

## Effects of Foliar Nutrition and varieties on Physicochemical, Nutritional and Shelf-life qualities of Sweet Pepper (*Capsicum annuum* L.) fruits in Ghana

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### ABSTRACT

The study was conducted to determine the effects of foliar nutrition and varieties on physicochemical, nutritional, and shelf-life qualities of sweet pepper in the Coastal Savanna agro-ecological zone. A 2 × 3 factorial arrangement in a Randomized Complete Block Design (RCBD) with three replications was used for the field experiment whereas for the laboratory studies, the experimental design was a 2 × 3 factorial arrangement in a Completely Randomized Design (CRD) with three replications. The first factor was varieties at two levels (Yolo Wonder and Sinbad F1). The second factor was fertilizer types were at three levels (Golden Soluble foliar fertilizer, Codafol Liquid foliar fertilizer, and soil-applied NPK + SOA as control). The foliar fertilisers were applied at three phenological stages (vegetative, flowering, and fruit development) whereas the soil-applied fertilizers (control) were applied at two phenological stages (vegetative and flowering). The heaviest fruit pulp weight was obtained from the Codafol Liquid x Sinbad F1 combination. The Codafol Liquid resulted in higher ash and crude fibre contents of the fruits. The foliar fertilizers also enhanced the nitrogen, phosphorus, potassium, iron, and zinc contents of the fruits better than the granular fertilizers. Sinbad F1x Golden Soluble treatment prolonged the shelf-life of the fruits better than the other treatment combinations. In conclusion, the application of the foliar fertilizers enhanced the physiochemical and nutritional qualities of the sweet pepper fruits. Furthermore, the hybrid variety (Sinbad F1) responded better to the foliar nutrition than the open-pollinated variety (Yolo Wonder) leading to enhanced physiochemical and nutritional quality characteristics of the fruits of the hybrid variety.

**Keywords:** Post-harvest quality, sweet pepper, foliar fertilizers, proximate composition, variety, nutrition

## INTRODUCTION

Sweet pepper (*Capsicum annum L.*), also known as Bell pepper, is one of the most widely cultivated vegetable crops globally and belongs to the family Solanaceae. It has gained economic significance worldwide due to its culinary versatility, favorable flavor profile, nutritional value and high market demand (Ghoname et al., 2010; Buczkowska et al., 2016; Cheema et al., 2018). The crop is rich in bioactive compounds—including flavonoids, phenolics and capsaicin—which contribute to its antioxidant, immune-modulating, and anti-carcinogenic properties (Patel et al., 2019). It is also a rich source of vitamin C, carotenoids, vitamin E and calcium which contribute to disease prevention and overall health (Marin et al., 2004; Ramana-Rao et al., 2011).

The rising global and national population has increased demand for nutrient-rich vegetables such as sweet pepper (Ghadami et al., 2021; Khazaeli et al., 2020). However, in Ghana, production remains low, a situation attributed to pre-harvest nutritional deficiencies and ineffective postharvest handling (Osei-Kwarteng *et al.*, 2017). Although soil fertilization remains a widely adopted practice, its effectiveness is limited by nutrient leaching, poor nutrient availability, and environmental stresses that hinder nutrient uptake (Reena et al., 2018). Consequently, foliar feeding has been suggested as an efficient method to address the nutrient deficiencies and improve fertilizer-use efficiency in sweet pepper production (Kolota, 2001).

Foliar fertilization involves applying essential nutrients directly to plant leaves to complement conventional soil nutrient application ((Barboza et al., 2019; Mavi, 2020). Generally, foliar fertilization enhances nutrient uptake, promotes growth under stress conditions, improves nutrient-use efficiency (NUE), boosts crop yields, and enhances the postharvest quality of harvested fruits (Vinković et al., 2007; Mora et al., 2010; Veronica et al., 2015). For sweet pepper, while some studies have shown that foliar fertilization can improve yield (Belakbir et al., 1998), other studies have shown varietal differences in the response of the crop to foliar fertilizer application (Ali et al., 2020; Ichwan et al., 2021). Furthermore, there is a dearth of information on foliar fertilization studies focusing on fruit physicochemical, nutritional qualities and shelf-life. Consequently, the objective of the study was to assess the interactive effects of different fertilizers and varieties on the postharvest physical, proximate, nutritional and shelf-life of sweet pepper fruits.

## MATERIALS AND METHODS

### Treatments and experimental design

The experiment was conducted from June - September 2023 at Ada, in the Ada East District of the Greater Accra Region. The study location experiences an annual sunshine of 2,500 – 2,900 hours and an average annual rainfall of 737 – 842 mm. The study location falls within the Coastal Savanna agro-ecozone. The predominant soil type is sandy clay loam. The field experiment was established using 2 x 3 factorial arrangement in a Randomized Complete Block Design (RCBD) with three replications. The experimental factors were sweet pepper variety at two levels (Yolo Wonder and Sinbad F1), and fertilizer type at three levels (Golden soluble foliar fertilizer (14.4mls /plant); Codafol liquid foliar fertilizer (14.4mls /plant); Farmer Practice as control (5 g/plant NPK + 6 g/plant sulphate of ammonia - SOA). Each foliar fertilizer type was applied at each of the three crop phenological stages: (i) Vegetative growth to first flowering (1–25 days after transplanting): application of Golden Soluble Starter and Codafol Liquid Starter (ii) Flowering to

fruit set (25–45 days after transplanting): application of Golden Soluble Grower and Codafol Liquid Grower and (iii) Fruit set to harvest (46–70 days after transplanting): application of Golden Soluble Finisher and Codafol Liquid Finisher. The nutrients composition of the foliar fertilizers is presented in Tables 1 and 2.

**Table 1** The nutrient composition of Codafol Liquid foliar fertilizer

	Nutrients (% w/w)								
	N	P	K	Cu	Fe	Mn	Zn	B	Mo
Codafol Liquid Starter	14.00	6.00	5.00	0.05	0.10	0.05	0.05	0.00	0.001
Codafol Liquid Grower	7.00	21.00	7.00	0.05	0.11	0.05	0.05	0.00	0.001
Codafol Liquid Finisher	4.00	16.00	28.00	0.00	0.00	0.00	0.00	0.28	0.020

**Table 2** The nutrient composition of Golden Soluble foliar fertilizer

	Nutrients (% w/w)									
	N	P	K	Mg	Cu	Fe	Mn	Zn	B	Mo
Golden Soluble Starter	28.00	10.00	10.00	3.00	0.002	0.019	0.009	0.002	0.008	0.001
Golden Soluble Grower	18.00	18.00	18.00	3.00	0.002	0.019	0.009	0.002	0.008	0.001
Golden Soluble Finisher	10.00	5.00	30.00	3.50	0.002	0.019	0.009	0.002	0.008	0.001

Seedlings were raised and transplanted 30 days after sowing onto designated plots measuring 9 m<sup>2</sup> (3 m × 3 m) at a planting spacing of 0.6 m x 0.6 m. Supplementary irrigation was used when no rainfall was recorded. For the control treatment, a basal application of 5 g of NPK (15:15:15) was applied two weeks after transplanting and followed up with 6 g of sulphate of ammonia at the flowering stage. Harvesting of the sweet pepper fruits was done in the morning when the fruits were physiologically mature and transported to the laboratory for the physical, proximate, nutritional, and shelf-life qualities assessments. In the laboratory, the experimental design used for the assessments was 2 x 3 in a Completely Randomized Design (CRD) with 3 replications. Data were collected on fruit physical characteristics, fruit proximate quality fruit nutritional quality and shelf-life. For the fruit physical characteristics, fruit firmness was determined using a digital Durometer. The instrument was pressed firmly against three equidistant points around the fruit circumference, and the reading were taken in triplicate and averaged for each treatment. The fruit

pericarp thickness was measured by making a transverse cut across fully matured fruits. A Vernier caliper was used to measure the thickness at three different points along the cut surface. Triplicate measurements were recorded and the mean value computed for each treatment. The fruit pulp weight was by manually extracting juice from the mature fruits and weighing the pulp on an electronic top-loading scale. Weights were taken in triplicates and mean pulp weight determined. For the proximate quality assessments, moisture and ash contents were determined by the methods of AOAC (1984); crude fat by the Soxhlet method (AOAC, 1984); crude fibre by the Weende method (AOAC, 2019) and crude protein by the Kjeldahl method (AOAC, 1984). For the nutritional quality assessments, phosphorus content was determined using the procedure of Motsa *et al.*, (2008); potassium, calcium and magnesium contents by the procedures of AOAC (2019) and iron, copper, zinc and manganese contents also by the procedures of AOAC (2019). Fruit flavonoid content was determined using the procedure of (Zhishen *et al.* 1999); phenolic content by the Folin-Ciocalteu method (Kujala *et al.*, 2000); carotenoids contents by the methods of Mackinney (1941) and Maclachan and Zalick (1963); beta carotenoid content by the high-performance liquid chromatography (HPLC) method (AOAC, 1980) and ascorbic acid by the iodine-starch redox titration method (AOAC, 1984). Shelf-life was assessed by counting the number of days required for the fruits to lose their marketable qualities based on visible deterioration, discoloration and decay.

### **Data analysis**

All data collected were subjected to analysis of variance (ANOVA) using STATISTIX software (version 10.0). Mean separation was conducted using Tukey's Honest Significant Difference (HSD) test.  $P = 0.05$  was used for field experimental data, while a  $P = 0.01$  was applied to the laboratory experimental data.

## **RESULTS**

### *Effects of varieties and foliar fertilizers on fruit firmness of sweet pepper*

There were significant variety x foliar fertilizer interactions for fruit firmness of sweet pepper (Table 3). Sinbad F1 x control (NPK+SOA) produced the greatest fruit firmness although similar to all the other treatment combinations, except Yolo Wonder x Codafol Liquid (Table 3). Yolo Wonder x Codafol Liquid produced the least fruit firmness. Across the varieties, the control (NPK+SOA) resulted in the highest fruit firmness, yet similar to those of Golden Soluble and Codafol Liquid foliar fertilizers. Across the foliar fertilizers, Sinbad F1 variety recorded the highest fruit firmness significantly different from that of Yolo Wonder variety (Table 3).

**Table 3.** Effects of varieties and foliar fertilizers on fruit firmness (shore units) of sweet pepper

Foliar Fertilizer	Varieties		Mean
	Yolo Wonder	Sinbad F1	
Golden Soluble	48.81	49.81	49.31
Codafol Liquid	42.14	52.54	47.34
Control (granular NPK fertilizer)	53.14	57.22	55.13
Mean	48.00	53.18	

HSD (0.01): Foliar fertilizer = 6.185; Varieties = 4.371; Foliar fertilizer x Varieties = 10.673

### ***Effects of varieties and foliar fertilizers on fruit pericarp thickness of sweet pepper***

There were no significant interactions as well as single effects for fruit pericarp thickness of sweet pepper. Pericarp thickness ranged from 4.05 – 4.76 mm.

### ***Effects of varieties and foliar fertilizers on fruit pulp weight of sweet pepper***

There were significant variety x foliar fertilizer interactions for fruit pulp weight of sweet pepper (Table 4). Sinbad F1 x Codafol Liquid produced the greatest fruit pulp weight although similar to those of Sinbad F1 x Golden Soluble and Sinbad F1 x control (NPK+SOA) (Table 4). Yolo Wonder x control (NPK+SOA) produced the least pulp weight. Across the varieties, the Codafol Liquid resulted in the highest pulp weight significantly greater than those of Golden Soluble and the control (NPK+SOA). Across the foliar fertilizers, Sinbad F1 variety recorded the highest pulp weight significantly different from that of Yolo Wonder variety (Table 4).

**Table 4.** Effects of varieties and foliar fertilizers on fruit pulp weight (g) of sweet pepper

Foliar Fertilizer	Varieties		Mean
	Yolo Wonder	Sinbad F1	
Golden Soluble	105.67	142.67	124.17
Codafol Liquid	127.00	160.00	143.50
Control (granular NPK fertilizer)	103.00	143.67	123.33
Mean	111.89	148.78	

HSD (0.01): Foliar fertilizer = 17.084; Varieties = 12.073; Foliar fertilizer x Varieties = 29.482

### ***Effects of varieties and foliar fertilizers on ash content of sweet pepper fruit***

There were significant variety x foliar fertilizer interactions for fruit ash content of sweet pepper (Table 5). Yolo Wonder x Codafol Liquid produced the greatest fruit ash content, significantly different from that of Yolo Wonder x control (NPK+SOA) and Sinbad F1 x control (NPK+SOA), yet similar to the other treatment combinations (Table 5). Sinbad F1 x control (NPK+SOA) produced the least fruit ash content. Across varieties, the Codafol Liquid produced the highest fruit ash content significantly greater than that of the control (NPK+SOA) but similar to that of the Golden Soluble. Across the foliar fertilizers, Yolo Wonder variety recorded the highest ash content significantly different from that of Sinbad F1 variety (Table 5).

**Table 5. Effects of varieties and foliar fertilizers on fruit ash content (g 100<sup>-1</sup> g) of sweet pepper.**

Foliar Fertilizer	Varieties		Mean
	Yolo Wonder	Sinbad F1	
Golden Soluble	5.95	6.30	6.13
Codafol Liquid	6.37	6.19	6.28
Control (granular NPK fertilizer)	5.35	5.13	5.24
Mean	5.89	5.87	

HSD (0.01): Foliar fertilizer = 0.320; Varieties = 0.226; Foliar fertilizer x Varieties = 0.553

***Effects of varieties and foliar fertilizers on fruit crude fat content of sweet pepper***

There were significant variety x foliar fertilizer interactions for fruit crude fat content of sweet pepper (Table 6). Yolo Wonder x control (NPK+SOA) produced the highest fruit crude fat content which was significantly different from all other combinations (Table 6). Yolo Wonder x Codafol Liquid produced the least fruit crude fat content. Across varieties, the control (NPK+SOA) produced the highest fruit crude fat content significantly greater than those of Codafol Liquid and Golden Soluble foliar fertilizers. Across the foliar fertilizers, Sinbad F1 variety recorded the highest crude fat content significantly different from that of Yolo Wonder variety (Table 6).

**Table 6. Effects of varieties and foliar fertilizers on fruit crude fat content (g 100<sup>-1</sup> g) of sweet pepper**

Foliar Fertilizer	Varieties		Mean
	Yolo Wonder	Sinbad F1	
Golden Soluble	8.91	9.51	9.21
Codafol Liquid	8.13	9.48	8.80
Control (granular NPK fertilizer)	10.45	9.51	9.98
Mean	9.16	9.50	

HSD (0.01): Foliar fertilizer = 0.326; Varieties = 0.230; Foliar fertilizer x Varieties = 0.562

***Effects of varieties and foliar fertilizers on fruit crude fibre content of sweet pepper***

There were significant variety x foliar fertilizer interactions for fruit crude fibre content of sweet pepper (Table 7). Yolo Wonder x Codafol Liquid produced the greatest fruit crude fibre content, significantly different from the other combinations except Sinbad F1 x Codafol Liquid (Table 7). Yolo Wonder x control (NPK+SOA) produced the least fruit crude fibre content. Across the varieties, the Codafol Liquid produced the highest fruit crude fibre content, significantly greater than those of the control (NPK+SOA) and Golden Soluble foliar fertilizer. Across the foliar fertilizers, however, there were no significant differences between the varieties (Table 7).

**Table 7. Effects of varieties and foliar fertilizers on fruit crude fibre content (g 100<sup>-1</sup> g) of sweet pepper**

Foliar Fertilizer	Varieties		Mean
	Yolo Wonder	Sinbad F1	
Golden Soluble	14.12	13.55	13.83
Codafol Liquid	14.86	14.58	14.72
Control (granular NPK fertilizer)	12.82	14.13	13.48
Mean	13.94	14.09	
HSD (0.01): Foliar fertilizer = 0.536; Varieties = 0.378; Foliar fertilizer x Varieties = 0.920			

*Effects of varieties and foliar fertilizers on fruit moisture content of sweet pepper*

There were significant variety x foliar fertilizer interactions for fruit moisture content of sweet pepper (Table 8). Yolo Wonder x Golden Soluble produced the greatest fruit moisture content, significantly different from the other combinations, except Yolo Wonder x Codafol Liquid (Table 8). Yolo Wonder x control (NPK+SOA) produced the least fruit moisture content. Across the varieties, the Golden Soluble produced the highest fruit moisture content significantly greater than that of the control (NPK+SOA) but similar to that of the Codafol Liquid foliar fertilizer. Across the foliar fertilizers, Yolo Wonder variety recorded the highest fruit moisture content significantly different from that of the Sinbad F1 variety (Table 8).

**Table 8. Effects of varieties and foliar fertilizers on moisture content (g 100<sup>-1</sup> g) of sweet pepper**

Foliar Fertilizer	Varieties		Mean
	Yolo Wonder	Sinbad F1	
Moisture Content (g 100 <sup>-1</sup> g)			
Golden Soluble	90.39	88.42	89.4
Codafol Liquid	90.31	88.47	89.39
Control (granular NPK fertilizer)	88.24	87.78	88.01
Mean	89.65	88.22	
HSD (0.01): Foliar fertilizer = 0.512; Varieties = 0.273; Foliar fertilizer x Varieties = 0.883			

*Effects of varieties and foliar fertilizers on fruit crude protein content of sweet pepper*

There were significant variety x foliar fertilizer interactions for fruit crude protein content of sweet pepper (Table 9). Sinbad F1 x Golden Soluble produced the greatest fruit crude protein content, significantly different from the other combinations. Yolo Wonder x control (NPK+SOA) produced the least fruit crude protein content. Across varieties, the Golden Soluble produced the highest fruit crude protein content significantly greater than that of the control (NPK+SOA) but similar to that of the Codafol Liquid foliar fertilizer. Across the foliar fertilizers, Sinbad F1 variety recorded the highest fruit crude protein content significantly different from that of Yolo Wonder variety (Table 9).

**Table 9. Effects of varieties and foliar fertilizers on fruit crude protein content (g 100<sup>-1</sup> g) of sweet pepper.**

Foliar Fertilizer	Varieties		Mean
	Yolo Wonder	Sinbad F1	
Golden Soluble	13.64	15.37	14.51
Codafol Liquid	14.34	13.91	13.12
Control (granular NPK fertilizer)	11.76	13.14	12.45
Mean	13.25	14.14	
HSD (0.01): Foliar fertilizer = 0.387; Varieties = 0.274; Foliar fertilizer x Varieties = 0.668			

***Effects of varieties and foliar fertilizers on fruit nitrogen content of sweet pepper***

There were significant variety x foliar fertilizer interactions for fruit nitrogen content of sweet pepper (Table 10). Sinbad F1 x Golden Soluble and Sinbad F1 x Codafol Liquid produced the greatest fruit nitrogen content, significantly different from the other combinations. Yolo Wonder x control (NPK+SOA) produced the least fruit nitrogen content. Across the varieties, the Golden Soluble produced the highest fruit nitrogen content significantly greater than that of the control (NPK+SOA) but similar to that of the Codafol Liquid foliar fertilizer. Across the foliar fertilizers, Sinbad F1 variety recorded the highest fruit nitrogen content significantly different from that of the Yolo Wonder variety (Table 10).

**Table 10. Effects of varieties and foliar fertilizers on nitrogen content (g 100<sup>-1</sup> g) of sweet pepper in the Coastal savanna agro-ecozone (Ada)**

Foliar Fertilizer	Varieties		Mean
	Yolo Wonder	Sinbad F1	
Golden Soluble	2.18	2.32	2.25
Codafol Liquid	2.00	2.32	2.23
Control (granular NPK fertilizer)	1.82	1.89	1.86
Mean	2.05	2.17	
HSD (0.01): Foliar fertilizer = 0.067; Varieties = 0.047; Foliar fertilizer x Varieties = 0.116			

***Effects of varieties and foliar fertilizers on fruit phosphorus content of sweet pepper***

There were significant variety x foliar fertilizer interactions for fruit phosphorus content of sweet pepper (Table 11). Yolo Wonder x Golden Soluble and Yolo Wonder x Codafol Liquid produced the greatest fruit phosphorus content, significantly different from the other combinations except Sinbad F1 x Codafol Liquid and Sinbad F1 x control (NPK+SOA). Yolo Wonder x control (NPK+SOA) produced the least fruit phosphorus content. Across the varieties, the Codafol Liquid produced the highest fruit phosphorus content, significantly greater than that of the control (NPK+SOA) but similar to that of the Golden Soluble foliar fertilizer. Across the foliar fertilizers, however, there were no significant differences between the varieties (Table 11).

**Table 11.** Effects of varieties and foliar fertilizers on fruit phosphorus content ( $\text{g } 100^{-1} \text{ g}$ ) of sweet pepper.

Foliar Fertilizer	Varieties		Mean
	Yolo Wonder	Sinbad F1	
Golden Soluble	0.96	0.85	0.90
Codafol Liquid	0.96	0.89	0.92
Control (granular NPK fertilizer)	0.74	0.88	0.81
Mean	0.89	0.87	
HSD (0.01): Foliar fertilizer = 0.071; Varieties = 0.050; Foliar fertilizer x Varieties = 0.122			

### ***Effects of varieties and foliar fertilizers on fruit potassium content of sweet pepper***

There were significant variety x foliar fertilizer interactions for fruit potassium content of sweet pepper (Table 12). Sinbad F1 x Codafol Liquid produced the greatest fruit potassium content, significantly different from the other combinations except Yolo Wonder x Codafol Liquid. Yolo Wonder x control (NPK+SOA) produced the least fruit potassium content. Across the varieties, the Codafol Liquid produced the highest fruit potassium content, significantly greater than that of the control (NPK+SOA) and the Golden Soluble foliar fertilizer. Across the foliar fertilizers, however, there were no significant differences between the varieties (Table 12).

**Table 12.** Effects of varieties and foliar fertilizers on fruit potassium content ( $\text{g } 100^{-1} \text{ g}$ ) of sweet pepper

Foliar Fertilizer	Varieties		Mean
	Yolo Wonder	Sinbad F1	
Potassium Content ( $\text{g } 100^{-1} \text{ g}$ )			
Golden Soluble	3.39	3.31	3.35
Codafol Liquid	3.74	3.88	3.81
Control (granular NPK fertilizer)	3.15	3.28	3.21
Mean	3.43	3.49	
HSD (0.01): Foliar fertilizer = 0.140; Varieties = 0.099; Foliar fertilizer x Varieties = 0.242			

### ***Effects of varieties and foliar fertilizers on fruit calcium content of sweet pepper***

There were significant variety x foliar fertilizer interactions for fruit calcium content of sweet pepper (Table 13). Yolo Wonder x control (NPK+SOA) produced the greatest fruit calcium content, significantly different from the other combinations except Sinbad F1 x control (NPK+SOA). Sinbad F1 x Golden Soluble produced the least fruit calcium content. Across the varieties, the Golden Soluble produced the highest calcium content, significantly greater than that of the control (NPK+SOA) and the Codafol liquid foliar fertilizer. Across the foliar fertilizers,

Yolo Wonder variety recorded the highest fruit calcium content, significantly different from that of the Sinbad F1 variety (Table 13).

**Table 13. Effects of varieties and foliar fertilizers on fruit calcium content ( $\text{g } 100^{-1} \text{ g}$ ) of sweet pepper**

Foliar Fertilizer	Varieties		Mean
	Yolo Wonder	Sinbad F1	
Golden Soluble	0.38	0.35	0.45
Codafol Liquid	0.42	0.38	0.4
Control (granular NPK fertilizer)	0.47	0.44	0.36
Mean	0.42	0.39	
HSD (0.01): Foliar fertilizer = 0.420; Varieties = 0.030; Foliar fertilizer x Varieties = 0.072			

### *Effects of varieties and foliar fertilizers on fruit magnesium content of sweet pepper*

There were significant variety x foliar fertilizer interactions for fruit magnesium content of sweet pepper (Table 14). Yolo Wonder x Golden Soluble and Sinbad F1 x control (NPK+SOA) produced the greatest fruit magnesium content, significantly different from the other combinations (Table 14). Yolo Wonder x control (NPK+SOA) produced the least fruit magnesium content. Across the varieties, the Golden Soluble produced the highest fruit magnesium content, significantly greater than that of the control (NPK+SOA) and the Codafol Liquid foliar fertilizer. Across the foliar fertilizers, Sinbad F1 variety recorded the highest fruit magnesium content significantly different from that the Yolo Wonder of variety (Table 14).

**Table 14. Effects of varieties and foliar fertilizers on magnesium content ( $\text{g } 100^{-1} \text{ g}$ ) of sweet pepper fruits in the Coastal savanna agro-ecozone**

Foliar Fertilizer	Varieties		Mean
	Yolo Wonder	Sinbad F1	
Golden Soluble	0.30	0.24	0.27
Codafol Liquid	0.22	0.21	0.22
Control (granular NPK fertilizer)	0.17	0.30	0.23
Mean	0.23	0.25	
HSD (0.01): Foliar fertilizer = 0.022; Varieties = 0.016; Foliar fertilizer x Varieties = 0.038			

### *Effects of varieties and foliar fertilizers on iron content of sweet pepper fruits*

There were significant variety x foliar fertilizer interactions for fruit iron content of sweet pepper (Table 15). Sinbad F1 x Codafol Liquid produced the greatest fruit iron content, significantly different from the other combinations. Sinbad F1 x Golden Soluble produced the least fruit iron content yet similar to that of Sinbad F1 x control (NPK+SOA). Across the varieties, the Codafol Liquid produced the highest fruit iron content, significantly greater than that of the Golden Soluble

and that of the control (NPK+SOA). Across the foliar fertilizers, however, there were no significant differences between the varieties (Table 15).

**Table 15. Effects of varieties and foliar fertilizers on iron content (g 100<sup>-1</sup> g) of sweet pepper fruits**

Foliar Fertilizer	Varieties		Mean
	Yolo Wonder	Sinbad F1	
Golden Soluble	0.0018	0.0014	0.0016
Codafol Liquid	0.0019	0.0022	0.0021
Control (granular NPK fertilizer)	0.0014	0.0018	0.0016
Mean	0.0017	0.0018	

HSD (0.01): Foliar fertilizer = 0.00018; Varieties = 0.00013; Foliar fertilizer x Varieties =0.00031

### ***Effects of varieties and foliar fertilizers on zinc content of sweet pepper fruits***

There were significant variety x foliar fertilizer interactions for fruit zinc content of sweet pepper (Table 16). Yolo Wonder x control (NPK+SOA) produced the greatest fruit zinc content, significantly different from the other combinations except Sinbad F1 x control (NPK+SOA) and Sinbad F1 x Codafol Liquid (Table 14). Yolo Wonder x Golden Soluble produced the least fruit zinc content. Across the varieties, the control (NPK+SOA). produced the highest fruit zinc content, significantly greater than that of the Golden Soluble and Codafol Liquid foliar fertilizers. Across the foliar fertilizers, however, there were no significant differences between the varieties (Table 16).

**Table 16. Effects of varieties and foliar fertilizers on zinc content (g 100<sup>-1</sup> g) of sweet pepper fruits**

Foliar Fertilizer	Varieties		Mean
	Yolo Wonder	Sinbad F1	
Zinc Content (g 100 <sup>-1</sup> g)			
Golden Soluble	0.0024	0.0026	0.0025
Codafol Liquid	0.0026	0.0028	0.0027
Control (granular NPK fertilizer)	0.0033	0.0032	0.0032
Mean	0.0027	0.0029	

HSD (0.01): Foliar fertilizer = 0.00031; Varieties = 0.00022; Foliar fertilizer x Varieties =0.00054

### ***Effects of varieties and foliar fertilizers on vitamin C content of sweet pepper fruits***

There were significant variety x foliar fertilizer interactions for fruit vitamin C content of sweet pepper (Table 17). Sinbad F1 x control (NPK+SOA) produced the greatest fruit vitamin C content,

significantly different from Yolo Wonder x control (NPK+SOA) yet similar to all the other treatment combinations. Yolo Wonder x control (NPK+SOA) produced the least fruit vitamin C content. Across the varieties, however, there were no significant differences between the foliar fertilizers. Similarly, across the foliar fertilizers, there were no significant differences between the varieties (Table 17).

**Table 17. Effects of varieties and foliar fertilizers on vitamin C content (g 100<sup>-1</sup> g) of sweet pepper fruits in the Coastal savanna agro-ecozone**

Foliar Fertilizer	Varieties		Mean
	Yolo Wonder	Sinbad F1	
Golden Soluble	29.38	34.68	32.03
Codafol Liquid	31.60	22.34	26.97
Control (granular NPK fertilizer)	20.05	36.81	28.43
Mean	27.01	31.28	
HSD (0.01): Foliar fertilizer = 8.518; Varieties = 6.020; Foliar fertilizer x Varieties = 14.700			

### ***Effects of varieties and foliar fertilizers on flavonoid content of sweet pepper fruits***

There were significant variety x foliar fertilizer interactions for fruit flavonoid content of sweet pepper (Table 18). Yolo Wonder x control (NPK+SOA) produced the greatest fruit flavonoid content, significantly different from the other combinations except Sinbad F1 x control (NPK+SOA). Yolo Wonder x Golden Soluble produced the least fruit flavonoid content. Across the varieties, the control (NPK+SOA) produced the highest fruit flavonoid content, significantly greater than that of the Golden Soluble and the Codafol Liquid foliar fertilizers. Across the foliar fertilizers, however, there were no significant differences between the varieties (Table 18.).

**Table 18. Effects of varieties and foliar fertilizers on flavonoid content (mg QE 100<sup>-1</sup> g) of sweet pepper fruits**

Foliar Fertilizer	Varieties		Mean
	Yolo Wonder	Sinbad F1	
Golden Soluble	1.31	2.79	2.05
Codafol Liquid	2.94	2.20	2.57
Control (granular NPK fertilizer)	5.80	4.40	5.10
Mean	3.35	3.13	
HSD (0.01): Foliar fertilizer = 1.261; Varieties = 0.891; Foliar fertilizer x Varieties = 2.176			

### ***Effects of varieties and foliar fertilizers on shelf life of sweet pepper fruits***

There were significant variety x foliar fertilizer interactions for fruit shelf life of sweet pepper (Table 19). Sinbad F1 x Golden Soluble produced the highest number of days of fruit shelf life,

significantly different from the other combinations except Yolo Wonder x control (NPK+SOA), Yolo Wonder x Codafol Liquid and Yolo Wonder x Golden Soluble (Table 19). Sinbad F1 x control (NPK+SOA) produced the least days of fruit shelf life. Across varieties, the Golden Soluble produced the highest fruit shelf life, significantly greater than that of control (NPK+SOA) and Codafol Liquid foliar fertilizer. Across the foliar fertilizers, Yolo Wonder variety recorded the highest fruit shelf life, significantly different from that of the Sinbad F1 variety (Table 19).

**Table 19. Effects of varieties and foliar fertilizers on fruit shelf life (days) of sweet pepper**

Foliar Fertilizer	Varieties		Mean
	Yolo Wonder	Sinbad F1	
Golden Soluble	20.00	21.00	20.50
Codafol Liquid	20.00	17.67	18.83
Control (granular NPK fertilizer)	20.67	17.00	18.83
Mean	20.22	18.56	
HSD (0.01): Foliar fertilizer = 1.076; Varieties = 0.761; Foliar fertilizer x Varieties = 1.857			

## DISCUSSION

In terms of the fruit postharvest quality traits, Sinbad F1 x control (NPK+SOA) resulted in the highest fruit firmness. This implied that the Sinbad F1 variety responded positively to the soil-applied nutrients which resulted in better cell wall development and tissue integrity of the fruits. Fruit firmness has also been linked to the functionality of potassium in maintaining cell wall integrity and turgor (Marschner, 2012; Mengel and Kirkby, 2001; Toivonen and Brummell, 2008). In the present study, potassium was amply supplied by the soil-applied NPK fertilizer. Cho *et al.*, (2015), also reported that *Capsicum* spp. supplied with nutrients through the root zone feeding, positively affected fruit structural quality traits, including firmness. For fruit pulp weight, Sinbad F1 variety had heavier pulp weight than the Yolo Wonder, a variation attributed to the genetic differences in fruit potential and sink strength (del Amor *et al.*, 2013).

The granular fertilizer application consistently enhanced carbohydrate and crude fat contents, particularly in the Yolo Wonder variety. This highlights the important role of soil supplied nitrogen and potassium in sustaining photosynthetic capacity, assimilate production, lipid biosynthesis, and translocation of assimilates to reproductive sinks under intermittent moisture stress (Marschner, 2012; Mengel and Kirkby, 2001), typical of the study location. A similar report on solanaceous crops grown under moisture limited environments also showed the enhancements in carbohydrates and fat contents of fruits following soil N and K supply (Almeselmani *et al.*, 2010; Lester *et al.*, 2010). For ash and crude fibre, higher contents were found in the fruits of both Yolo Wonder and Sinbad F1 to which the Codafol Liquid foliar fertilizer had been applied. These findings could be attributed to the higher micronutrient contents in the Codafol Liquid fertilizer which promoted the optimum uptake and use of the macronutrients thereby leading to the enhanced synthesis of structural carbohydrates generally found to be closely associated with fruit texture and firmness

(Toivonen and Brummell, 2008; Aboyeji et al., 2021). The application of the foliar fertilizers also resulted in higher fruit moisture and crude protein contents suggestive of the higher contents of nitrogen and potassium in these foliar fertilizers in comparison to the granular soil-applied NPK fertilizer. del Amor et al., (2013) reported that potassium and nitrogen nutrition are usually associated with improved protein deposits and moisture retention in *Capsicum* fruits cultivated under stressed conditions of moisture and temperature. Similarly, Fernández and Brown (2013), also reported of similar enhancements in mineral composition of fruits of tomato and pepper following foliar feeding of fertilizers laden with macronutrients and micronutrients as compared to soil fertilization.

Higher flavonoid and vitamin C contents were found in the fruits of the plants which enjoyed the soil-applied NPK fertilizer. The stress conditions (high temperatures and low moisture regimes) of the study location might have activated the defensive metabolic pathways in the plants that favored the synthesis of phenolics, flavonoids, and antioxidants at the expense of growth-related processes (Herms and Mattson, 1992; Dixon and Paiva, 1995). This assertion is supported by Navarro *et al.*, (2006) and Kim et al., (2012) who reported that on solanaceous crops such as pepper and tomato, stress conditions including water deficit, and temperature extremes, increase the concentrations of phenolic compounds, capsaicinoids, carotenoids, and other secondary metabolites in the fruits as a stress-adaptive mechanism. In terms of shelf life, the Sinbad F1 × Golden Soluble foliar treatment produced fruits which had longer shelf-life under ambient room conditions than the other treatments. This could be attributed to the high concentration of macro and micro nutrients in the Golden Soluble foliar fertilizer which might have enhanced fruit structural stability, reduced moisture loss and delayed senescence. Foliar fertilizers rich in potassium and micronutrients have been shown to strengthen cell walls, regulate osmotic balance, and reduce postharvest water loss in solanaceous crops, thereby extending the shelf life of the fruits (Fanasca *et al.*, 2006; Lester et al., 2010). Additionally, several studies on solanaceous crops have reported that balanced nutrient supply before harvest, improved cuticle development and reduced fruit softening (Dorais and Papadopoulos, 2001; Toivonen and Brummell, 2008; Rubio et al., 2009).

## CONCLUSION

The study concluded that, the application of the foliar fertilizers enhanced the physicochemical and nutritional qualities of the sweet pepper fruits better than the use of granular NPK+SOA treatment. Furthermore, the hybrid variety (Sinbad F1) responded better to the foliar nutrition than the open-pollinated variety (Yolo Wonder) leading to enhanced physicochemical and nutritional quality characteristics of the fruits of the hybrid variety.

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