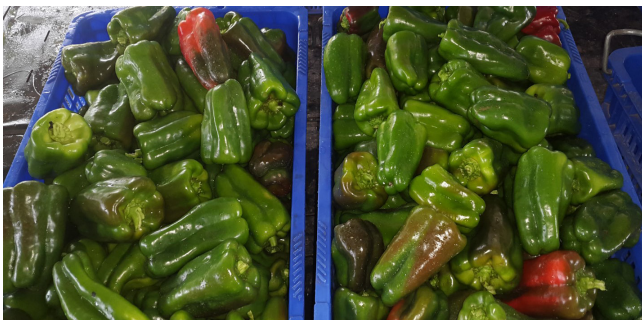


Bell Pepper (*Capsicum annuum*) A Potential Commercial Crop for Guam

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Introduction

The bell pepper, also known as sweet pepper, is a widely cultivated vegetable crop that originates from central and South America. Although there are various shapes of sweet peppers, most are bell-shaped, which is why the term ‘bell pepper’ is more common (Department of Agriculture, Forestry, and Fisheries, Republic of South Africa, 2013). They belong to the same species as many varieties/cultivars of hot chili peppers, *Capsicum annuum*. The major difference along with the commonly larger bell shape is that bell peppers are considered “sweet” and chili peppers are “hot”.

Bell peppers are very popular throughout the world. They are sold as a fresh vegetable in markets. In Guam stores, fresh bell green peppers average \$4.00/lb, and fully ripened red, yellow, or orange bell peppers are usually sold at \$4.99 to \$6.99/lb.

Bell peppers are commonly used as a fresh vegetable in salads and sandwiches, and as a cooked vegetable for a wide variety of dishes throughout the world.

There are numerous health benefits of bell pepper. Bell peppers are rich in Vitamin C, Vitamin A, and B-complex group of vitamins including Vitamin B-1 (niacin and pyridoxine) and Vitamin B-6 (riboflavin and thiamin) (Rudrappa, 2016). Fig. 1 shows basic nutrition facts of raw, green bell pepper as provided by the United States Department of Agriculture (USDA)

Nutrition Facts	
Serving Size 149 g	
Amount Per Serving	
Calories 30	Calories from Fat 2
% Daily Value*	
Total Fat 0g	0%
Saturated Fat 0g	0%
Trans Fat	
Cholesterol 0mg	0%
Sodium 4mg	0%
Total Carbohydrate 7g	2%
Dietary Fiber 3g	10%
Sugars 4g	
Protein 1g	
Vitamin A 11%	Vitamin C 200%
Calcium 1%	Iron 3%
*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.	
NutritionData.com	

Fig. 1. Nutrition facts of raw, green bell pepper. Source: USDA

Growing Bell Pepper

Bell peppers can be transplanted as a seedling or direct-seeded in to the ground (University of Missouri Extension, 2010). Seeds usually germinate within 2 weeks in the nursery or ground. Commercially, bell peppers are commonly spaced 1-2 feet between plants (single or double rows) and 4-5 feet rows.

In open fields, plants grow up to 2 feet tall (Albert, 2009). They grow best in temperatures of 75-85°F (24-30°C) (Hartz et al, 2008), but can tolerate Guam's hotter temperatures, and can be cultivated all year round on Guam. In tropical regions, bell peppers grow as perennial plants (can grow for more than one season) plants, but because plants are tender and are easily killed by frost, bell peppers are most often cultivated as an annual (one growing season) in temperate regions (University of Missouri Extension, 2010).

A general fertilizer recommendation for one growing season for Bell pepper is 1000 lbs of 18:20:15 (N-P2O5-K2O) per acre, or approximately 2.3 lbs. of the same nutrient ratio for every 100 sq ft. (Hartz et al, 2008).

Bell Pepper plants grow best in moderately fertile, well-drained soils (Iowa State University Extension, 2009) such as Akina silty clay, Guam-Saipan complex, Guam-Yigo complex, Pulantat clay, and Togcha soils. Guam cobbly clay loam is a shallow limestone soil that is not very fertile, but with proper management, bell pepper can be productive in this soil. The plants are not particularly sensitive to soil pH, but best results are obtained when soil is in the 6.0-6.8 range (Iowa State University Extension, 2009).

Watering regularly will keep your plants producing fruits. Bell pepper plants prefer moist but not wet soils (Institute of Food and Agricultural Sciences, University of Florida, 2014). Irrigation of bell pepper should consist of light, frequent watering. During dry periods, ensure soils are kept moist and not saturated. During extended rainfall events, watering may not be necessary until soils are nearly dried up. Mulching around pepper plants will conserve moisture.

Common Pests and Diseases

Bell pepper is a host for a wide range of pests and diseases. Many of these pests and diseases are found on Guam.

Some common insects of peppers found on Guam include aphids (Family: Aphididae), whiteflies (*Bemisia spp.*), fire ants (*Solenopsis geminata*), leafhoppers (*Liriomyza spp.*), green semi-looper (*Chrysodeisix eriosoma*), and the cluster caterpillar (*Spodoptera litura*).

Registered insecticides can help control insect infestations. Insect pests can also be controlled by cultural practices such as monitoring, crop rotation, weeding, and general field sanitations (Seminis, 2006; Guam Cooperative Extension, 2016).

Some common diseases include Bacterial Spot (*Xanthomonas campestris*) (bacteria), Bacterial Wilt (*Ralstonia solanacearum*) (bacteria), Cercospora Leaf Spot (*Cercospora spp.*) (fungus), Damping Off (*Pythium spp.*) (fungus), Anthracnose Fruit Rot (*Colletotrichum spp.*) (fungus), Cucumber Mosaic (*Cucumber mosaic virus*) (virus), and Tobacco Mosaic Virus (virus). Some fungal and bacterial disease can be controlled with registered fungicides and bactericides. Viral diseases may not be controlled, but controlling the insect vector will reduce spread of the virus. Some prevention measures to reduce chances of diseases and avoid pesticide use include growing bell pepper in full sunlight, avoid long periods of soil saturation, keep farm tools clean, and choose disease resistant varieties if possible (Seminis, 2006; Guam Cooperative Extension, 2016).

Plant Care

It is always good practice to consistently monitor plants for pests and diseases. If a pest or disease is unknown, collect samples if possible and submit to CNAS Extension & Outreach program for correct identification and treatment recommendations.

Weeding and mulching around plants will reduce weed competition and conserve soil moisture.

It is also advisable to keep good records of all field activities. Good record-keeping will identify good practices and mistakes, along with identifying desired varieties of plants. This will improve decision-making for future crops.

Harvest

Bell peppers can be harvested at any stage of fruit growth desired. Most varieties mature approximately 60-90 days after planting. Fruits are often harvested when green, but can be left on the plant longer to ripen to full maturity and change color to red, orange, yellow, and other colors depending on variety. With

proper management and care, plants can produce quality harvest for more than one growing season.

Post-Harvest Handling

Immediately after harvest, bell peppers should be cooled and stored at 45-50°F (7-10°C) at 95 percent relative humidity to slow down water loss and decay. Bell peppers stored at temperatures colder than 45° (7°C) will result in chilling injury. Extended periods of storage at temperatures greater than 50° (10°C) will cause peppers to change color, lose fresh weight and decay. (University of Missouri Extension, 2010)

2016 Bell Pepper Trial on Guam

There are numerous bell peppers varieties available on the internet from seed companies like Baker Creek Heirloom Seed Co. (<http://www.rareseeds.com/>), Kitazawa Seed Co. (<http://www.kitazawaseed.com/>), Johnny's Selected Seeds (<http://www.johnnyseeds.com/>), Burpee (<http://www.burpee.com/>), and Twilley seeds (<http://www.twilleyseed.com/Home.html>).

A variety trial was conducted at the Western Pacific Tropic Research Center, Yigo Agricultural Experiment Station, College of Natural and Applied Sciences, University of Guam (Fig. 2). On March 24, 2016, five varieties of bell pepper were transplanted in Guam Cobbly Clay Loam soil, a commonly cultivated soil in northern Guam, after growing in plant trays for 24 days.



Fig. 2. Bell pepper varieties grown in Guam Cobbly Clay Loam in Yigo, Guam.

The five varieties grown for the variety trial included California Wonder, King Arthur F1, Intruder F1, Chinese Giant, and Gourmet F1 (Fig. 3). Growth characteristics were observed and marketable yield data was collected. Harvesting occurred from May 19 through June 27, 2016. Yield data was collected from 1 to 1½ month harvests fruits coming from each of the five varieties. Green fruits were harvested and weighed, and classified as marketable or non-marketable. Attempts to harvest marketable yield of full ripe (red and orange varieties) resulted in mostly diseased fully ripe fruits (Anthracnose fruit rot). The field was terminated due to heavy thrip (*Thrips spp.*) and mite (*Steneotarsonemus pallidus*) infestations.

Bell pepper varieties

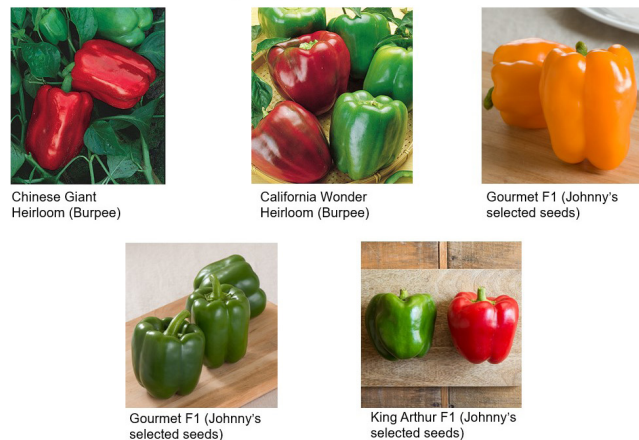


Fig. 3. Five bell pepper varieties trial from respective seed companies (Burpee and Johnny's Selected Seeds) selected for the variety trial. Sources: <http://www.burpee.com/> and <http://www.johnnyseeds.com/>

Marketable fruits harvested from all varieties resulted in slightly smaller sized fruits in comparison to their respective advertised sizes. Intruder F1 and King Arthur F1 produced fruits that nearly equaled advertised sizes. The growing conditions such as extended high temperatures of 90°F (32°C) and above (May-June, 2016) and particularly the low fertility of Guam Cobbly Clay Loam soil may have been contributing factors to the plants producing smaller than advertised size of fruits. Advertised sizes and average of harvested sizes of length from this variety trial (Length x Width) for varieties are shown in Table 1.

Variety	Advertised Length x Width (in)	Advertised Length x Width (cm)	Average Harvest from Trial Length x Width (in)	Average Harvest from Trial Length x Width (cm)
California Wonder	4 x 3.5	10 x 9	3 x 3	8 x 7
Chinese Giant	4 x 4	10 x 10	3 x 3	8 x 7.5
Gourmet F1	4 x 4	10 x 10	3 x 3	8 x 7
Intruder F1	4 x 4.75	10 x 12	4 x 4	10 x 10
King Arthur F1	4.5 x 4.5	11 x 11	4 x 4	10 x 9.5

Table 1. Advertised and Average Harvested Bell pepper fruit sizes from selected varieties (Length x Width).

All varieties produced marketable quality green fruit, but as indicated earlier, most fully maturing fruits were infected with anthracnose fruit rot (Fig. 4, Fig. 5, and Fig. 6). Gourmet F1, in particular, was singled out to await full maturity because of its attractive orange color when fully ripened. In local stores, orange and yellow bell peppers are sold at a range of \$4.99-\$6.99/lb versus mature green and fully ripened red bell peppers which are commonly sold at a range of \$3.99-\$4.99/lb. Sun scalding, fruit damage from extreme exposure to sun rays, occurred on a few fruits, particularly those not protected from canopy/leaf cover. Heavy thrip and mite infestations were apparent in the first week June. These infestations inhibited plant productivity resulting in very poor growth and development of immature fruits (Fig. 7). Fig. 8 are bar graphs depicting results from harvest data from the variety trial.



Fig 4. King Arthur F1 harvest at mature green stage.



Fig 5. Intruder F1 harvest at mature green stage.



Fig 6. Gourmet F1 harvested at full maturity infected with Anthracnose fruit rot.



Fig 7. Heavy mite infestation on immature fruit.

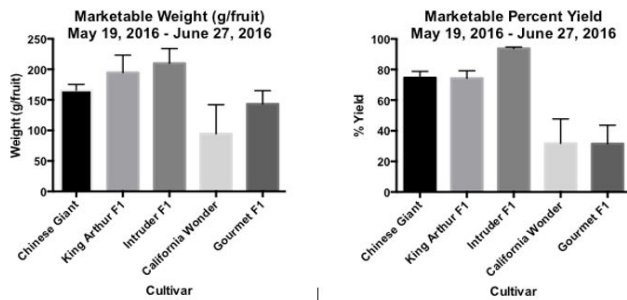


Fig 8. Bar graphs depicting results of harvest data recorded from Bell pepper variety trial. Harvest data was collected from May 19-June 27, 2016.

Discussion

Bell pepper is a nutritious vegetable that can be grown commercially or in home gardens. It is served in many restaurants and home prepared meals on Guam. Thus, there is surely a high demand for bell pepper. In recent research, all varieties produced well, but must be watched for infestations. Bell pepper is definitely a potential commercial crop for Guam growers. Historically, bell pepper has been commercially cultivated locally. Currently, only a very small number of local producers cultivate bell pepper. When choosing a variety, it is advisable to choose those that have resistance to certain diseases, and those that can tolerate high temperatures of 90°F (32°C) and above.

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