in plant nutrition. Fluid J. Winter, 1-3

El-al, A.and Faten S. (2009). Effect of urea and some organic acids on plant growth, fruit yield and its quality of sweet pepper (*Capsicum annum*). Res. J. Agric. Biol.Sci., 5:372-379.

Geetha, H.M. and Shelly, H.S. (2002). Induction of resistance in pearl millet against downy mildew disease caused by *Sclerospora graminicola* using benzothiadizole, calcium chloride and hydrogen peroxide: A comparative evaluation. Crop. Prot., 21:601-610.

Gomez, M.D., BAille, A., Gonzales, M.M., and Mercader, J.M. (2003). Dry matter partitioning of green house cucumber crops as affected by fruit load. *Acta. Hort., 614:*573-578.

Hepler, P.K. (2005). Calcium: a central regulator of plant growth and development. Plant cell 17, 2142-2155.

Homin, K. and Kuenwoo, P. (1999). Effect of packaging methods and handling temp. on postharvest quality during storage of cucumber. *J.Kor. Soc.Sci, 4*0:9-12.

Huber, D.J. (1984). Strawberry fruit softening: the potential role of polyuronides and hemicelluloses. *J. Food Sci. 49*, 130-1315.

Jilani, M.S., Bakar, A., Waseen, K. and Kiran, M. (2009). Effect of different levels of NPK on the growth and yield of cucumber under the plastic tunnel. *J. Agric. Soc. Sci., 5*:99-101.

Khalifa, K.R.M., Hafez, O.M. and Abd-el-hair, H. (2009). Influence of foliar spraying with boron and calcium on productivity, fruit quality, nutritional status and controlling of blossom end rot disease of anna apple trees. *World. J. Agric. Sci., 5*:237-249.

Kumar, D., Kumar, T., Joshi, V. and Goud C. (2021). Effect of plant nutrients on quality and shelf life of papaya (Carica papaya L.) Cv. Taiwan Red Lady. *Journal of Pharmacognosy and Phytochemistry, 10*(1), 1912-1916.

Kwon, H.R., Park, K.N, and Kang, H.M. (1999). Effect of postharvest heat treatment and calcium application on the storability of cucumber. *J. Kor. Soc. Sci. Hort.Sci. 40*:183-187.

Leghari, S., Wahocho, N., Laghari, G., Afeezlaghari, A. Musatafabhabhan, G. Hussaintalpur, K. and Lashari, A. (2016(. Role of nitrogen for plant growth and development: A review. Advances in Environmental Biology, *10(*9), 209-219.

Marschener, M. (1995). Mineral nutrition of higher plants. 2nd Edn., Academic Press, London and New York, ISBN-10:0124735436, pp.200-255

Miaruddin, M., Chowdhury, M.G.F., Rahman, M.M., Khan. (2001). Effect of ripening chemicals on postharvest quality of tomato. Research report (2010-2011) on postharvest tech.of crops. Postharvest technology Division. BARI., Gazipur-1701, pp. 29-85

Mignani, I., Greve, I.C., Ben-arie, Stotz, H.U., Li, C. (1995). The effect of GA3 and divalent cations on aspects pf pectin metabolism and tissue softening in ripening tomato pericarp. *Physiol, Plant 93* (1), 108-115.

Misra, N. and Gupta, A.K. (2006). Interactive effects of sodium and calcium on proline metabolism in salt tolerant green gram cultivar. Am. J. Plant Physiol., 1:1-12.

Mitra, S.K. (1997). Postharvest physiology and storage of tropical and subtropical fruits. CAB.INT., Nadia, West Bengal, India, pp.85-122.

Morsy, M.H., Abdelaal, A.M.K. (2008). Attempts to find post-harvest treatment required for obtaining marketable fruits and its effect on storage life of manfalouty pomegranate. Minia. *J. Agric. Res. Dev. 23* (1), 263-293.

Okezie, B.O. (1998). World food security: The role of post-harvest technology. *Food technol., 52*:64-69.

Pandya, Y.H., Bakshi, M., Shalma, A. (2023). .Effect of calcium nitrate and calcium carbonate on plant growth, fruit quality and yield of Papaya Cv. Red lady. International Journal of Agriculture and Animal Production. ISSN 2799-0907. Vol.03, No.03.https://doi.org/10.55529/ijaap.33.25.32

Pooviah, B.W. (1997). Role of calcium in ripening and senescence. Commun. Soil Sci. *Plant Anal. 10*, 80-88.

Sinha, B.B. and Mandal, G. (2000). Effect of Plant Growth Regulators on growth and sex expression in cucumber (*Cucumis sativus* L.). J. Applied Biol., 10:32-36.

Young-sik, P., Je-chang, L., Joo-hyun, K., Jeong, H., and Jae-yun, H. (2022). Effect of calcium nitrate treatment on reduction of berry shattering in ‘Cheongsoo’grape cultivars. Notulae Scientia Biologicae, 14(1), 11158-11158.