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Growth and Fruit Physico-chemical Characteristics of 'MD-2' Pineapple (*Ananas comosus* L.) at Varying Seedbed Configurations

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ABSTRACT

Seedbed configuration inevitably affects the growth and development of fruit crops in a way that canopy overlaps which might lead to intraspecific competition. Hence, this study was conducted to evaluate the effects of varying seedbed configurations on growth and fruit physico-chemical characteristics of 'MD-2' pineapple. The experiment was arranged in a randomized complete block design (RCBD) with four treatments and three replications. Seedbed configurations (25, 28, 30 and 32 seedbeds block^{-1}, respectively) with a constant of 75,000 planting density hectare^{-1} served as treatments. All plants received similar intercultural management practices employed in commercial pineapple farm. Results revealed that growth and fruit physico-chemical characteristics of 'MD-2' pineapple were comparable in all seedbed configurations used. The results indicate that 'MD-2' pineapple production is still feasible using the 25 to 32 seedbeds block^{-1} configurations with a 75,000 planting density hectare^{-1}.

Keywords: 'MD-2' pineapple, pineapple density, pineapple planting, planting configuration, seedbed per block

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INRODUCTION

Pineapple is one of the major fruit crops grown in the world. Its worldwide yield increased from 15.7 million tons in 2001 to 21.6 million tons in 2011 (Genefol et al., 2017). In the Philippines, pineapple production increased by 3.0 percent during last quarter of 2017 reaching the level of 699.22 thousand metric tons (Philippine

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Statistics Authority [PSA], 2017) of which Northern Mindanao region is the major producer.

One of the major factors to consider in commercial pineapple production is seedbed configuration. This cultural management practice could significantly affect the yield and physico-chemical characteristics of fruit crops including pineapple. Several studies have been conducted using varying plant population per hectare in PR-1 67 (*Ramírez* & Gandia, 1982), Chinese Smooth Cayenne (Hung et al., 2011) and MD-2 (Genefol et al., 2017) cultivars using similar number of seedbeds block^{-1}.

Areas intended for mechanized field operations may be laid out in blocks separated by roads. The dimensions of blocks are designed to accommodate equipment and effectively accomplished the required field operations (Hepton, 2003). Each block is typically composed of raised seedbeds. If boom sprayer equipment is to be used, block width is usually twice as wide as the spray boom (Hepton, 2003). In Valencia City, Bukidnon, Philippines, the 25 double row seedbed block^{-1} with a 75,000 planting density hectare^{-1} is recommended for commercial pineapple production (T.S. Castro, personal communication, November 8, 2013). However, this configuration has closer distance between hills which might contribute to inferior plant growth, smaller fruits and/or poor fruit quality.

Hence, this study was conceptualized to evaluate the effects of varying seedbed configurations on the growth and fruit physico-chemical characteristics of 'MD-2' pineapple.

MATERIALS AND METHODS

The experiment was conducted at Mt. Kitanglad Agricultural Development Corporation (MKADC), Lurugan, Valencia City, Bukidnon, Philippines with in an elevation of 450 meters above sea level (masl). The soil was identified as Adtuyon clay. Based on laboratory analysis, soil texture was classified as clay loam. Moreover, soil pH was within the optimum range of growing pineapple. Organic matter, P, Ca and Mg were above the critical levels. Only K was found below the critical level (Table 1) for pineapple production.

Prior to the conduct of experiment, three months fallow period was employed in the particular research area. Harrowing of the experiment area was conducted twice at monthly interval. Deep plowing (mouldboard) then commenced one month after the last harrow activity. Seedbed establishment was done through the use of animal-drawn plow to attain the desired seedbed width, distance between seedbeds and walk-space distances which are some of the variations comprising each treatment (Table 3).

The experiment was laid out in a randomized complete block design (RCBD) with four treatments replicated into three. Each experiment unit had an area of 0.13 hectare with 10,000 plants. Roads were constructed (Figure 1) to separate each experiment unit. Figures 2, 3 and 4 shows the seedbed configurations employed at MKADC farm which served as the control treatment. Distances in Figures 2 and 3 were adjusted and number of seedbeds block^{-1}

(Figure 4) being modified to come up with varying number of seedbeds which served as treatments whereas maintaining the planting density per hectare to 75,000. Regardless of treatment, seedbed height was maintained at 25-30 cm (Figure 5).

Planting material used was medium sucker weighing 300 to 350 grams. Moreover, four data stations comprising a total of 800 data plants (200 data plants station^{-1}) were established within each experiment unit.

Table 1
Soil physico-chemical properties of the experiment area prior to planting

SOIL PHYSICO-CHEMICAL PROPERTY	Texture	pH	Organic Matter (%)	P	K	Ca	Mg
				ppm			
Experiment area	Clay loam	5.00	3.04	16	179	384	121
Critical level[1/]	nd	4.50-5.20	3.00	12	300	100	50

[1/]- critical levels adopted by MKADC (T.S. Castro, personal communication, November 8, 2013)

Similar cultural management practices such as rate/timing of fertilizer application, pest/disease control, and flower induction treatment were employed to all treatments after planting. Total plant nutrients (462 kg N, 143 kg P, 523 kg K, 223 kg Ca, 205 kg Mg, 24 kg Fe, 4 kg Zn, 3 kg B and 560 kg S) per hectare were applied through pre-plant application (dolomite), side dress applications (di-ammonium phosphate, ammonium sulphate, potassium sulphate and magnesium sulphate) and foliar applications (urea, iron sulphate, zinc sulphate, solubor, potassium sulphate, calcium phosphate and calcium boron) based on MKADC farm fertilization program. Flower induction treatment (Ethrel + urea) was applied at 11.5 months after planting (MAP). As a standard practice in commercial pineapple production, degreening or fruit ripening solution (Ethrel + phosphoric acid) was applied 155 days after flower induction treatment. Fruits were harvested at shell color index 2-3. In this experiment, four harvest rounds were made to clear all data fruits in each experimental unit.

Data gathered were the following:

1. Plant height- measurement of plant height was conducted at 6 months after planting (MAP), 8 MAP, 10 MAP and prior to flower induction treatment. Height (ground level to the tip of tallest leaf) of plant was measured using a measuring stick. Average plant height (APH) was computed using the formula:

$$\text{Plant height} = \frac{\sum \text{Plant height}}{\text{Number of data plants}}$$

2. Plant mass- this data was taken at 6 months after planting (MAP), 8 MAP, 10 MAP and prior to flower induction treatment. Three representative plants from the border rows were pulled-out and

weighed excluding the stump apex (below ground level). The mass of three representative plants served as baseline data in estimating the plant mass of data plants. Average plant mass was computed using the formula:

Plant mass =

$$\frac{\sum \text{Plant mass}}{\text{Number of data plants}}$$

3. Fruit size distribution- fruits with peel color index 2-3 based on the MKADC pineapple color index guide (Figure 6) were harvested. A total of five harvest rounds (3 days interval) were conducted to clear all fruits inside the data rows. Harvested data fruits were weighed and sorted using the MKADC grading standard.

4. Fruit mass- all harvested fruits were weighed. Average fruit mass was computed using the formula:

Fruit mass =

$$\frac{\sum \text{Fruit mass}}{\text{Number of data fruits}}$$

5. Plant mortality- plant mortality was gathered during the termination of the research. Missing hills and rotten plants were counted. Percent plant mortality was then computed using the formula:

Plant mortality (%) =

$$\frac{\sum \text{missing hills and rotten plants}}{\text{Number of data plants}}$$

6. Translucency rating- five samples per experimental unit per harvest round were utilized in this parameter. Fruits were cut vertically into halves. Translucency rating was determined using the hedonal rating scale as shown in Table 2. Average translucency rating was computed using the formula:

Average translucency rating =

$$\frac{\sum \text{Translucency rating}}{\text{Number of fruit samples}}$$

7. Total soluble solids (TSS) - five samples per experimental unit per harvest round were utilized in this parameter. Pineapple fruit juice (10 mL) was extracted and brix was measured using an Atago handheld refractometer.

Table 2
Determination of translucency rating using the hedonal rating scale

TRANSLUCENCY RATING	DESCRIPTION	REMARKS
1	No translucence	Good fruits for export
3	Translucence affecting ≤10 % of flesh	Tolerable for export
5	Translucence affecting ≤15 % of flesh	Tolerable for local
7	Fruits with translucence affecting >15% of flesh	Reject

8. Titratable acidity (TA) - five samples per experimental unit per harvest round was utilized in this parameter. Pineapple fruit juice (10 mL) was placed inside a beaker, and 2 mL of phenolphthalein solution was added. Titration then follows by adding a basic solution (0.1 N sodium hydroxide, NaOH) to the fruit juice until the color turns to light red. The formula was then used to determine the %TA:

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

9. TSS/TA- five samples per experimental unit per harvest round were utilized in this parameter. This was determined using the formula:

   TSS/TA= TSS ÷ TA

Statistical Analysis

All data gathered were subjected to analysis of variance (ANOVA) using the Statistical Package for the Social Sciences (SPSS) 14 for Windows Evaluation version program. Standard deviation of means was also computed. Post hoc comparison between means was not performed since all data were not statistically different based on the ANOVA.

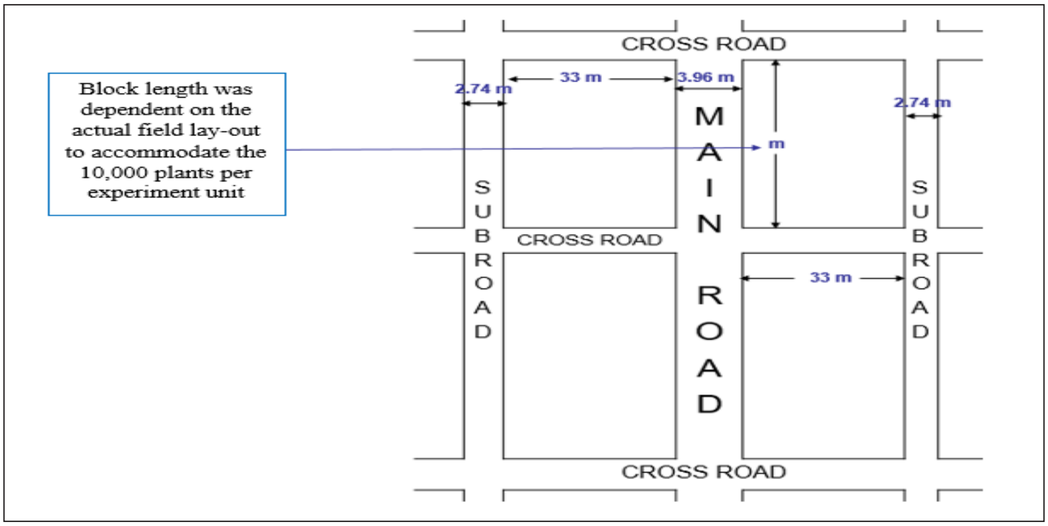

Figure 1. A typical view of the roads' dimensions which separate each experiment unit

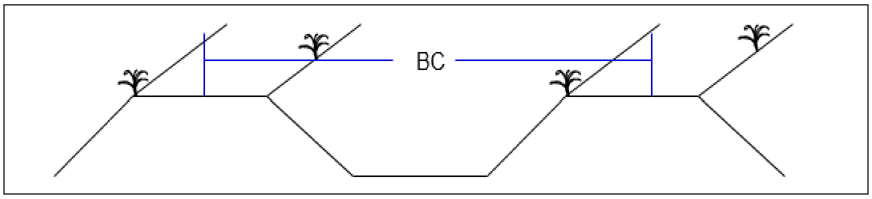

Figure 2. Typical design of a commercial pineapple seedbed (BC- distance between center of seedbeds; planting system used is quincunx)

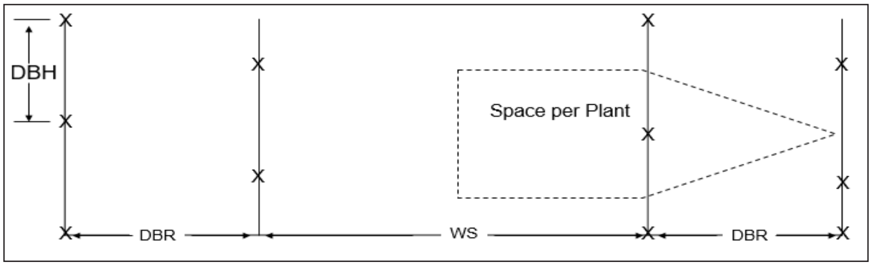

Figure 3. Top view of commercial pineapple seedbed orientation (DBH- distance between hills; DBR- distance between rows; WS- walking space)

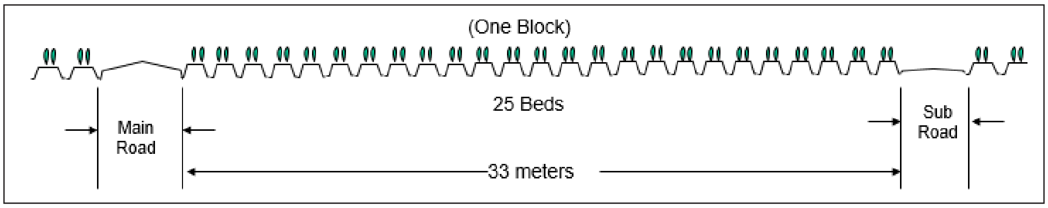

Figure 4. One pineapple block comprising 25 seedbeds with 75,000 plants per hectare serving as the control treatment

Figure 5. Photo exhibiting the height (25-30 cm) of each seedbed employed to all treatments

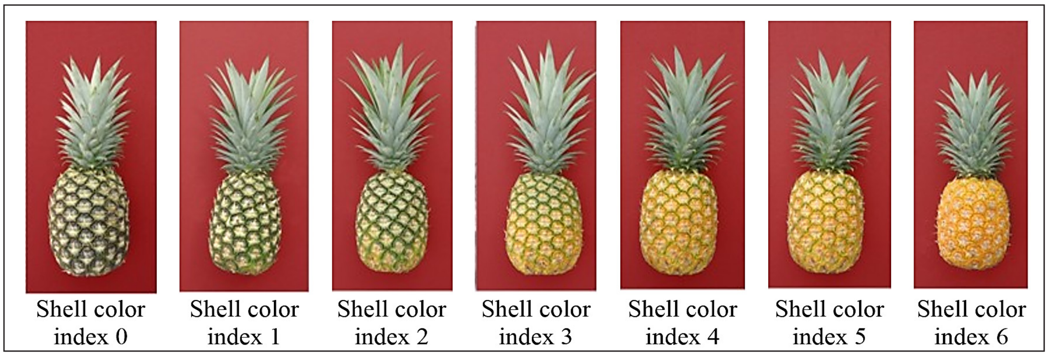

Figure 6. 'MD-2' pineapple shell color index (Source: MKADC Technical Research Group). Shell color index (SCI) 0- 0% of shell is yellow; SCI 1- 1-20% of shell is yellow; SCI 2- 21-40% of shell is yellow; SCI 3- 41-60% of shell is yellow; SCI 4- 61-80% of shell is yellow; SCI 5- 81-99% of shell is yellow; SCI 6- 100% of shell is yellow

Table 3
Dimensions of seedbed configuration per treatment

TREATMENT CODE	TREATMENT DESCRIPTION						
	Planting density hectare^{-1}	Number of rows seedbed^{-1}	Distance between hills (cm)	Distance between center of beds (cm)	Walk-space (cm)	Block width (m)	Number of seedbeds block^{-1}
T1	75000	2	19.80	134.70	83.80	33	25
T2	75000	2	21.60	120.00	69.10	33	28
T3	75000	2	24.10	110.60	59.70	33	30
T4	75000	2	25.40	105.00	54.10	33	32

RESULTS AND DISCUSSION

Plant Growth

The four seedbed configurations used in this study have comparable effects in all parameters gathered. For plant growth data, varying seedbed configurations did not influenced the plant mass (Table 4) and plant height (Table 5) of 'MD-2' pineapple plants at 6 MAP until flower induction treatment. This result implies that seedbed configurations used in the study are all feasible for 'MD-2' pineapple production. Planting density might be a better tool to improve pineapple crop growth rather than seedbed configuration.

The study of Wee (1969) revealed that pineapple leaves were longer (taller plants) and narrower at higher planting density. Moreover, Malézieux et al. (2003) reported that specific leaf mass of pineapple significantly decreased (lighter plants) at planting density higher than 6 plants m^{-2}. Although number of seedbeds block^{-1} were modified in this experiment, same planting density (75,000 planting density per hectare) was used. Hence, there were equal number of plants m^{-2} which prevented or minimized the occurrence of intraspecific competition.

Table 4
Plant mass of 'MD-2' pineapple at varying ages in response to varying seedbed configurations

TREATMENT	PLANT AGE (months after planting)			
	6	8	10	At flower induction
	Plant mass, kg			
25 seedbeds block^{-1}	0.66±0.01	1.26±0.05	1.91±0.06	2.07±0.07
28 seedbeds block^{-1}	0.71±0.03	1.24±0.08	1.74±0.04	1.80±0.05
30 seedbeds block^{-1}	0.70±0.05	1.21±0.02	1.95±0.11	2.05±0.12
32 seedbeds block^{-1}	0.65±0.04	1.17±0.08	1.77±0.13	1.84±0.12

Note: Mean ± standard deviation, values in the same column are not significantly different ($p<0.05$) by DMRT

Table 5
Plant height of 'MD-2' pineapple at varying ages in response to varying seedbed configurations

TREATMENT	PLANT AGE (months after planting)			
	6	8	10	At flower induction
	Plant height, cm			
25 seedbeds block^{-1}	63.39±1.05	74.02±1.75	91.39±1.17	98.52±1.35
28 seedbeds block^{-1}	70.37±1.58	73.45±4.20	92.76±7.30	97.50±7.51
30 seedbeds block^{-1}	68.35±2.26	72.02±2.36	97.87±1.00	102.93±2.34
32 seedbeds block^{-1}	66.33±2.16	70.70±4.39	84.05±1.79	90.93±2.26

Note: Mean ± standard deviation, values in the same column are not significantly different ($p<0.05$) by DMRT

Fruit Size Distribution and Fruit Mass

Fruit sizes distribution per hectare (Table 6) was not significantly influenced by seedbed configuration although it was noted that 25 seedbeds block^{-1} had the better fruit size distribution (with more fruits weighing above 1 kg) and higher percentage of bigger fruits. Based on author's knowledge, foreign markets such as Japan, Korea, etc. preferred fruits weighing ≥1 kg. On the other hand, the 32 seedbeds block^{-1} resulted to production of higher percentage (59.33 %) of fruits weighing below 1 kg although not significant. The results imply that modified seedbed configurations with same planting density per hectare does not affect fruit sizes distribution in 'MD-2' pineapple.

Likewise, mean fruit mass of 'MD-2' pineapple was comparable in all seedbeds block^{-1} treatments although the 28 seedbeds block^{-1} resulted to heaviest fruit mass (1.32 kg). Certainly, modifying planting density rather than seedbed configuration will result to significant differences in fruit mass of pineapple. Valleser (2018) reported that heavier fruits of 'Sensuous' pineapple was obtained in lower planting densities per hectare (45,000 to 55,000), whereas yield per hectare increases with the increasing planting density. Further, Malézieux et al. (2003) stated that yield of pineapple increased with increasing planting density per hectare. Also, Genefol et al. (2017) reported that 70,000 plants per hectare was the best planting density when compared to lower density (50,000 plants hectare^{-1}) for 'MD-2' pineapple grown in short rainy season in Southern Côte d'Ivoire. At densities above or below 74,000 plants per hectare, fruit recovery percentage as well as the quantity and quality of fruits declines (Malézieux et al., 2003).

Plant Mortality

Plant mortality was gathered during the experiment termination (last round of harvest) and still was not aggravated by the seedbed configurations used. This result means that there is a proper aeration of plants in all seedbed configurations used. Hepton (2003) mentioned that drainage and the removal of water were critical to the successful growing of pineapple, as the root system was intolerant of poorly aerated soils.

Thus, it can be concluded that plan mortality of 'MD-2' pineapple was not dependent on the various seedbed configurations as well as the spacing dimensions used in this study.

Table 6
Fruit size distribution, fruit mass and plant mortality of 'MD-2' pineapple grown at varying seedbed configurations

TREATMENT	PERCENT FRUIT SIZE DISTRIBUTION					Mean fruit mass (kg)	Percent plant mortality
	2.5-2.8 kg	2.0-2.49 kg	1.5-1.99 kg	1.0-1.49 kg	< 1.0 kg		
25 seedbeds block^{-1}	1.00	10.00	22.00	21.00	36.33	1.12±0.10	9.67
28 seedbeds block^{-1}	0.33	6.33	14.00	21.67	48.33	1.32±0.28	9.33
30 seedbeds block^{-1}	0.33	4.67	21.33	19.33	43.33	1.14±0.13	11.00
32 seedbeds block^{-1}	0.00	2.33	10.00	17.33	59.33	1.02±0.09	11.00

Note: Mean ± standard deviation, values in the same column are not significantly different (p<0.05) by DMRT

Physico-chemical Characteristics

In pineapple, the lower the translucency rating of fruit is the superior one. Translucency is when the pineapple flesh has a water-soaked appearance (Paull & Chen, 2003). Seedbed configurations used in this study resulted to acceptable translucency rating in pineapple compared to the set standard of MKADC farm (Castro, T. S., personal communication, November 5, 2013).

The results indicate that TSS, TA and TSS/TA of pineapple fruits were statistically comparable among treatments (Table 7). The TSS (16.80 to 17.39), TA (0.56 to 0.59) and TSS/TA (30.20 to 30.94) 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). Malézieux et al. (2003) stated that at densities above or below 74,000 planting density per hectare, fruit recovery percentage as well as the quantity and quality of fruits declined. In this study however, fruit physico-chemical characteristics were similar certainly because of the constant planting density per hectare used regardless of seedbed configuration.

Table 7
Physico-chemical characteristics of 'MD-2' pineapple grown at varying seedbed configurations

TREATMENT	PHYSICO-CHEMICAL CHARACTERISTICS OF FRUITS			
	Translucency rating	Total soluble solids (TSS)	Titratable acidity (TA)	TSS/TA
25 seedbeds block^{-1}	3	16.80±0.46	0.58±0.02	30.91±2.66
28 seedbeds block^{-1}	3	17.18±0.45	0.59±0.06	30.74±4.80
30 seedbeds block^{-1}	3	16.81±0.91	0.56±0.03	30.94±0.99
32 seedbeds block^{-1}	3	17.39±0.54	0.59±0.06	30.20±2.17

Note: Mean ± standard deviation, values in the same column are not significantly different (p<0.05) by DMRT

CONCLUSION AND RECOMMENDATION

Results of the study revealed that the four seedbed configurations had comparable effects on the growth and physico-chemical characteristics of 'MD-2' pineapple. Hence, all seedbed configurations used in this study can be employed in the establishment of commercial 'MD-2' pineapple farm considering the dimensions of existing farm equipment. It therefore depends to end user which seedbed configuration to employ.

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