Planting Density Influenced the Fruit Mass and Yield of 'Sensuous' Pineapple

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ABSTRACT

One of the approaches to attain better yield especially in newly developed fruit crop varieties is through planting density optimization. Hence, this study was conceptualized to 1) determine the effects of varying planting densities on the vegetative growth of 'Sensuous' pineapple, 2) evaluate the effects of planting density on the fruit mass and yield of 'Sensuous' pineapple and 3) compare the fruit chemical properties of 'Sensuous' pineapple at varying planting densities. Treatments include 45,000, 55,000, 65,000 and 75,000 planting density hectare^{-1}, respectively. The experiment was laid-out in a randomized complete block design (RCBD) with four replications. Results revealed that growth of 'Sensuous' pineapple was comparable in all planting densities. The lower planting densities hectare^{-1} (45,000 and 55,000) resulted to heavier fruit mass. On the other hand, yield hectare^{-1} was directly proportional with planting density. Nonetheless, fruit chemical properties were not affected by planting density. Results indicate that fruit mass and yield of 'Sensuous' pineapple can be improved through appropriate planting density.

Keywords: novel pineapple, planting density, pineapple fruit, fruit mass, pineapple yield

INTRODUCTION

Pineapple, scientifically known as *Ananas comosus*, is found in almost all tropical and subtropical areas of the world, and it ranks third in production of tropical fruits, next to banana and citrus (Paull and Duarte, 2011). In the Philippines, pineapple production in January-March 2016 reached 591.25 thousand metric tons (Philippine Statistics Authority, 2016) of which majority of the produced are being exported to other countries.

Pineapple export industry in the Philippines is concerted in the province of Bukidnon. Among the commercial varieties grown are MD-2, Dole Cayenne and Del Monte Cayenne. New varieties such as "Sensuous", "Ulam Pine" and "PACO" were developed by local plant breeders and already registered in the Plant Variety Protection Office (PVPO) of the Bureau of Plant Industry. 'Sensuous' pineapple was developed by Dr. Juan C. Acosta (T.S. Castro, personal communication, September 11, 2009), a Filipino plant breeder. The variety has high total soluble solids (Valleser and Castro, 2018) content compared to 'MD-2' pineapple and other local varieties. The commercialization of 'Sensuous' pineapple takes place in Mt. Kitanglad Agricultural Corporation (MKADC) at Valencia City, Bukidnon, Philippines. Since this novel pineapple variety was just recently introduced, cultural management practices need to be established specifically planting density hectare^{-1}.

Studies have been conducted using varying planting densities hectare^{-1} in PR-1 67 (Ramirez and Gandia, 1980), Chinese Smooth Cayenne (Hung et al., 2011) and MD-2 (Genefol et al., 2017) pineapple cultivars. Pineapple planting densities vary according to the cultivar, product destination, level of mechanization, use of irrigation and other factors (Malézieux et al., 2003). High planting densities favours greater productivity, lower densities generally permit the production of a higher percentage of large fruits, which get higher prices in the market for fresh fruits (Malézieux et al., 2003). Hence, this study was conducted to 1) determine the effects of varying planting densities on the vegetative growth of 'Sensuous' pineapple, 2) assess the effects of planting density on the fruit mass and yield of 'Sensuous' pineapple and 3) evaluate the fruit chemical properties of 'Sensuous' pineapple at varying planting densities.

MATERIALS AND METHODS

The experiment was conducted at the Pineapple Research Station of Mt. Kitanglad Agricultural Development Corporation, Valencia City, Bukidnon, Philippines on November 2010 to January 2013.

Healthy suckers (250-300 grams) used in the experiment were collected from 'Sensuous' pineapple planting material production field at MKADC Research station. Collected suckers were cured and treated with recommended fungicide and insecticide following the standard practice of MKADC commercial pineapple farm.

The experiment site was prepared following the recommended practice of MKADC commercial pineapple farm. Varying planting densities (Table 1) served as treatments. The experiment was then laid-out in a randomized complete block design (RCBD) with four replications resulting to 16 plots. Each plot measured 26.94 m^2 with four seedbeds. The two inner seedbeds served as the data rows, whereas the two outer seedbeds as the border rows. An alley of 0.5 meter separated each treatment plot within a replication or block.

Experiment plants received similar intercultural management practices except planting density which served as treatment. Recommended flower-induction treatment solution (1.5% calcium carbide) was applied when 'Sensuous' pineapple plants were 11.5 months old after planting.

Table 1. Detailed description of planting densities used in the study

PLANTING DENSITY HECTARE^{-1}	ROWS BED^{-1}	DISTANCE BETWEEN HILLS (cm)	CENTER OF SEEDBEDS DISTANCE (m)	WALK SPACE (m)	BLOCK WIDTH (m)
45,000	2	33.00	1.347	0.838	33.53
55,000	2	26.90	1.347	0.838	33.53
65,000	2	22.90	1.347	0.838	33.53
75,000	2	19.80	1.347	0.838	33.53

Data Gathered

1. Plant Biomass- this was taken at 11.5 months after planting (MAP) or at flower-induction treatment. Three randomly selected plants from the border rows were uprooted and weighed using a pre-calibrated weighing scale. Mean plant biomass was computed using the formula:

$$\text{Plant biomass (kg)} = \frac{\sum \text{Plant biomass (kg)}}{\text{No. of plant samples}}$$

2. D-leaf Mass- D-leaf is the longest leaf of a pineapple plants. 10 D-leaf samples were pulled-out from 10 plant samples in the border rows. D-leaf samples were weighed using a pre-calibrated weighing scale. Mean D-leaf mass was computed using the formula:

$$\text{D-leaf mass (g)} = \frac{\sum \text{D-leaf mass (g)}}{\text{No. of D-leaf samples}}$$

3. Fruit Mass- fruits in the data rows were harvested manually when 30-40% of the peel exhibits yellow color. All harvested fruits were weighed using a pre-calibrated weighing scale. Mean fruit mass was computed using the formula:

$$\text{Fruit mass (kg)} = \frac{\sum \text{Fruit mass (kg)}}{\text{No. of harvested fruits}}$$

4. Yield- The formula was used to compute the yield (kg hectare^{-1}) of ‘Sensuous’ pineapple:

$$\text{Yield} = \frac{\text{Mean fruit mass x percent plant survival x planting density x 10,000 m}^2}{\text{Number of data plants x 13.47 m}^2}$$

Yield computed was then converted to tons hectare^{-1}.

5. Total Soluble Solids (TSS)- five randomly selected fruits (1.50-1.75 kg) in each plot were utilized for this data. Pineapple fruit juice was collected per fruit sample and TSS was determined based on the recognized standard procedure (https://archive-resources.coleparmer.com/Manual_pdfs/Sku8115008.pdf) using a refractometer.

6. Titratable Acidity (TA)- 10 mL of pineapple juice was placed inside a beaker, and 2 mL of phenolphthalein solution was added. Titration then followed by adding a basic solution (0.1 N NaOH) to the fruit juice until the color turned to light red. The equation was used to determine the TA:

TA = mL NaOH added x 0.1 (NaOH concentration) x 0.064 x 100 ÷ volume of juice

7. TSS/TA- this was computed using the formula:

TSS/TA= TSS ÷ TA

RESULTS AND DISCUSSION

Plant Biomass

The biomass (fresh mass basis) of ‘Sensuous’ pineapple plants at flower-induction treatment ranged from 3.36-3.53 kg (Table 2) and did not vary significantly in response to the different planting densities used. Data indicates that ‘Sensuous’ pineapple plants in all planting densities are mature enough and inevitably will produce better fruit mass. T.S. Castro (personal communication, July 8, 2006) stated that in order to attain higher recovery of marketable fruits in ‘MD-2’ pineapple, plant biomass must be ≥2.50 kg. Py et al. (1987) reported that average plant mass of most crops decreases with increasing plant population density due to interplant competition for light, but no data illustrating this effect on pineapple were found. Results revealed that the planting densities used in this study did not influenced the biomass of pineapple.

D-Leaf Mass

Malézieux et al. (2003) reported that specific leaf mass of pineapple significantly decreased when planting density was more than 6 plants m^{-2}. A D-leaf is the youngest among the adult leaves of pineapple as well as the most physiologically active. Its mass is reflective of the readiness of pineapple for flower-induction treatment and basis in forecasting fruit mass at harvest.

Table 2. Plant biomass and D-leaf mass of ‘Sensuous’ pineapple at flower-induction treatment in response to varying planting densities

PLANTING DENSITY HECTARE^{-1}	PLANT BIOMASS (kg)	D-LEAF MASS (grams)
45000	3.36	115.12
55000	3.53	113.88

65000	3.53	111.00
75000	3.42	109.50
Significance	ns	ns
cv (%)	4.94	4.52

ns- means within a column are not significantly different at 5 % DMRT

According to Fornier et al. (2006), in pineapple "Flhoran 41", a D-leaf of 70 g is sufficient to get exportable fruits, whereas 80 g is the standard for "MD2" and "Smooth Cayenne". In "Perola", it was recommended that the plant can be induced to flower when D-leaf has a minimum fresh mass of 80 g and a minimum length of 1.0 m in order to get fruits weighing more than 1.5 kg (Reinhardt et al, 1987). However, in this study 'Sensuous' pineapple showed comparable 'D' leaf mass when at varying planting densities.

Fruit Mass

'Sensuous' pineapple showed an increasing fruit mass with decreasing planting density (Figure 1). Heaviest fruit mass (1.77 kg) was obtained in 45,000 planting density and was comparable to 55,000 planting density with fruit mass of 1.68 kg. On the other hand, lightest fruit mass (1.54 kg) was obtained in highest (75,000) planting density per hectare. Result indicates that planting density has a significant influenced on fruit mass of 'Sensuous' pineapple. Experiments on the effect of density on average fruit mass have shown quite predictable results. Average fruit mass decreases linearly with increasing density, but the effect is variety and site-specific (Hepton, 2003). For 'Smooth Cayenne' in Hawaii, fruit mass decreases by 2.4% per 1000 increase in plants per acre over a wide range of densities (Hepton, 2003).

Yield

Yield of 'Sensuous' pineapple was found directly proportional with planting density (Figure 2). Highest yield (101 tons hectare^{-1}) was recorded in highest (75,000) planting density, whereas lowest planting density (45,000) resulted to lowest yield (59 tons hectare^{-1}). Results imply that it is still possible to produce higher yield using ≥75,000 planting densities per hectare. According to Hepton (2003), total yield per unit land area generally increases curvilinearly with increasing density. However, studies also show that at densities higher or lower than 74,000 plants per hectare, the percentage of fruit recovered as well as the quantity and quality of fruit declines (Malézieux et al, 2003). For 'Smooth Cayenne', typical planting density (Hepton, 2003) range from about 60,000 to 80,000 plants ha^{-1}. Hepton (2003) suggests further that the optimum density for a given farm or region and variety must be determined by the available technology, environmental resources and market requirements.

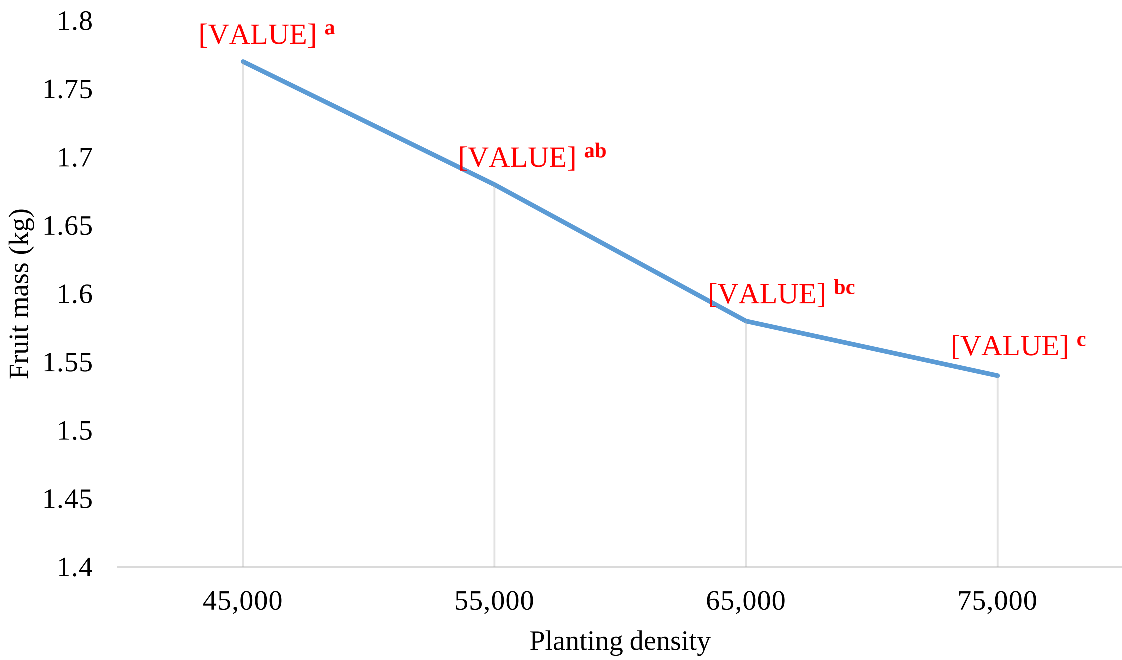

Figure 1. Mean fruit mass of ‘Sensuous’ pineapple at harvest as influenced by planting density

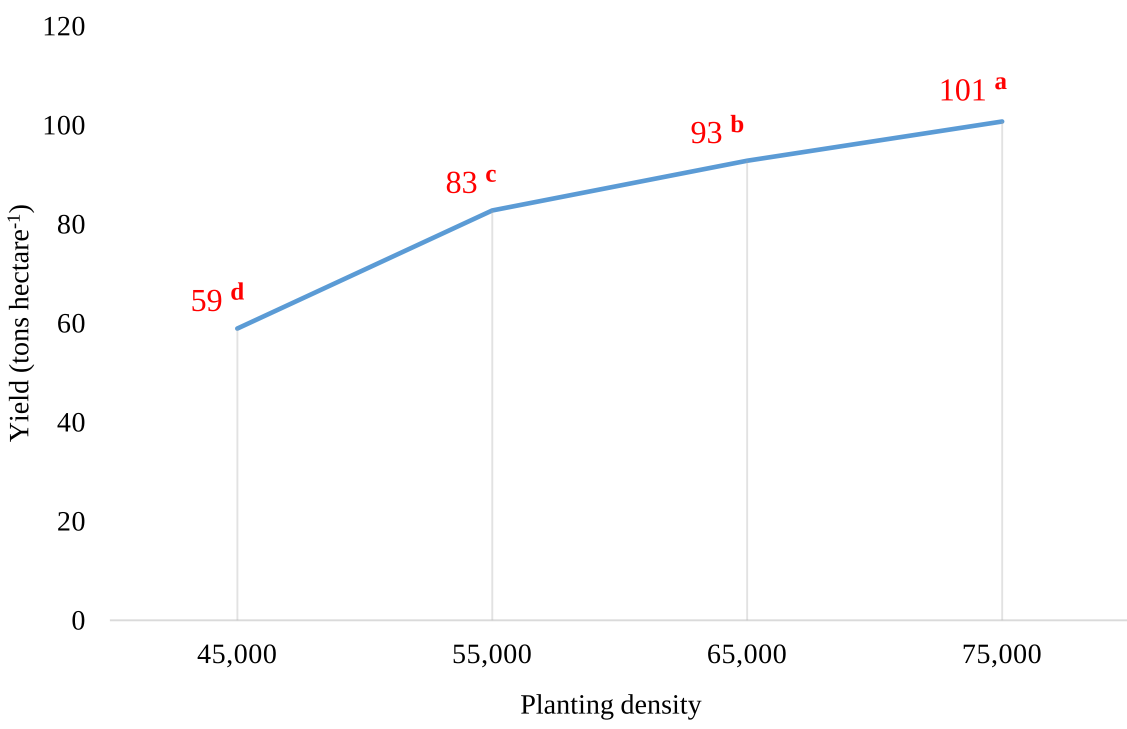

Figure 2. Yield (tons hectare^{-1}) of ‘Sensuous’ pineapple as influenced by varying planting densities

Fruit Chemical Properties

Total soluble solids (TSS), titratable acidity (TA) and TSS/TA of ‘Sensuous’ pineapple fruits were comparable in all planting densities used. TSS (19.82 to 20.17), TA (0.59 to 0.69) and TSS/TA (30.47 to 34.82) values surpassed the market standard which requires only a TSS value of 13, TA value of 0.5-0.7 and TSS/TA value of 20-40 ("Fresh fruit varieties", 2006). At densities above or below 74,000 planting density per hectare, fruit recovery percentage as well as the quantity and quality of fruits declines (Malézieux et al., 2003).

Table 3. Fruit chemical properties of 'Sensuous' pineapple at harvest in response to varying planting densities

PLANTING DENSITY HECTARE^{-1}	TOTAL SOLUBLE SOLIDS (TSS)	TITRATABLE ACIDITY (TA)	TSS/TA
45000	20.09	0.66	31.65
55000	20.14	0.63	32.80
65000	19.82	0.69	30.47
75000	20.17	0.59	34.82
Significance	ns	ns	ns
cv (%)	5.62	13.98	14.43

ns- means within a column are not significantly different at 5 % DMRT

CONCLUSIONS

Results of the study indicates that planting densities used have no significant effects on plant biomass and D-leaf mass of 'Sensuous' pineapple at flower-induction treatment. On the other hand, heaviest fruit can be obtained using lower (45,000 to 55,000) planting density hectare^{-1}. Moreover, yield (tons hectare^{-1}) of 'Sensuous' pineapple is directly proportional with planting density. Highest yield can be attained using highest (75,000) planting density hectare^{-1}. The chemical properties of 'Sensuous' pineapple fruit is not dependent on planting density.

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