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# Effect of Cucumber Variety, $(NH_4)_2SO_4$ and NPK on the Physical Quality and Total Soluble Sugars (TSS)

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## Abstract:

The experiment was conducted in the experimental field of the Horticulture Department, University for Development Studies (UDS), Nyankpala campus with the aim of determining the response of three cucumber cultivars (Marketer, Nandini, Pointset) to the application of sulphate of ammonia as top dressing with respect to fruit yield, and shelf life. It was a 3 x 3 x 2 factorial arranged in a randomized complete block design with three replications. Data was collected on total fruit yield, shelf life and percentage fruit decay in storage. Their effect on the varieties differed significantly to a varying degree. The factors, however, had no significant impact and caused no difference in the fruit yield and fruit weight. 15:15:15 NPK effect on the cucumbers caused a high decay incidence when applied alone or in combination with $(NH_4)_2SO_4$. Therefore, the application rate may be revised or reduced to experiment if decay incidence would decline in storage. Further studies may extensively be carried out to note if varying the rate of NPK would impact positively on the shelf life of cucumber. $(NH_4)_2SO_4$ effect increased weight loss in cucumbers hence, better storage techniques should be considered by controlling high temperatures. Complete fertilizer; 15:15:15 NPK and $(NH_4)_2SO_4$ had a positive impact on protein and fibre. Hence, their application is recommended for increasing protein and fibre level in cucumbers.

## Keywords:

Total Soluble Sugars (TSS), Shelflife, Decay, Weight Loss, Dry Matter

## 1. Introduction

Commercial vegetable production is gaining prominence in Ghana due to the production of crops with export potential , as well as public education from health experts and nutritionist on the need to consume more vegetable to avoid diseases including cancer, hypertension, coronary diseases, diabetes, hepatitis B and anaemia [1, 2-3]. Ghana is currently in an advantageous position in meeting the demand for crops such as okra, pepper, tomato and cucumber among other forms of vegetables required for the European market [4]. Cucumber requires a warm climate. The optimum temperature for growth is about 30 °C and the optimum night temperature

18-21 °C. In the tropics, elevations up to 1700 m appear to be suitable for cucumber cultivation. A lot of light tends to increase the number of staminate (male) flowers. Cucumbers need a fair amount of water but they cannot stand water logging. High relative humidity encourages downy mildew. The soil should preferably be fertile and well-drained, with a pH of 6.5-7.5 [5].

Cucumber plant requires 16 essential elements for growth and development. Carbon, hydrogen and oxygen are derived from the atmosphere and soil water. The remaining 13 essential elements including nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, zinc, manganese, copper, boron, molybdenum, and chlorine are supplied either from minerals and soil organic matter through the application of organic or inorganic fertilizer. Each type of plant is unique and has an optimum nutrient range as well as a minimum requirement level. Below this minimum level, plants start to show nutrient deficiency symptoms. Excessive nutrient uptake can also cause poor growth because of toxicity. Therefore, the proper amount of application and the placement of nutrients are important in cucumber production [6]. The population growth rate for people living in the cities of West Africa would rise from 40 % as was in 1990 to 60 % in 2020 [7]. This rise in population calls for increase in food production.

Exotic vegetables such as lettuce, cabbage and cucumber have increasingly become common in many Ghanaian diets [8]. There is also an increase in demand from the export market. The low yield of cucumber in the country is attributed to poor soil fertility and cultivation of low yielding cultivars by local farmers. The situation is worsened by high postharvest losses. The improvement of cucumber production practices is an important way that one can use to improve the yield potential of this vegetable. One way this can be done is by the application of sulphate of ammonia as top dressing to cucumber fields. Also, the fruit yield of cucumber in the country can be improved by cultivating high yielding varieties. There is the need to determine whether the application of NPK types (15:15:15 and 23:10:5) can improve the quality and shelf-life of cucumber fruits with three different varieties. The main objective of the study was to determine the effect of NPK types (15:15:15 and 23:10:5) on three different cucumber cultivars. The specific objective was to determine the effect of NPK types (15:15:15 and 23:10:5) on; Cucumber fruit yield, Nutritional quality of cucumber fruits, and Shelf - life of cucumber fruits in storage.

### *1.1. Varieties and Cultivars of Cucumbers and their Characteristics*

Vast diversity of cucumber varieties can be used for growing. Normally farmers select the most disease resistant varieties and those varieties with good yield and good quality properties. Generally, two types of cucumbers are grown: Slicing which is 15 to 20 cm long and 3cm or more in diameter when mature and Pickling which is 8 to 10 cm long and up to 2.5 cm in diameter at maturity. Both types can be used for pickling if picked when small [9].

A study explained that cultivar selection is one of the most important decisions made during crop production process [10]. Selection of cultivars adapted to local growing conditions and seed quality are significant production factors that deserve careful planning and consideration. Desirable traits required for local cultivars include high productivity, high fruit crispness and firmness, and resistance to watermelon mosaic virus; zucchini mosaic virus, cucumber mosaic virus, powdery mildew and angular leaf spot.

There are different cultivars of cucumber in Ghana but the most commonly grown are Ashley, Nagano, Marketer and Poinsett. These are monoecious cultivars that bear separate male and female flowers on the same plant but genetically the female flowers are far less than the male compared to the gynoecious cultivars which produce only female flowers. Ghanaian farmers are therefore, faced with problem of low yield since the female flowers which produce fruit are few on the plant [8].

#### *1.1.1. Shelf-Life*

Shelf-life is a period of time which starts from harvesting and extends up to the start of rotting of fruits [11]. Fruit shelf-life during storage is an important feature from producers and distributers point of view, allowing the determination of risks arising from the loss of commercial value of fresh fruit in trade turnover [12]. Storage of cucumber is 10 to 14 days at 25-30°C with 95% humidity. Cucumbers are subject to chilling injury if stored at lower temperatures. Cucumbers do not produce much ethylene themselves but they are sensitive to it. Cucumbers should not be stored or shipped with produce that generates ethylene [13]. Fruits harvested from chilli pepper plants applied with high nitrogen fertilizer (9g NPK+10g S/A) took the shortest time in storage to start rotting [14].

#### *1.1.2. Fruit Decay*

Researchers stated that, the main causes of postharvest losses are decay and external damages incurred during harvesting and handling [15]. Mechanical injuries such as bruises, cuts, punctures etc. that occur during harvesting and handling are predominant causes for decay because they provide infection courts for decay pathogens. Once it initiates, a decay pathogen often can engulf the rest of the fruits [16]. Cultivar types can influence fruit decay [17]. The degree of fruit rot is increased by more severe wounding, by storing in the dark instead of in the light and by higher nitrogen fertilization of the crop. It is very likely that the amount and composition of available nutrients for fungus growth determine the degree of rotting of the fruits. External fruit rot can be best controlled by reducing the chances of wounding in the pre- and post-harvest period [18].

#### *1.1.3. Fruit Weight Loss/ Water Loss*

Water loss is the main cause of fruit softening and shrivelling. Many fruits, vegetables and flowers become shrivelled after losing only small percentage of their original weight due to water loss [19]. Cucumber fruits are very sensitive to postharvest storage conditions and their quality is highly reduced after harvesting because of loss of water, shrivelling and yellowing [20]. Storage temperature is an important factor in maintaining quality and shelf-life of fresh produce. And weight loss increases with prolonged storage and overall weight loss is greater at 27 °C [20].

#### *1.1.4. Dry Matter*

Researchers observed that respiration result in loss of fruit dry matter and weight. They indicated that dry matter content changes with ripening and fruit colour which is the main indicator of maturity [21]. A study reported that tomato fruit quality for fresh consumption is determined by firmness and dry matter. Fruits with high dry matter content have low pericarp thickness and low water content [22]. Dry matter content reduces with time as the continuation of living processes within the produce uses up the food reserves [23].

### *1.1.5. Moisture Content*

USDA Nutrient Database indicated that cucumber fruits contain about 95.23 % water [24]. A scientific study stated that the moisture content of postharvest products can have a pronounce effect on the rate of respiration [25]. Respiration and metabolic processes decrease moisture content of the fruits leading to reduction in shelf-life and quality. The rate of absorption of moisture is nearly directly proportional to that of transpiration, a phenomenon of water loss [26].

### *1.1.6. Total Soluble Solid (TSS)*

Total soluble solids and dry matter are known to increase fruit quality, which fits in well with consumers' demand for high quality produce [27, 28]. Soluble solids content varies between cultivars and between stages of ripeness. For instance, in some hybrids of banana, soluble solids content increase to a peak and then decline (the drop in total soluble solids may be due to the conversion of sugar in pulp to alcohol), while in others, total soluble solids continue to increase with ripening [29]. Studies have associated high consumer acceptance with high soluble solids concentration in many commodities [30]. A study revealed that increment of soluble solids is caused by biosynthesis processes or degradation of polysaccharides during maturity [31]. Total soluble solids content increases with ripening but may increase or decrease during storage as carbohydrates are utilized during fruit respiration and may increase due to the action of sucrose-phosphate syntheses which is activated by the ripening process itself, ethylene and by cool storage [32].

### *1.2. Effect of NPK Fertilizers On Cucumber Production*

Fertilizer is a major part of the crop expenses for cucumber production and it is critical for successful crop yields and high fruit quality. Fertilizer requirement of cucumber are quite high due to its high yielding potential per unit area and time. Accordingly, mineral nutrition with suitable level of nitrogen, phosphorus, and potassium had a key role for improving the growth and fruit yield of cucumber, as well as influence the cucumber plant's ability to withstand negative effect from pest, water, temperature, and other stresses. N, along with P and K, are classified as primary macronutrient, which are needed in relatively large quantities and are often deficient in crops not receiving fertilizer application [33]. Cucumbers respond well to inorganic fertilizers. A general recommendation of 700 kg/ha of an NPK mixture, followed by nitrogen fertilizer every 2-3 weeks until the fruits form is ideal. However, it is best to base fertilizer gifts on a soil analysis before planting. Micronutrients are essential for good development; shortages can result in strong deficiency symptoms in plants and fruits, leading to low quality yields [34].

The intervention of chemical fertilizers has allowed farmers to raise soil productivity higher than could be attained by relying on natural recycling process. Many studies on various crops have shown significant advantages of applying inorganic fertilizers [35]. However, the excessive use of NPK fertilizers create pollution of agro-ecosystem through contamination of the underground water with nitrate ($NO_3$) and increasing $NO_3$ accumulation in food chain causing hazardous effects, as well as destroy micro-organisms and friendly insects, making the crop disposed to disease and reduce soil fertility [36, 37]. Moreover, most NPK fertilizers are highly soluble and the crop uses about 50 % of the amount applied especially in the sandy soil and the rest lost by lixiviation, or goes into the atmosphere [38].

Another study indicated that extensive use of inorganic fertilizer had a depressing effect on the yield of watermelon as it causes reduction in the number of fruits, delay in fruit set and maturity [39]. Studies conducted by researchers showed that cucumber fields which receive high NPK (15-15-15) fertilizer rates (greater than 2500 kg/ha) resulted in a high deficiency of magnesium causing fruits to develop light green colour and thus reduced the quality of fruits [10]. A study observed that heavy doses of nitrogen fertilizer like ammonium sulphate (20.5 % nitrogen, 23.4 % sulphur) or ammonium nitrate (32.5 % Nitrogen) can cause toxicity in water melon (Citrus vulgaris) and Musk melon (Cucurbita melovarreticulatus) and as a result, retarded the growth of the plant. He, however, had recommended 220-1100 kg/ha of NPK (15-15-15) as suitable for good productive soils that has pH of 5.5 to 6.5 [1].

## 2. Materials and Methods

### *2.1. Experimental Site*

The experiment was conducted at the Horticulture Department field of the University for Development Studies (UDS) Nyankpala Campus. The field lies in the Guinea Savannah Agro-ecological zone, located at longitude 0° 95’ N, latitude 09° 25’ S and altitude 183 m [40]. The experiment was carried out in the dry season between November, 2015 and February, 2016. The area has a unimodal rainfall of 1,034 mm distributed fairly from April to late November with a uniform mean monthly temperature of 22°C during the rainy season and maximum of 34°C during the dry season. Relative humidity is at its maximum during the rainy season with a monthly value of 80 % which declines to 53 % during the dry season as minimum monthly value [41].

### *2.2. Soil and Vegetation*

The soil at the study area is of the Nyankpala series. It is also known as plinthic Archrosol. The soil is an Alfisol based on the USDA system of classification. It is brown, moderately drained and sandy-loam, free from concretion, very shallow with a hardpan underneath the top few centimetres. The soil is a type of Savannah Ochrosol developed from Voltarian Sandstones [42]. A composite soil sample was collected at depth 0-30cm before ploughing (planting) to determine the soil pH, soil nutrient status and soil particle size (soil texture).

### *2.3. Cropping History of Site*

The site had previously been cropped and the vegetation has been greatly modified by human activities such as continuous cropping. Some of the cultivated vegetables included cucumber (*Cucumis sativus*), tomato (*Lycopersicon esculentum*), sweet pepper (*Capsicum annum*), okra (*Abelmoschus esculentus*) and amaranthus (*Amaranthus spp*).

### *2.4. Research Design*

The experiment was 3*3*2 factorial arranged in a Randomized Complete Block Design (RCBD) with two (2) replications.The factors considered were:

a. Three cucumber varieties (Nandini, Pointset and Marketer)
b. Two NPK types and a control (15:15:15, 23:10:5 and 0:0:0)

**Seed Sowing**

Direct sowing of seeds was done on 17th November, 2015. Two seeds were planted per hill to a depth of about 2 cm. Dry grass was used to mulch the field and watering was done immediately.

**Cultural Practices**

Hoeing, hand picking of weeds and regular watering were done. Thinning began when plants had attained 3-4 true leaves and by the end of two weeks after seeds germinated, each stand was left with one plant. 'Dimeking', with active ingredient dimethoate 400 g/L EC, an inorganic insecticide was used to control insect pests. The rate of the 'dimeking' was 12 ml/16L knapsack at seedling emergence, during flowering and at fruiting. There was no disease control measure since no incidence of disease was observed.

***Figure 1: Cultural Practices***

### *2.5 Fertilizer Application*

NPK (15:15:15 and 23:10:5) was applied seven days after seedling emergence at nine (9) g per plant. The method of application was side dressing. Four point five grams (4.5 g) of sulphate of ammonia per plant was applied at twenty-one (21) days after seedling emergence. The method of application was side dressing.

### *2.6 HARVESTING*

Harvesting was done regularly at three days' interval. The first harvesting was done Forty-five (45) days after sowing.

***Figure 2(a).*** *Harvesting.*

***Figure 2(b).*** *Harvesting.*

### *2.7. Sampling and Data Collection*

#### *2.7.1. Shelf-Life*

Five fruits were selected from each treatment, washed with salt solution and placed on a well cleaned table for observation under an average room temperature of 30°C. Record taking commenced on day of rotting, shrivelling and disease incidence until day all the fruits got rotten. The number of days rot was observed and the occurrence observed. The shelf-life was calculated as average number of days rot were observed.

***Figure 3.*** *Experimental set-up for shelf life determination.*

### *2.7.2. Decay (in storage)*

Rot, shrivelled and disease incidence were used to determine decay. Once any of these factors was observed or seen the fruits were considered decayed. Decay was then expressed as a percentage of the total initial fruit number (Parker and Maalekuu, 2013).

### *2.7.3. Cucumber Fruit Water Loss per Day*

The amount of water lost by a fruit per day was determined by taking the initial weight of five (5) fruits. These fruits were weighed 7 days later and the total water loss by the fruits was found by calculating the difference of the two weights, after which the total water loss per fruit was calculated through the average. Fruit water loss per day was then determined by dividing the total water lost per fruit by the number of days the fruits were kept and it was measured in grams (g) using an electronic balance.

### *2.7.4. Mean Fruit Weight*

This was determined by dividing the weight of harvested fruits by the number of harvested fruits per treatment. It was measured in kilogram (kg).

### *2.7.5. Total Soluble Solids*

Total soluble solid was determined by using the refractometer procedure as reported by Emma and Theresa (2015). The refractometer prism surface was first cleaned with damp tissue and dried. Then fresh amount of cucumber juice (a couple of drops) was dropped onto the prism of the refractometer. Observation was made by looking through the eye piece while pointing the prism in the direction of good light (not directly at the sun). The light was well focused and took the readings of where the base of the blue colours sat on the scale and recorded the percentage total soluble solids (Brix) (Emma and Theresa, 2015).

### *2.8. Statistical Analysis*

All data collected were subjected to analysis of variance (ANOVA) using Statistix Student version. Differences between means were determined using the least significant difference (LSD) test at 1% level and the results were presented in figures and tables.

# 3. Results and Discussion

## *3.1. Effect of Cucumber Variety on the Physical Quality and TSS*

### *3.1.1. Shelf life*

There was no significant variation ($p>0.01$) in the shelf life of the cucumbers as regards to difference in the varieties.

### *3.1.2. Decay*

There was a significant variation ($p<0.01$) in the level of decay observed in the varieties of the cucumbers. Pointset suffered the highest level of decay (61.67%) as compared to Nandini (48.33%) and Marketer (43.33%).

### *3.1.3. Weight loss*

Weight loss in the variety of cucumbers varied significantly ($p<0.01$) with the highest (4.77 g) observed in Nandini, followed by Marketer (4.51 g) and then Pointset (4.43 g) daily in order of declining value.

### *3.1.4. Dry matter*

Significant variation ($p<0.01$) was seen in the dry matter of three cucumber varieties. Pointset had higher dry matter than Marketer and Nandini with 4.17, 4.11 and 3.84 percent respectively.

### *3.1.5. Total soluble sugars (TSS)*

TSS varied significantly ($p<0.01$) among the varieties of cucumber with 3.20, 3.17 and 3.07 ºBrix detected in Pointset, Nandini and Marketer respectively.

***Table 1.*** *The effect of varietal variation on the physical quality and TSS of cucumber.*

| Variety | Shelf life (days) | Decay (%) | Weight loss (g/day) | Dry matter (%) | TSS (ºBrix) |
|---|---|---|---|---|---|
| Marketer | 13.33 a | 43.33 c | 4.51 b | 4.11 b | 3.07 c |
| Nandini | 12.00 a | 48.33 b | 4.77 a | 3.84 c | 3.17 b |
| Pointset | 13.33 a | 61.67 a | 4.43 c | 4.17 a | 3.20 a |
| Lsd (%) | 1.44 | 1.02 | 0.08 | 0.02 | 0.02 |
| CV | 11.01 | 1.92 | 0.37 | 0.41 | 0.53 |

## *3.2. Effect of $(NH_4)_2SO_4$ on the Physical Qualities and TSS of Cucumber*

### *3.2.1. Shelf life*

There was a distinct variation ($p<0.01$) in the shelf life of cucumbers as result of $(NH4)_2SO_4$ treatment. Cucumber which received $(NH4)_2SO_4$ application had fruits of longer shelf life (13.33 days) as compared to the ones (11.78 days) without treatment.

### *3.2.2. Decay*

Level of fruit decay varied significantly ($p<0.01$) between cucumbers of, and without $(NH4)_2SO_4$. Low level of decay (47.78%) was observed in cucumbers which received $(NH4)_2SO_4$ treatment during growth as compared to the ones without (54.44%).

### 3.2.3. Weight loss

Higher (4.93 g) weight loss was observed in fruits of cucumbers that had $(NH4)_2SO_4$ application during growth as compared to the ones which did not had the treatment with 4.21 g weight loss daily. The difference in the mean was significant ($p<0.01$).

### 3.2.4. Dry matter

There was significant variation ($p<0.01$) in the dry matter of the cucumbers as regards to the impact of the $(NH4)_2SO_4$ application. Fruits of cucumbers subjected to the $(NH4)_2SO_4$ treatment had higher dry matter than the ones not treated with 4.06% and 4.02% respectively.

### 3.2.5. Total soluble sugars (TSS)

TSS of cucumber fruits was higher when $(NH4)_2SO_4$ was applied than when not applied with 3.22 and 3.07 ºBrix. The difference between the means was significant ($p<0.01$).

***Table 2.*** *The effect of $(NH_4)_2SO_4$ on physical qualities and TSS of cucumber.*

| SA Top-dresser | Shelf life (days) | Decay (%) | Weight loss (g/day) | Dry matter (%) | TSS (ºBrix) |
|---|---|---|---|---|---|
| No SA | 11.78 b | 54.44 a | 4.21 b | 4.02 b | 3.07 b |
| SA | 13.33 a | 47.78 b | 4.93 a | 4.06 a | 3.22 a |
| Lsd (1%) | 1.02 | 0.73 | 0.01 | 0.01 | 0.01 |
| CV | 11.01 | 1.92 | 0.37 | 0.41 | 0.53 |

**SA = Sulphate of Ammonia [(NH4)2SO4]*

## 3.3. Effect of NPK Levels on the Physical Qualities and TSS of cucumber

### 3.3.1. Shelf life

There was significant variation ($p<0.01$) in the shelf life of the cucumber fruits due to the NPK application of different level or composition. Cucumber grown without NPK had higher shelf life (13.67 days) than cucumbers which had NPK treatment of different kind (11.83 to 12.17 days).

### 3.3.2. Decay

A distinct variation ($p<0.01$) was observed in the cucumber fruits in regards to the decay due to effect of the NPK application. Decay was highest in cucumbers treated with 15:15:15 NPK with 60.00%. The lowest (45.00%) was observed in cucumbers grown without NPK application. The ones which received 23:10:05 NPK treatment had 48.33% decayed fruits.

### 3.3.3. Weight loss

Weight loss was significantly ($p<0.01$) influenced by the application of NPK of different level. Cucumbers grown without NPK application had the highest weight loss of 4.76g daily as compared to the ones with 15:15:15 or 23:10:05 NPK with 4.65g and 4.31g weight loss daily respectively.

### *3.3.4. Dry matter*

There was a significant variation ($p<0.01$) in the dry matter content due to the NPK application. The dry matter was highest (4.19%) when 23:10:05 NPK was applied. It was also lowest (3.95%) when 15:15:15 NPK was applied. Without NPK application, dry matter content was 3.98%.

### *3.3.5. Total soluble sugars (TSS)*

A significant variation ($p<0.01$) was also observed in the TSS of the cucumbers due to difference in the NPK application. 15:15:15 NPK influenced 3.32º Brix, the highest in cucumbers as compared to 3.12º Brix when 23:10:05 NPK was applied. Those not subjected to NPK treatment had 3.00º Brix, the least.

***Table 3:*** *The effect of NPK levels on the physical qualities and TSS of cucumber.*

| NPK Type | Shelf life (days) | Decay (%) | Weight loss (g/day) | Dry matter (%) | TSS (ºBrix) |
|---|---|---|---|---|---|
| No NPK | 13.67 a | 45.00 c | 4.76 a | 3.98 b | 3.00 c |
| 15:15:15 | 11.83 b | 60.00 a | 4.65 b | 3.95 c | 3.32 a |
| 23:10:05 | 12.17 b | 48.33 b | 4.31 c | 4.19 a | 3.12 b |
| Lsd (1%) | 1.44 | 1.02 | 0.02 | 0.02 | 0.02 |
| CV | 11.01 | 1.92 | 0.37 | 0.41 | 0.53 |

## *3.4. Combined Effect of Variety and (NH4)2SO4 on the Physical Qualities and TSS*

### *3.4.1. Shelf life*

No significant variation ($p>0.01$) was observed among the means as regards to the shelf life due to the interaction effect of the varieties and top-dresser ($(NH4)_2SO_4$) except between 14.33 and 11.33 or 11.67 days recorded for Marketer which had $(NH4)_2SO_4$ treatment, Pointset and Nandini of no $(NH4)_2SO_4$ application respectively.

### *3.4.2. Decay*

There was a distinct variation ($p<0.01$) in the level of decayed fruits of the cucumbers as result of the varietal and $(NH4)_2SO_4$ effect. In order of decreasing value, fruit decay was highest (63.33%) in Pointsett which had $(NH4)_2SO_4$ treatment during growth as well as 60.00% without the treatment. Nandini and Marketer without $(NH4)_2SO_4$ application had 53.33 and 50.00 percent decay but 43.33 and 36.67 percent respectively when $(NH4)_2SO_4$ was applied on them.

### *3.4.3. Weight loss*

The interaction of the varietal and $(NH4)_2SO_4$ also had a significant effect on the weight loss of the cucumbers. The means distinctively varied from one another. The highest (5.09 g/day) was observed in Nandimi variety when $(NH4)_2SO_4$ was applied while the least (4.02 g/day), was detected in Marketer with no $(NH4)_2SO_4$ application. The application of $(NH4)_2SO_4$ on Marketer and Pointset influenced 5.01 and 4.71 gram weight loss per day. Also, 4.45 and 4.15 gram loss in weight was recorded in Nandini and Pointset when no $(NH4)_2SO_4$ was applied.

### 3.4.4. Dry matter

Dry matter content in the cucumbers were significantly ($p<0.01$) affected by the interaction between the varietal and $(NH4)_2SO_4$ effect. Marketer had the highest dry matter content of 4.38% when $(NH4)_2SO_4$ was applied but its effect was not different from 4.37% noted in Pointset of no $(NH4)_2SO_4$ application. When $(NH4)_2SO_4$ was applied on Pointset, it had 3.96% dry matter. Nandini (3.85%) and Marketer (3.84%) had similar dry matter content of no difference without $(NH4)_2SO_4$ application. And when $(NH4)_2SO_4$ was applied to Nandini, the dry matter content was also 3.84%.

### 3.4.5. Total soluble sugars (TSS)

There were also significant variation ($p<0.01$) in the TSS of the cucumbers due to the interaction effect of the varieties and $(NH4)_2SO_4$. The means differed from one another. However, Marketer of and Nandini of no $(NH4)_2SO_4$ treatment had the same TSS value of 3.10 ºBrix, the third highest. The highest TSS (3.33 ºBrix) was noted in Pointset and followed by 3.23 ºBrix in Nandini when $(NH4)_2SO_4$ was applied. Pointset also had 3.07 ºBrix and Marketer, 3.03 ºBrix when no $(NH4)_2SO_4$ was applied.

***Table 4.*** *The interaction effect of variety and $(NH_4)_2SO_4$ on the physical qualities and TSS of cucumber.*

| Variety*SA Top-dresser | Shelf life (days) | Decay (%) | Weight loss (g/day) | Dry matter (%) | TSS (ºBrix) |
|---|---|---|---|---|---|
| Marketer*No SA | 12.33 ab | 50.00 d | 4.02 f | 3.84 c | 3.03 e |
| Marketer*SA | 14.33 a | 36.67 f | 5.01 b | 4.38 a | 3.10 c |
| Nandini*No SA | 11.67 b | 53.33 c | 4.45 d | 3.85 c | 3.10 c |
| Nandini*SA | 12.33 ab | 43.33 e | 5.09 a | 3.84 c | 3.23 b |
| Pointset*No SA | 11.33 b | 60.00 b | 4.15 e | 4.37 a | 3.07 d |
| Pointset*SA | 13.33 ab | 63.33 a | 4.71 c | 3.96 b | 3.33 a |
| Lsd (1%) | 2.38 | 1.69 | 0.03 | 0.03 | 0.03 |
| CV | 11.01 | 1.92 | 0.37 | 0.41 | 0.53 |

## 3.5. Combined Effect of Variety and NPK on Physical Qualities and TSS of Cucumber

### 3.5.1. Shelf life

Except between 14.50 and 11.00 days, no significant difference ($p>0.01$) was noted in the means of the shelf life due to effect of the interaction between the variety and NPK type. Marketer had the longest shelf life when no NPK was applied. The shortest shelf life was however observed in Nandini when 15:15:15 NPK was applied. And both treatments samples did not differ from the rest as regards to their effect.

### 3.5.2 Decay

There was significant difference ($p<0.01$) in the means of treatment samples due to the interaction effect of variety and NPK. Also, the interaction effect could influence same decay level. Decay was highest (70.00%) when 15:15:15 NPK was applied on Pointset but lowest (40.00%), in Marketer and Nandini when no NPK was applied or in Marketer when 23:10:05 NPK was applied. 60.00% and 55.00% decay was recorded in Pointset when 23:10:05 or no NPK was applied. When 15:15:15 and 23:10:05 NPK were applied separately on Marketer and Nandini, fruit decay were 50.00% and 45.00% respectively.

### *3.5.3. Weight loss*

Significant difference (p<0.01) was seen in the mean weight loss of the samples due to the interaction effect of the variety and NPK application. The highest weight loss, 4.91g per day was detected in Nandini which had no NPK application. Its effect did not differ from 4.87% g per day in Marketer of no NPK treatment. Both however varied from the rest of the means. The least weight loss (4.05 g/day) was observed in Pointset which had been treated with 23:10:05 NPK. The result also showed, Nandini and Pointset cucumbers had 4.80 and 4.76 grams of weight loss per day when they received 15:15:15 NPK application, then 4.61 g loss of weight in Nandini when 23:10:05 was applied. With no treatment, Pointset suffered 4.49 g weight loss daily higher than 4.40 and 4.27 grams weight loss per day in Marketer when 15:15:15 and 23:10:05 NPK were separately applied in turn.

### *3.5.4. Dry matter*

There was significant variation (p<0.01) in the dry matter content of the cucumbers due to the interaction effect of varieties and NPK type. Dry matter content was highest and lowest in Marketer (4.57%) and Nandini (3.55%) when no NPK was applied. 4.52, 4.19 and 3.86 percent dry matter were observed in Pointset, Marketer and Nandini in turn when 23:10:05 NPK was applied. The dry matter level 3.86% was same as 3.84% of Pointset which had no NPK treatment. Also, both 4.14% and 4.13% showed no difference but varied from 3.59% dry matter in Pointset, Nandini and Marketer in turn when treated with 15:15:15 NPK.

### *3.5.5. Total soluble sugars (TSS)*

The results showed TSS values varied distinctly (p<0.01) due to the interaction effect of the varieties and NPK type. Also, it was observed that when either 23:10:05 or 15:15:15 NPK were separately applied on Nandini variety, the TSS value (3.25 ºBrix) was same just as the level found in Pointset when no NPK was applied. The amount was lower than 3.50 ºBrix noted in Marketer when 15:15:15 NPK was applied but higher than 3.25 and 3.20 ºBrix in Pointset when subjected to 15:15:15 and 23:10:05 NPK treatment in turn, and then 3.00 ºBrix in Nandini of no NPK treatment. Marketer had 2.95 ºBrix when 23:10:05 NPK was applied and 2.75 ºBrix, the least with no NPK application during growth.

***Table 5.*** *The interaction effect of variety and NPK types on the physical qualities of cucumber.*

| Variety*NPK Type | Shelf life (days) | Decay (%) | Weight loss (g/day) | Dry matter (%) | TSS (ºBrix) |
|---|---|---|---|---|---|
| Marketer*No NPK | 14.50 a | 40.00 f | 4.87 a | 4.57 a | 2.75 g |
| Marketer*15:15:15 | 13.00 ab | 50.00 d | 4.40 f | 3.59 f | 3.50 a |
| Marketer*23:10:05 | 12.50 ab | 40.00 f | 4.27 g | 4.19 c | 2.95 f |
| Nandini*No NPK | 13.50 ab | 40.00 f | 4.91 a | 3.55 g | 3.00 e |
| Nandini*15:15:15 | 11.00 b | 60.00 b | 4.80 b | 4.13 d | 3.25 b |
| Nandini*23:10:05 | 11.50 ab | 45.00 e | 4.61 d | 3.86 e | 3.25 b |
| Pointset*No NPK | 13.00 ab | 55.00 c | 4.49 e | 3.84 e | 3.25 b |
| Pointset*15:15:15 | 11.50 ab | 70.00 a | 4.76 c | 4.14 d | 3.20 c |
| Pointset*23:10:05 | 12.50 ab | 60.00 b | 4.05 h | 4.52 b | 3.15 d |
| Lsd (1%) | 3.13 | 2.28 | 0.04 | 0.04 | 0.04 |
| CV | 11.01 | 1.92 | 0.37 | 0.41 | 0.53 |

### *3.6. Combined Effect of (NH4)2SO4 and NPK on the Physical Qualities and TSS of Cucumber*

#### *3.6.1. Shelf life*

The interaction effect of NPK and $(NH4)_2SO_4$ application had a significant ($p<0.01$) impact on the shelf life of cucumbers in storage. However, there were similarity in some of the means as regards to their effect. Longer shelf life (13.67 days) was observed when none of the fertilizers or only $(NH4)_2SO_4$ was applied. And no difference was seen when cucumbers of 13.67 days shelf life was compared to those of 13.00 or 13.33 days as result of the impact of NPK and $(NH4)_2SO_4$ application. When 23:10:05 or 15:15:15 NPK was solely applied, the cucumbers had 11.00 or 10.67 days of shelf life in turn for which the latter was the least.

#### *3.6.2 Decay*

Decay varied significantly ($p<0.01$) as result of interaction effect of the NPK and $(NH4)_2SO_4$. The application of only $(NH4)_2SO_4$ or in combination with 23:10:05 NPK as a top-dresser had same impact on level of decay in the cucumbers. The effect influenced the lowest level of decay (43.33%) observed. Cucumbers which received 15:15:15 NPK without a top-dresser suffered the highest level of decay (63.33%). When the cucumbers were subjected to both 15:15:15 NPK and $(NH4)_2SO_4$, 56.67% decay was noted, then 53.33% when only 23:10:05 NPK was applied and 46.67% with no fertilizer applied.

#### *3.6.3. Weight loss*

Weight loss was significantly ($p<0.01$) affected by the combined effect of NPK and $(NH4)_2SO_4$ application. Weight loss in cucumber was highest (5.17g/day) and lowest (3.97 g/day) when $(NH4)_2SO_4$ and 23:10:05 NPK were separately applied. When no fertilizer was applied, weight loss per day was 4.34 g. Its effect was not different from 4.32 g weight loss seen when only 15:15:15 NPK was applied. Also, when 15:15:15 and 23:10:05 NPK were applied separately on the cucumbers and then top-dressed with $(NH4)_2SO_4$, 4.98 and 4.65 grams loss in weight were observed respectively.

#### *3.6.4. Dry matter*

Dry matter content as influenced by the interaction effect of NPK and $(NH4)_2SO_4$ varied significantly except between 3.90% and 3.89% when 23:10:05 and 15:15:15 NPK were applied separately without $(NH4)_2SO_4$. Dry matter content in cucumber was highest (4.47%) when 23:10:05 NPK and $(NH4)_2SO_4$ were applied but lowest (3.70%), when only $(NH4)_2SO_4$ was applied. 4.27% dry matter was observed in cucumber when no fertilizer was applied. The application of both 15:15:15 NPK and $(NH4)_2SO_4$ influenced 4.01% dry matter in cucumber.

#### *3.6.5. Total soluble sugars (TSS)*

TSS values varied significantly ($p<0.01$) among the cucumbers as result of interaction between types of NPK and $(NH4)_2SO_4$. TSS was highest (3.37 ºBrix) when 23:10:05 NPK and $(NH4)_2SO_4$ were applied but lowest (2.87 ºBrix), when only 23:10:05 NPK was applied. When 15:15:15 NPK and $(NH4)_2SO_4$ were applied, TSS was 3.33 ºBrix but 3.30 ºBrix, when the fore was only applied. When no fertilizer was applied, 3.03 ºBrix was noted in the cucumbers. Also, 2.97 ºBrix was noted in cucumbers that had only $(NH4)_2SO_4$ application.

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***Table 6.*** *The interaction effect of $(NH4)_2SO_4$ and NPK on the physical qualities and TSS of cucumber.*

| SA Top-dresser*NPK Type | Shelf life (days) | Decay (%) | Weight loss (g/day) | Dry matter (%) | TSS (ºBrix) |
|---|---|---|---|---|---|
| No SA*No NPK | 13.67 a | 46.67 d | 4.34 d | 4.27 b | 3.03 d |
| No SA*15:15:15 | 10.67 c | 63.33 a | 4.32 d | 3.89 d | 3.30 c |
| No SA*23:10:05 | 11.00 bc | 53.33 c | 3.97 e | 3.90 d | 2.87 f |
| SA*No NPK | 13.67 a | 43.33 e | 5.17 a | 3.70 e | 2.97 e |
| SA*15:15:15 | 13.00 abc | 56.67 b | 4.98 b | 4.01 c | 3.33 b |
| SA*23:10:05 | 13.33 ab | 43.33 e | 4.65 c | 4.47 a | 3.37 a |
| Lsd (1%) | 2.38 | 1.69 | 0.03 | 0.03 | 0.02 |
| CV | 11.01 | 1.92 | 0.37 | 0.41 | 0.53 |

### *3.7. Combined Effect of Variety, NPK and (NH4)2SO4 on the Physical Qualities and TSS of cucumber*

#### *3.7.1. Shelf life*

No distinct variation ($p<0.01$) was observed in the mean length of shelf life of the specific treatment samples as result of the interaction effect of the variety, NPK and $(NH4)_2SO_4$ except between 15.00 days noted for Marketer when treated with $(NH4)_2SO_4$ without NPK and 10.00 days observed for both Pointset and Nandini when 15:15:15 NPK was applied with $(NH4)_2SO_4$. The result thus indicates the application of 15:15:15 NPK and $(NH4)_2SO_4$ had similar impact on the shelf life of Marketer (14 days), Pointset (13 days) and Nandini (12 days). Likewise, when 23:10:05 NPK and $(NH4)_2SO_4$ were applied, the interactive effect on Marketer (14 days), Pointset (14 days) and Nandini (12 days) caused no difference.

When 15:15:15 NPK was solely applied on Marketer (12 days), Nandini (10 days) and Pointset (10 days), the effect was same. Also, 23:10:05 NPK had same impact on the shelf life (11 days) of the varieties. No difference was also observed when only $(NH4)_2SO_4$ was applied on the varieties as shelf life was within 13 to 15 days. And the shelf life (13 to 14 days) did not differ among the varieties when no fertilizer was applied.

#### *3.7.2. Decay*

Decay in the cucumber was significantly ($p<0.01$) influenced by combined effect of variety, NPK and $(NH4)_2SO_4$ in regards to the means. Some of the treatment interactions had same effect. When 15:15:15 NPK was applied solely or in combination with $(NH4)_2SO_4$ influenced the highest decay of 70% in Pointset. Likewise, when $(NH4)_2SO_4$ was applied solely or in combination with 23:10:05 NPK influenced the lowest (30%) in Marketer and Nandini.

When 23:10:05 NPK was applied alone or in combination with $(NH4)_2SO_4$, same effect (40%) was observed as when both 15:15:15 NPK and $(NH4)_2SO_4$ were applied on Marketer. Their impact was same when no fertilizer or only $(NH4)_2SO_4$ was applied on Nandini. Similarly, Pointset and Marketer had same level of decay (50%) when no fertilizer was applied. The rest of the treatment samples also had no difference as they had 60% of decay.

The result further showed variation in level of decay among the varieties when both 23:10:05 NPK and $(NH4)_2SO_4$ were applied on Pointset (60%), Marketer (40%) and

Nandini (30%). When 15:15:15 NPK and $(NH4)_2SO_4$ were applied, the varieties had 70%, 40% and 60% decay in turn and the variation was significant. Both Nandini and Pointset suffered same level of decay (60%) but varied from that (40%) noted in Marketer when 23:10:05 NPK was applied. Similarly Marketer and Nandini suffered 60% decay which varied from 70% in Pointset when 15:15:15 NPK was applied. When $(NH4)_2SO_4$ was applied alone, 60%, 40% and 30% decay were observed in Pointset, Nandini and Marketer respectively. With no application of fertilizer, 50% decay of Marketer and Pointset, and 40% of decayed Nandini were recorded. Both means varied from each other.

### *3.7.3. Weight loss*

There was significant variation ($p<0.01$) observed in weight loss due to the treatment interactions in respect to effect of variety, NPK and $(NH4)_2SO_4$. Weight loss on the daily basis was highest (5.63 g) and lowest (3.72 g) in Marketer when subjected to $(NH4)_2SO_4$ and 23:10:05 NPK application separately. The latter treatment also had similar effect on Pointset as it influenced 3.78 g weight loss.

When 23:10:05 NPK and $(NH4)_2SO_4$ were applied on both Marketer and Nandini, the weight loss (4.82 g) was not different but varied from that observed in Pointset (4.32 g). 15:15:15 NPK and $(NH4)_2SO_4$ when applied, influenced 5.27, 5.10 and 4.57 grams weight loss in Nandini, Pointset and Marketer respectively.

When 23:10:05 NPK was applied alone, 4.40, 3.78 and 3.72 grams loss in weight were noted in Nandini, Pointset and Marketer respectively. The mean 4.40 g differed from both 3.78 and 3.72 grams. The weight loss in Pointset (4.41 g), Nandini (4.32 g) and Marketer (4.23 g) varied in their effect when 15:15:15 NPK was applied alone. Also, the application of $(NH4)_2SO_4$ alone caused variation in the varieties with 5.63, 5.17 and 4.71 grams weight loss recorded in Marketer, Nandini and Pointset in turn.

And when no fertilizer was applied, the weight loss also varied with 4.64, 4.27 and 4.11 grams recorded in Nandini, Pointset and Marketer respectively in order of decreasing amount.

### *3.7.4. Dry matter*

There was significant variation ($p<0.01$) noted in the dry matter content of the cucumbers as result of the combined interaction of the varietal, NPK and $(NH4)_2SO_4$ effect. Dry matter content was highest (4.82%) in Pointset when 23:10:05 NPK and $(NH4)_2SO_4$ were applied. Its effect was not different from 4.76% in Marketer when only $(NH4)_2SO_4$ was applied. The least (3.04%), was recorded in Pointset with the application of $(NH4)_2SO_4$ without NPK.

The result also showed there were difference in the means of dry matter when 23:10:05 NPK and $(NH4)_2SO_4$ were applied on the varieties with 4.82, 4.52 and 4.07 percent noted in Pointset, Marketer and Nandini. Also, when 15:15:15 NPK and $(NH4)_2SO_4$ were applied, 4.15%, 4.01% and 3.87% dry matter content were observed in Nandini, Pointset and Marketer in order of declining value.

When 23:10:05 NPK was applied without $(NH4)_2SO_4$, the dry matter varied with 4.21, 3.86 and 3.64 percent noted in Pointset, Marketer and Nandini in turn. When 15:15:15 NPK was applied solely, 4.27, 4.11 and 3.30 percent dry mater were observed in Pointset, Nandini and Marketer respectively. As regards to $(NH4)_2SO_4$

application alone, 4.76, 3.29 and 3.04 percent were recorded for Marketer, Nandini and Pointset in turn.

When no NPK and $(NH4)_2SO_4$ were applied, the dry matter content also varied with 4.64, 4.37 and 3.80 percent observed in Pointset, Marketer and Nandini respectively.

### *3.7.5. Total soluble sugars (TSS)*

There was a distinct variation ($p<0.01$) in the TSS values as result of the interaction of the treatments – varietal variation, NPK and $(NH4)_2SO_4$. From the results, it was observed that TSS was highest (3.60 ºBrix) in both Marketer and Nandini when 15:15:15 and 23:10:05 NPK were separately applied and top-dressed with $(NH4)_2SO_4$. The lowest (2.70 ºBrix) TSS was noted when only $(NH4)_2SO_4$ was applied on Marketer.

It was also observed from the results that when 23:10:05 NPK and $(NH4)_2SO_4$ were applied, the TSS varied among the varieties with 3.60, 3.50 and 3.00 ºBrix recorded in Nandini, Pointset and Marketer in turn. Likewise, when 15:15:15 NPK and $(NH4)_2SO_4$ were applied, the TSS values varied with 3.60, 3.30 and 3.10 ºBrix recorded in Marketer, Nandini and Pointset respectively in order of decreasing value.

When 23:10:05 NPK was solely applied, 2.90 ºBrix was recorded in both Marketer and Nandini, and it varied from 2.80 ºBrix in Pointset. There was also a difference when 15:15:15 NPK was applied on Marketer (3.40 ºBrix), Pointset (3.30 ºBrix) and Nandini (3.20 ºBrix).

Likewise, the TSS values varied when $(NH4)_2SO_4$ was applied alone on Pointset (3.40 ºBrix), Nandini (2.80 ºBrix) and Marketer (2.70 ºBrix) in order of decreasing amount. And when no NPK and $(NH4)_2SO_4$ were applied, the TSS also differed among the means with 3.20, 3.10 and 2.80 ºBrix noted in Nandini, Pointset and Marketer in turn in order of declining value.

***Table 7.*** *The effect of variety, NPK and (NH4)2SO4 interaction on the physical qualities and TSS of cucumber.*

| Variety*SA Top-dresser*NPK Type | Shelf life (days) | Decay (%) | Weight loss (g/day) | Dry matter (%) | TSS (ºBrix) |
|---|---|---|---|---|---|
| Marketer*No SA*No NPK | 14.00 ab | 50.00 c | 4.11 l | 4.37 d | 2.80 i |
| Marketer*No SA*15:15:15 | 12.00 ab | 60.00 b | 4.23 k | 3.30 m | 3.40 c |
| Marketer*No SA*23:10:05 | 11.00 ab | 50.00 c | 3.72 m | 3.86 jk | 2.90 h |
| Marketer*SA*No NPK | 15.00 a | 30.00 e | 5.63 a | 4.76 a | 2.70 j |
| Marketer*SA*15:15:15 | 14.00 ab | 40.00 d | 4.57 h | 3.87 j | 3.60 a |
| Marketer*SA*23:10:05 | 14.00 ab | 40.00 d | 4.82 e | 4.52 c | 3.00 g |
| Nandini*No SA*No NPK | 14.00 ab | 40.00 d | 4.64 g | 3.80 k | 3.20 e |
| Nandini*No SA*15:15:15 | 10.00 b | 60.00 b | 4.32 j | 4.11 gh | 3.20 e |
| Nandini*No SA*23:10:05 | 11.00 ab | 60.00 b | 4.40 i | 3.64 l | 2.90 h |
| Nandini*SA*No NPK | 13.00 ab | 40.00 d | 5.17 c | 3.29 m | 2.80 i |
| Nandini*SA*15:15:15 | 12.00 ab | 60.00 b | 5.27 b | 4.15 fg | 3.30 d |

| | | | | | |
|---|---|---|---|---|---|
| Nandini*SA*23:10:05 | 12.00 ab | 30.00 e | 4.82 e | 4.07 hi | 3.60 a |
| Pointset*No SA*No NPK | 13.00 ab | 50.00 c | 4.27 jk | 4.64 b | 3.10 f |
| Pointset*No SA*15:15:15 | 10.00 b | 70.00 a | 4.41 i | 4.27 e | 3.30 d |
| Pointset*No SA*23:10:05 | 11.00 ab | 60.00 b | 3.78 m | 4.21 ef | 2.80 i |
| Pointset*SA*No NPK | 13.00 ab | 60.00 b | 4.71 f | 3.04 n | 3.40 c |
| Pointset*SA*15:15:15 | 13.00 ab | 70.00 a | 5.10 d | 4.01 i | 3.10 f |
| Pointset*SA*23:10:05 | 14.00 ab | 60.00 b | 4.32 j | 4.82 a | 3.50 b |
| Lsd (1%) | 4.96 | 3.53 | 0.06 | 0.06 | 0.06 |
| CV | 11.01 | 1.92 | 0.37 | 0.41 | 0.53 |

**SA = Sulphate of Ammonia [(NH4)$_2$SO$_4$]*

## 4. Conclusion and Recommendations

Decay, weight loss, dry matter and TSS varied significantly among the cucumber varieties except for shelf life. The effect of sulphate of ammonia increased shelf life, dry matter and TSS as well as weight loss of cucumbers. 15:15:15 NPK had negative effect on decay and shelf life. It induced high incidence of decay and reduced shelf life to a greater extent. It increased TSS value but reduced dry matter content and influenced a moderate weight loss. 23:10:05 also influenced a dip in shelf life and caused minimal decay. It increased dry matter content and influenced a moderate TSS level and the least weight loss. The effect of the treatment interactions of the factors did caused variations in the means. The specific cucumber varieties responded differently to the treatments in regards to the interaction effect. NPK 15:15:15 effect on the cucumbers caused a high decay incidence when applied alone or in combination with $(NH_4)_2SO_4$. It is therefore recommended that, the application rate may be reduced or revised to experiment if decay incidence would decline in storage. $(NH_4)_2SO_4$ effect increased weight loss in the cucumbers hence, it is recommended that, better storage techniques should be considered by controlling high temperatures.

## Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

## Data Availability Statement

Data is available on request from the corresponding author.

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