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Poster #20

Papaya Growth in Double-Row Systems Established During the Dry Season

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ABSTRACT.
Papaya is an important fruit in the tropics due to its nutritional level and year round production. Papaya production in the Virgin Islands is hindered by the lengthy dry season in this semi arid environment where fresh water is lacking. Three selected papaya varieties, 'Maradol', 'Tainung 5' and 'Yuen Nong 1' were grown in 1 x 1 m, 1 x 2 m or 1 x 3 m double-row spacing regime randomized block design incorporating drip irrigation with 4L/hr emitters at 1 m intervals and grass-hay mulch. The objective was to determine water usage, plant growth and fruit set during the first six months establishment in the dry season of the U.S. Virgin Islands. Tensiometers set at 30 cm depth were used to determine when water was applied and indicated that the 1 x 1 m double row depleted the water quicker than the other two spacing regimes. Data was collected included: rainfall, irrigation water applied, plant height, height to first flower, height to first fruit, stem diameter at 1 m and number of fruit set after six months. Plants grown in the 1 x 1 m double row were taller, had thinner stems and significantly fewer fruit set for all varieties during the six months of plant establishment and growth. The 1 x 2 m double row grown papaya were similar to the 1 x 3 m double row plants for height, stem diameter and fruit set. The 1 x 2 m double row growing system is recommended to increase production where space and water are limiting factors. A grass/hay mulch is very effective in controlling weeds, conserving soil moisture and protecting the soil from erosion during sudden short heavy tropical rains.

INTRODUCTION

The crop farms in the U.S. Virgin Islands are mainly comprised of small farmers. The average amount of land for a crop farmer is 4.7 acres (National Agricultural Statistics, 2000). Though this average includes livestock farmers, the crop farmers are less than 2 acres. The small size limits the investment the farmer can make to produce a crop. They have to see a strong benefit to a technology before they invest in it and adapt it to their farming practices. New technologies are being developed for papaya production. Papaya requires nine months from seed, in the early varieties, to have a marketable crop. To have fruits available during the holiday season and peak tourist season, papayas need to be planted in late February through March. However, February through August are normally the driest months of the year in the US Virgin Islands.

Plant spacing from the past project indicated that growth and production were not influenced by plant spacing (Kowalski and Zimmerman, 2006). The plant spacing was 3 m x 3 m, 2 m x 3 m and a double-row 1 m x 3 m. The double-row provided a higher planting density and a more efficient use of space and irrigation water.

Drip irrigation technology permits the resourceful use of water and can help maximize the use of semiarid lands for agricultural use. This technology is particularly

suited to widely spaced crops as papaya. Though multiple field trials have shown the economic beneficial use of drip irrigation on vegetable and herb production in the Virgin Islands (Palada et al, 1995; Crossman et al, 1997; Palada and O'Keefe, 2001) limited information is available on the use of drip irrigation for papaya production (Kowalski and Zimmerman, 2001; 2006). It has been suggested that the water needs for papaya in Hawaii are ideally supplied with 100 mm of rainfall each month (Nakasone and Paull, 1998). This amount is seldom encountered in the semiarid climate of the Virgin Islands where erratic rainfall patterns and extended dry periods are the norm. Also, the local preference is for large, greater than two pounds, red papayas while most papaya research from Hawaii has focused on small, yellow one pound or smaller fruit. Not only are the varieties different between the Virgin Islands and Hawaii but also the soil. The soils of the Virgin Islands are calcareous, having a high pH around 8 versus volcanic base in Hawaii. Breeding and selection of papayas at the University of the Virgin Islands has resulted in early bearing varieties that meet the fruit preferences of the Virgin Islanders (Zimmernan and Kowalski, 2004).

Water is most often the limiting factor to crop production in the U.S. Virgin Islands. The municipal source of water is from desalination of ocean water. Due to the cost of the desalinated municipal water, farmers use the water sparingly. The most efficient use of water can result in economical gains for the local farmers. This research expanded on the double-row concept to include closer double-row spacing to determine the best intensive plant spacing for the most efficient use of water for fruit set.

MATERIALS & METHODS

The objectives of this research were to develop a commercial papaya producing field plot that incorporates drip irrigation and mulch for growing selected papaya varieties at multiple double-row spacing regimes and determine water usage during the dry season in the U.S. Virgin Islands. Specifically to integrate water conservation through drip irrigation and mulching into papaya production, determine water requirements of papaya grown under multiple double-row plant spacing regimes and determine the growth and production potential of papaya as influenced by spacing under drip irrigation and biodegradable mulch.

Papaya plants were established in double-row spacings during February from greenhouse grown seedlings. Water usage was recorded over a six month period which corresponds to the annual dry season from March through August with the assistance of a prebaccalaureate student. Tensiometers were used to record soil moisture levels and determine when irrigation water needed to be applied.

To study the integrate water conservation through drip irrigation and mulching into papaya production, papaya were established from seed in a greenhouse one and a half months prior to transplantation to the field at the University of the Virgin Islands Agricultural Experiment Station on St. Croix. The three varieties used were 'Maradol', 'Tainung 5' and 'Yuen Nong 1'. 'Maradol' is a compact variety producing red 4-5 lb fruit. 'Tainung 5' and 'Yuen Nong 1'are standard sized trees that produce large red and yellow fruit respectively.

A double-row plant spacing regime was followed. A nine foot distance was between double-rows to allow for tractor cultivation until the plants attain three feet. Each double-row was three feet apart. The distance between each plant within a row of

the double-row varied from three feet, six feet or nine feet which corresponds to 2,400, 1,200, or 800 plants per acre respectively. Each plant spacing was replicated three times and had ten plants of each variety per replication. Guard rows were planted on both sides of the field and between replications. Guard plants were also planted at the end of each row.

One drip line of irrigation was installed at the time of transplanting six-eight inch tall seedlings into the field. The spacing of the orifices in the linear irrigation tubing was three feet and exude one gallon per hour. The drip lines were placed near the plant base and moved outward to a distance of 1.5 feet from the base of the plant. A final drip line was added between the double rows when the plants were at three feet in height. The double rows then had a drip line outside of each row and one between the double-rows for a total of three lines per double-row. Hay mulch was applied to the whole field after the third drip line was installed. The drip lines were under the mulch and in contact with the soil. The hay mulch was spread to a depth of the three inches between plants and rows. The straw/hay was obtained from the VI Department of Agriculture as large round bales.

To determine water requirements of papaya grown under double-row plant spacing regimes soil moisture tensiometers were placed throughout the plots at a depth of 15 cm and 30 cm. The tensiometers were used to determine soil moisture content. Water meters were installed for each plant spacing plots and the amount of water applied recorded over time. Rainfall information was obtained from the IVI-AES weather station.

During the initial six month growth of the papaya plot corresponding to the dry season, data was collected on plant height, height to first flower, height to first set fruit, stem diameter at three feet from the soil surface and number of fruit set when the first fruit was ripening. This growth and production data was obtained to determine the influence of spacing and drip irrigation on papaya yield.

RESULTS AND DISCUSSION

Papaya were established under field plot conditions in early 2007 from seeds germinated in a greenhouse. The first six months of 2007, during the establishment of the papaya plot, a typical dry season was experienced on St Croix (Figure 1). Low rainfall started in January and when plant establishment occurred in early February, the soil was dry. There was a spike in rainfall during April. Heavy rains were received that lasted a week and provided seven inches of rainfall. The soil moisture content was at field capacity during these heavy rains causing the tensiometer to read zero for ten days (Figure 2). The soil tensiometers' readings increase in value as the soil dries. When the soil is saturated the readings decrease to zero. Figure 2 also indicates that plant spacing did have an influence on soil moisture available to the plants. The same dripline, with three foot emitters, was used for all spacing treatments and the 1 m x 1 m double row spacing configuration had drier soil before and after the heavy April rains. The closer the plant spacing results in more competition from the plants roots for the water available in the soil. The papaya plants in the 1 m x 1 m spacing competed more for the available water, reducing the soil moisture quicker, then was observed for either the 1 m x 2 m or 1 m x 3 m double row spacing.

During the initial six months of papaya establishment and growth, water was applied as indicated in Figure 3. The wet soils from the heavy April rains resulted in less water being applied to the papayas in April. The mulch was very effective in controlling weeds, conserving soil moisture and protecting the soil from erosion during sudden short heavy tropical rains. However, the straw mulch absorbs the light showers preventing the water from reaching the soil. Most light showers have minimal effect on the soil and availability to plants due to the high evaporation rate (Goenaga et al., 2004). The total amount of water given to each plant was 62 gallons over seven and one half months for the 1 m x 2 m plant spacing during which plant establishment, floral induction and fruit set occurred.

Plant spacing did have an influence on the height of 'Maradol' plants over time. After two months of growth, the 1 m x 1 m spacing caused the plants to be taller then the more distant spacings (Figure 4). 'Maradol' is a compact papaya variety that has a slower rate of growth but the close plant spacing caused it to stretch to have a difference of 50 cm by the forth month. 'Maradol' grew at the same rate for the 1 m x 2 m and 1 m x 3 m plant spacing.

Both 'Tainung 5' and 'Yuen Nong 1' are standard sized papaya trees. However, the close 1 m x 1 m spacing had taller plants after one month (Figures 4 and 5). The leaves start interacting with each other after a month's growth at the close plant spacing. As the plants became taller with age, the close spacing caused the plants to grow outwards resulting in a 'V' shaped double row. This leaning outward was not observed in the 1 m x 2 m or 1 m x 3 m spacing which grew perpendicular to the soil.

The stem diameter can have an influence on the plants ability to support a column of fruit as well as have tolerance to wind. Thinner stemmed plants tend to snap in wind when carrying a heavy fruit set. These varieties are grown because they are able to set 30-50 fruits (Kowalski and Zimmerman, 2001). For all three varieties the close plant spacing had the thinnest stems (Table 1). The 1 m x 3 m plant spacing resulted in significantly thicker stems then the 1 m x 1 m spacing. With 'Tainung 5' both the 1 m x 3 m and 1 m x 2 m spacing had significantly thicker stems then the 1 m x 1 m spaced plants.

The height to first flower and height of the first set fruit indicate how low the fruit is set on the stem. These three varieties were chosen because they set fruit early. Flowers are present between the first and second of field establishment. Papaya trees that set fruit early have a lower center of gravity and less prone to high winds (Zimmerman and Kowalski, 2004). Both the 1 m x 2 m and the 1 m x 3 m spaced plants had earlier flowering and fruit set lower to the soil surface for all varieties then the 1 m x 1 m plants (Figure 7). Lower fruit set also allows more fruit to be within reach for a longer period of time.

The main reason for growing papaya is for production. The number of fruit set on a papaya stem column was recorded when the first fruit ripened and indicates expected production for the tree. For all three varieties, the 1 m x 1 m double row spacing set significantly less fruit then either the 1 m x 2 m or 1 m x 3 m double row spacing (Figure 7). This indicates that the close plant spacing can't hold as many fruit and may be influenced by the water availability to the plant previously discussed. The 1 m x 2 m and 1 m x 3 m double spaced plants were not significantly different for fruit set. The 1 m x 2

m double row spacing was the most efficient for water usage and land area to produce the most fruit.

CONCLUSIONS

The papaya plants for 'Maradol', 'Tainung 5' and 'Yuen Nong 1', grown in a 1 m x 1 m double row system were taller, had thinner stems and significantly fewer fruit set then the 1 m x 2 m or 1 m x 3 m double row spacing regime during a normal dry season of six months for plant establishment and growth. The 1 m x 2 m double row grown papaya were similar to the 1 m x 3 m double row plants for height, stem diameter and fruit set. The 1 m x 2 m double row growing system is recommended to increase production where space and water are limiting factors. A grass/hay mulch is very effective in controlling weeds, conserving soil moisture and protecting the soil from erosion during sudden short heavy tropical rains.

REFERENCES

Crossman, S.M.A., M.C. Palada and J.A Kowalski. 1997. Comparison of mulch type effect on yield of parsley in the Virgin Islands. Caribbean Food Crops Society. 33:216-220.

Goenaga, R., E. Rivera and C. Almodovar. 2004. Yield of papaya irrigated with fractions of class A pan evaporation in a semiarid environment. Journal of Agriculture University of Puerto Rico 88:1-10.

Kowalski, J.A. and T.W. Zimmerman. 2001. Evaluation of papaya germplasm in the U.S. Virgin Islands. Caribbean Food Crops Society. 37:24-28.

Kowalski, J.A. and T.W. Zimmerman. 2006. Papaya production under different spacing regimes. Caribbean Food Crops Society. 42: 399-402.

Nakasone H.Y. and R.E. Paull. 1998. Tropical Fruits. CAB International, New York, NY

National Agricultural Statistics. 2000. Virgin Islands of the United States 1998 Census of Agriculture. http://www.nass.usda.gov/census/census97/vi/vi.htm

Palada M.C. and D.A. O'Keefe. 2001. Response of hot pepper cultivars to levels of drip irrigation. Caribbean Food Crops Society. 37:190-196.

Palada M.C., S.M.A. Crossman and J.A Kowalski. 1995. Water use and yield of basil as influenced by drip irrigation levels and mulching. Caribbean Food Crops Society. 31:143-149.

Zimmerman, T.W. and J.A. Kowalski. 2004. Breeding and selection for early bearing papayas. Acta Horticulturae 632:53-55.

Table 1. Diameter of papaya stems taken at a one meter height for three varieties as influenced by plant spacing in a double row system.

	Spacing (ft)*		
Variety	**3x3**	**3x6**	**3x9**
Maradol	**6.70 a**	**7.80 ab**	**9.01 b**
Tainung 5	**6.49 a**	**8.67 b**	**9.36 b**
Yuen Nong 1	**7.01 a**	**8.35 ab**	**9.86 b**

*Mean separation within rows conducted using LSD P=0.05

Table 2. Number of fruit set at the time of the first ripe fruit for three papaya varieties as influenced by plant spacing in a double row system.

	Spacing (ft)*		
Variety	**3x3**	**3x6**	**3x9**
Maradol	**23.3 a**	**35.9 b**	**38.8 b**
Tainung 5	**27.9 a**	**46.1 b**	**49.0 b**
Yuen Nong 1	**23.1 a**	**36.5 b**	**39.1 b**

*Mean separation within rows conducted using LSD P=0.05

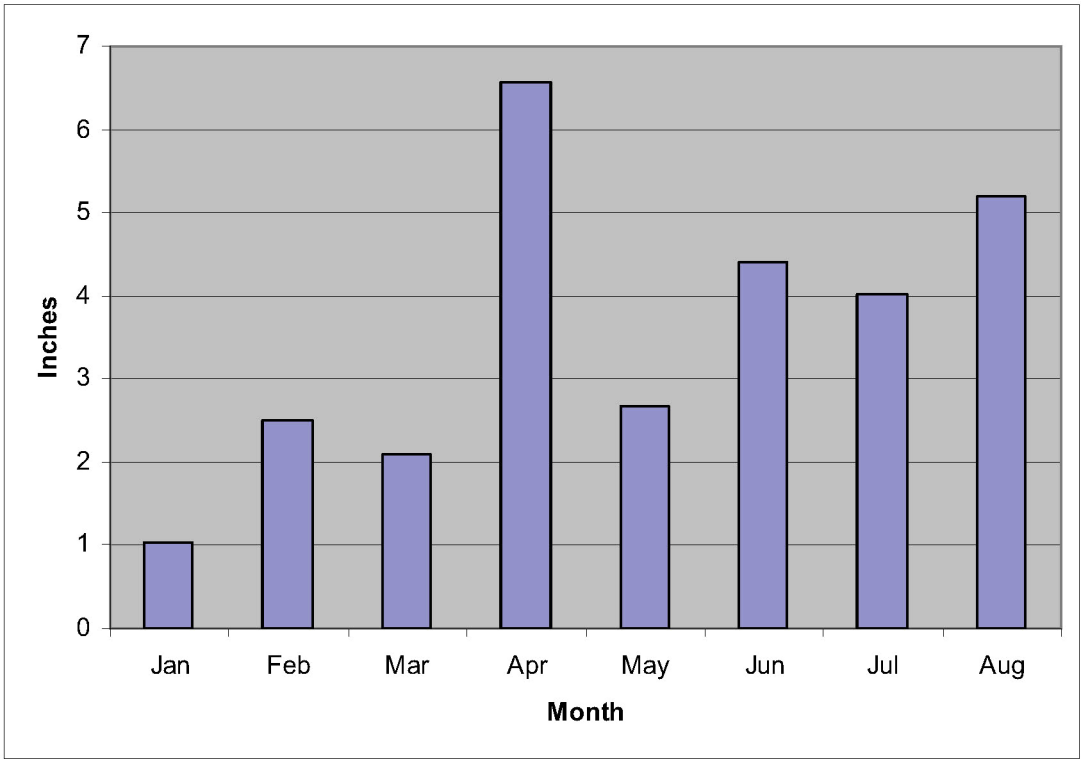

Fig. 1. Average monthly rainfall during 2007.

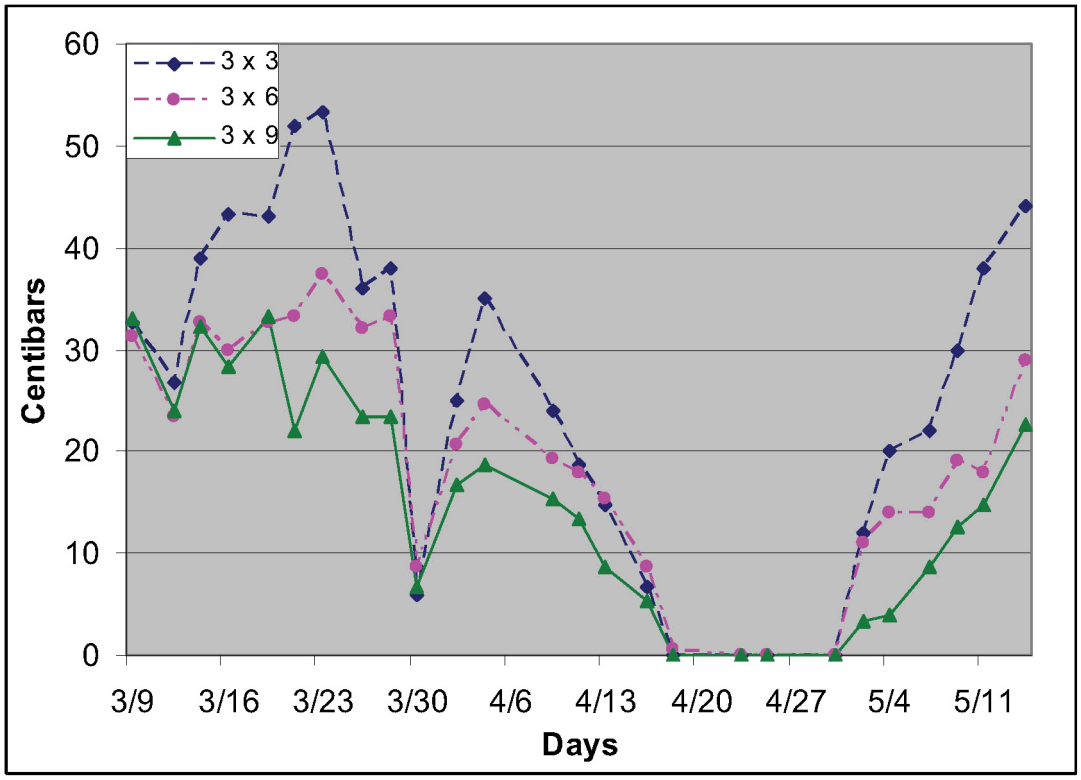

Fig. 2 Soil tensiometer readings, in centibars, over time for each papaya spacing.

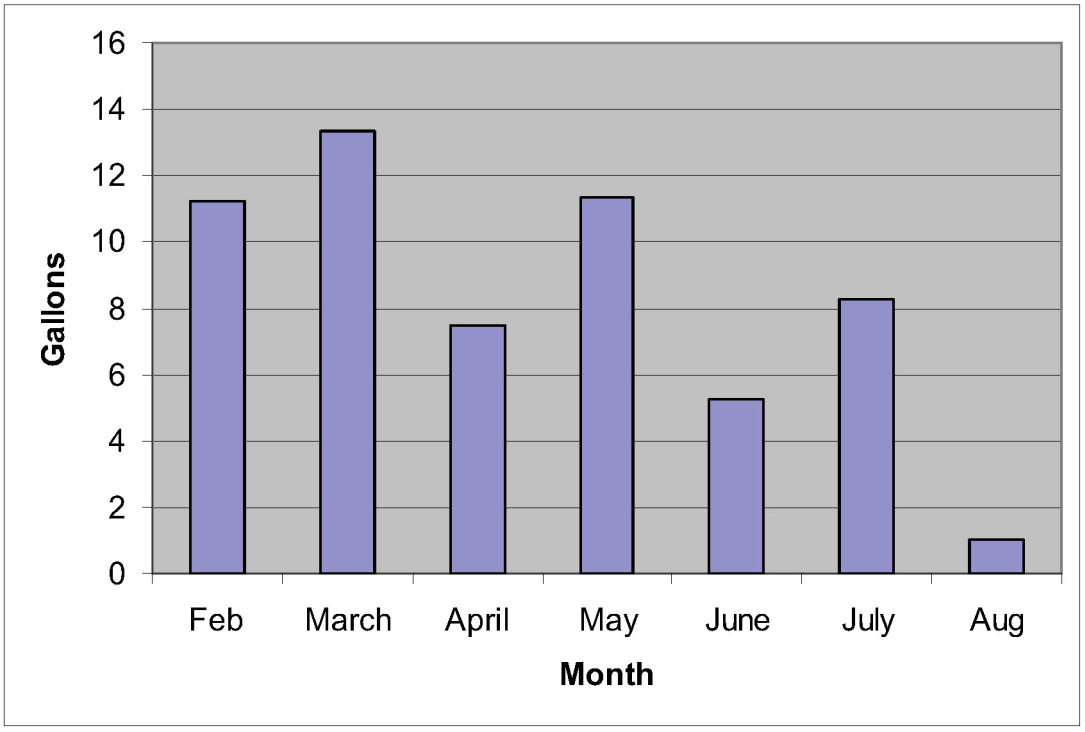

Fig. 3. Average gallons of water applied to each papaya plant.

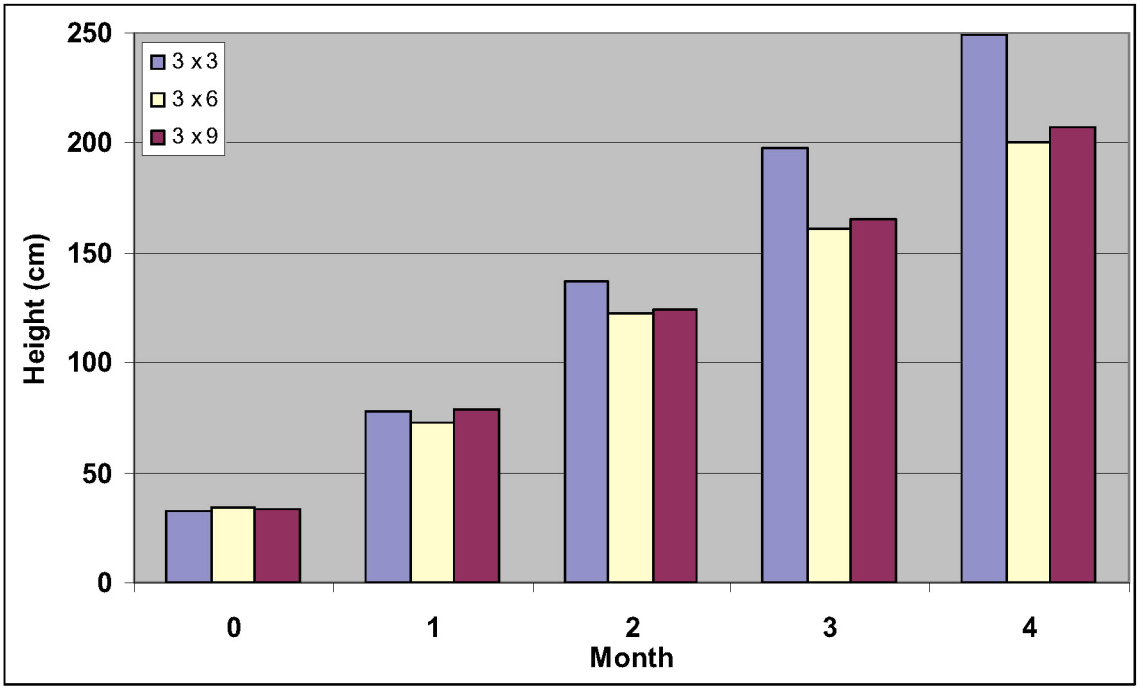

Fig. 4. Plant height of the 'Maradol' papaya plants during the first four months.

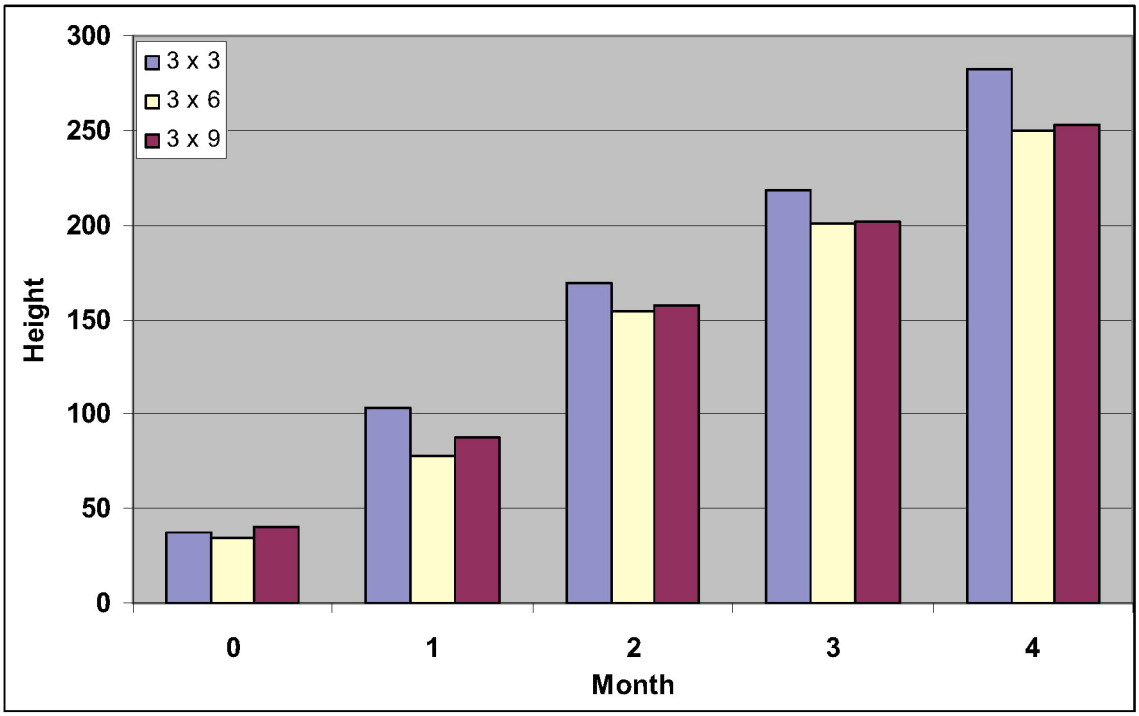

Fig. 5. Plant height of the 'Tainung 5' papaya plants during the first four months.

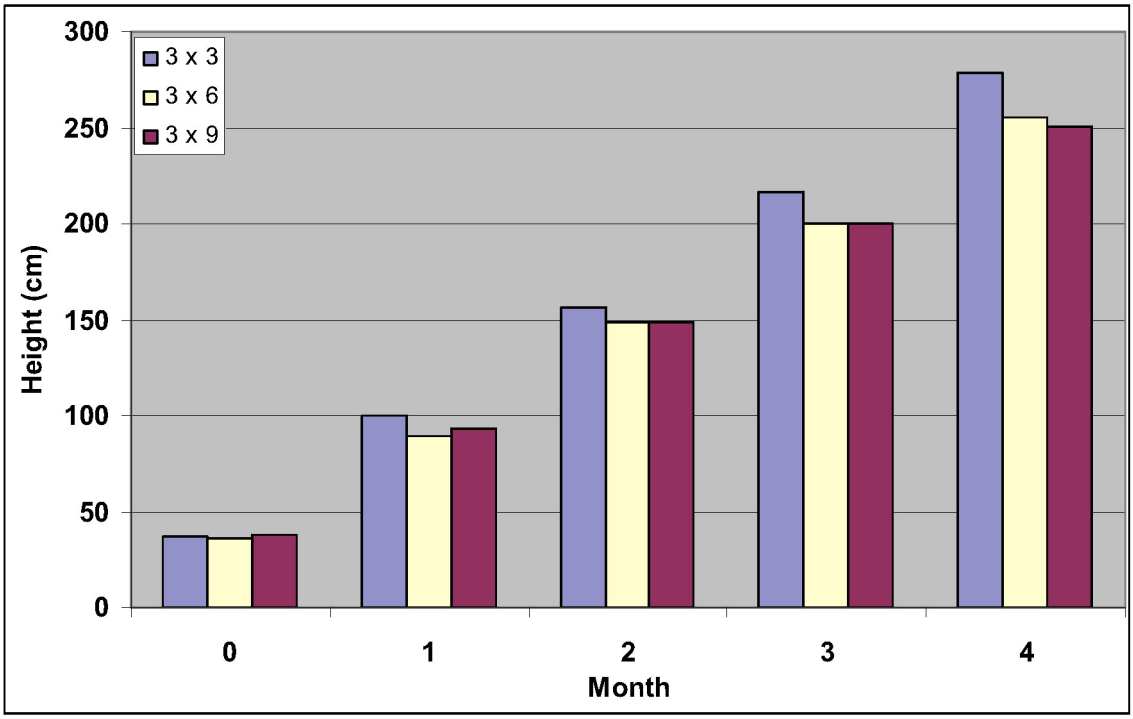

Fig. 6. Plant height of the 'Yuen Nong 1' papaya plants during the first four months.

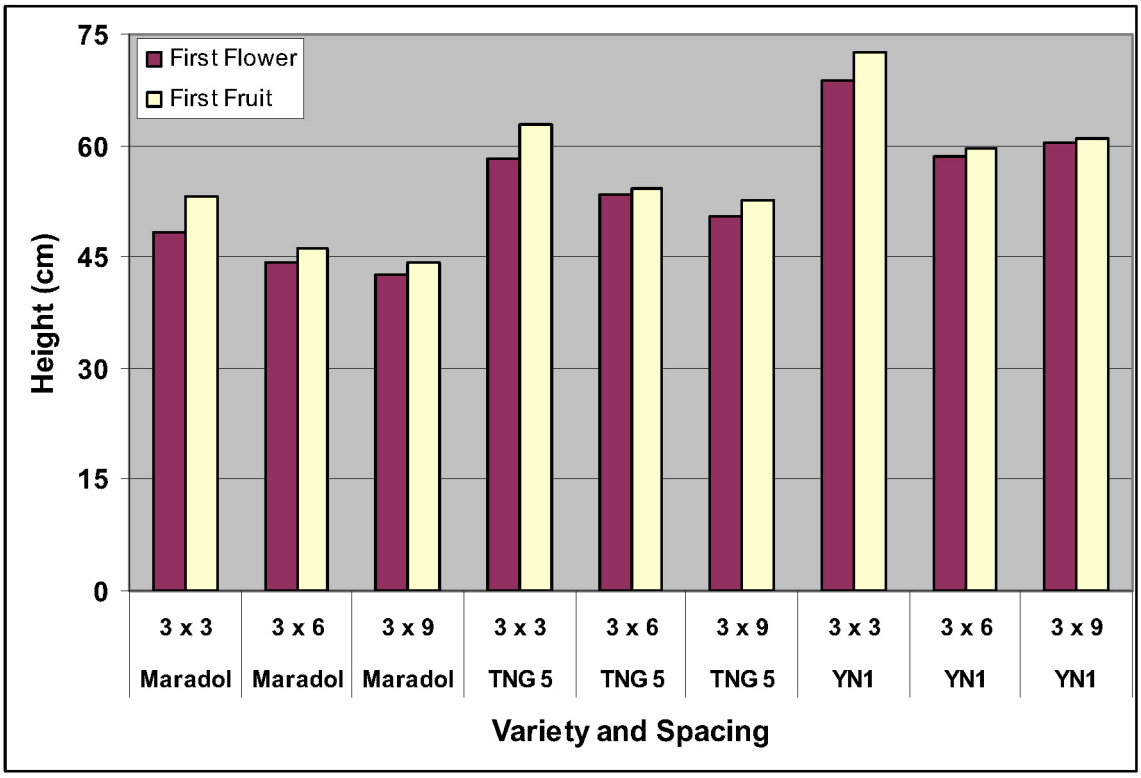

Fig. 7. Effect of plant spacing on the initiation of the first flower and setting of the first fruit for three papaya varieties.