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EFFECT OF DIFFERENT WATER PH LEVEL ON SEEDLINGS GROWTH PERFORMANCE AT NURSERY

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ABSTRACT – *An experiment was conducted to evaluate the effects of different water pH levels on the growth performance of cocoa seedlings at the Malaysian Cocoa Board Research and Development Centre nursery in Tawau, Sabah. The study was laid out in Random Complete Block Design (RCBD) with three water treatments: T1 - Tap Water (pH ±7.5), T2 - Distilled Water (pH ±5.5), and T3 - Kangen Water (pH ±9.5) in three replicates. Two growth parameters—stem diameter (cm) and height (cm)—were recorded weekly over 13 weeks after planting (WAP). PBC 123 clone seedlings were used as rootstock, and each treatment was applied to 30 seedlings (three replicates of 10 seedlings each). Seedlings received 100ml of water daily, and their growth performance was monitored throughout the trial. Results showed that Kangen Water produced a slightly higher mean stem diameter, though differences were not significant (p>0.05). However, the study suggests that Kangen Water may be beneficial for improving seedling growth, particularly in acidic soils. Despite its advantages, the use of Kangen Water may be limited due to cost factors.*

Keywords: Cocoa, water pH levels, seedlings, growth development, Kangen Water

INTRODUCTION

The quality of water, especially the pH level, is essential for plant growth and the availability of nutrients. The pH of irrigation water can affect root development, nutrient absorption, and the overall physiology of plants. Cocoa (*Theobroma cacao* L.), as a tropical crop, is particularly sensitive to its growing conditions, which include both soil and water quality.

Cocoa typically thrives in slightly acidic conditions, with the ideal soil pH range noted to be between 5.5 and 6.5 (Aikpokpodion, 2010). Nevertheless, the impact of irrigation water pH in nursery settings has not been extensively recorded. Cocoa seedlings, which are particularly vulnerable during their initial growth phases, may react adversely to water with extreme pH levels, leading to inadequate nutrient absorption, chlorosis, or diminished root and shoot growth.

Furthermore, specific elements including iron, manganese, and phosphorus become less accessible at elevated pH levels, whereas others, such as aluminum, may exhibit toxicity at significantly low pH levels (Marschner, 2012). Considering that cocoa seedlings are frequently irrigated on a daily basis, particularly in tropical nurseries, the pH of the water may have cumulative impacts on plant growth.

As stated by Anozie *et al*. (2016), fluctuations in water pH can affect the solubility of vital nutrients and harmful substances, consequently impacting plant development and productivity. Therefore, it is good to understand how different pH levels in irrigation water affect cocoa seedling growth. Such knowledge would help establish baseline recommendations for water quality in cocoa nurseries and guide management practices in areas where water sources vary in chemical composition.

This study aims to evaluate the effect of different water pH levels on the growth performance of cocoa seedlings in a nursery environment thus provide practical recommendations for water pH management in cocoa nurseries.

MATERIALS AND METHODS

The trial was conducted at the Malaysian Cocoa Board Research and Development Centre nursery in Tawau, Sabah, beginning in early October 2020. A Randomized Complete Block Design (RCBD) was applied.

Three water types representing different pH levels were used. The treatments were; T1: Tap Water (pH ±7.5), T2: Distilled Water (pH ±5.5) and T3: Kangen Water (pH ±9.5), produced via electrolysis. The pH of each water type was verified weekly using a calibrated pH meter to ensure consistency throughout the study. Kangen Water is an unconventional approach in a nursery for seedling growth, however its potential benefits and suitability for plant nurseries should be explored. Therefore, in this study, Kangen

Water was freshly prepared daily before application. In addition, nursery soil pH also was recorded before and after the experiment (initial pH 5.8; final pH 5.9), confirming minimal change and indicating a stable buffering capacity. Later, each treatment was applied to 30 seedlings (10 seedlings × 3 replicates), using the PBC 123 cocoa seed clone. Blocks symbolized nursery benches to address micro environmental variation. Seedlings were watered daily with 100 ml of the respective treatment water.

Data collection started at the fourth week after planting (WAP) and continued for 13 weeks. Growth parameters measured included plant height (from soil surface to apical tip using a measuring tape) and stem diameter (using vernier calipers just above the cotyledon attachment).

Data were analyzed using one-way ANOVA followed by Tukey's HSD post hoc test ($\alpha = 0.05$) in SPSS. F-values, degrees of freedom, and p-values were reported for each parameter. Effect size (η^2) was calculated to indicate the magnitude of treatment effects even if non-significant.

(a) (b)

Figure 1. Measurement of (a) plant height and (b) stem girth

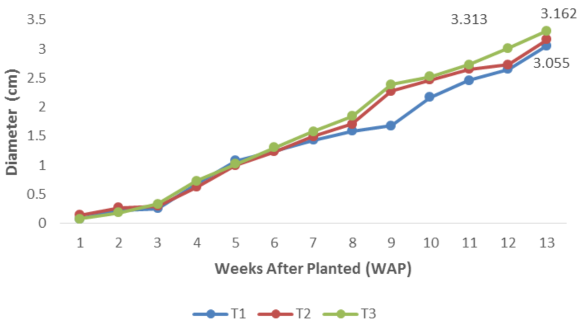
RESULTS AND DISCUSSIONS

Plant Diameter

Table 1: Total mean diameter after 13 WAP for each treatment

Treatment	Mean Diameter (± S.D)
T1 – Tap Water (pH ±7.5)	5.43 ± 0.38 a*
T2 – Distilled Water (pH ±5.5)	5.51 ± 0.73 a
T3 – Kangen Water (pH ±9.5)	5.71 ± 0.38 a
F-Test	0.22
CV (%)	8.55

*column means followed by the same letter are not significantly different (P>0.05, Tukey Test)



Note: T1: - Tap water, T2: – Distilled water, T3: – Kangen water

Figure 2. Effects of different water pH level on the plant diameter increment

Table 1 presents the mean stem diameter after 13 weeks across the three treatments. Although Kangen Water yielded the highest mean diameter (5.71 ± 0.38 cm), ANOVA results ($F(2,6) = 0.22$, $p = 0.81$, $\eta^2 = 0.07$) indicated no statistically significant difference among treatments.

Figure 2 illustrates the weekly increment in stem diameter for the three irrigation water treatments throughout the 13-week study. All treatments exhibited a gradual and steady increase in diameter, with Kangen Water (T3) showing a slightly higher numerical trend compared to Tap Water (T1) and Distilled Water (T2). The consistent upward pattern across treatments suggests that seedlings maintained uniform growth irrespective of water pH. However, the marginally greater increment observed under alkaline conditions (T3) may reflect the buffering capacity of Kangen Water, which helps moderate soil acidity and stabilize nutrient uptake. Although these differences were not statistically significant ($p > 0.05$), the visual trend in Figure 2 supports the observation that neutral-to-alkaline irrigation water may promote more stable early stem development in cocoa seedlings.

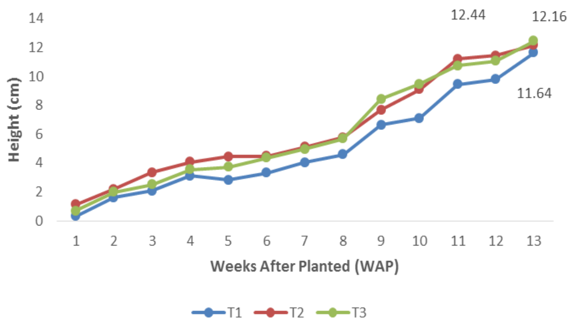
In addition, Kangen Water (T3) showed the highest mean diameter, though the ANOVA results ($F = 0.22$, $p > 0.05$) indicated no significant differences. The consistency of T3 diameter increments throughout the study, suggesting its potential benefits over time. As highlighted by Jones (2001), even minor changes in stem diameter during early development stages can be indicators of long-term plant vigor and resilience.

Plant Height

Table 2: Total mean height after 13 WAP for each treatment

Treatment	Mean Height (± S.D)
T1 – Tap Water (pH ±7.5)	32.43 ± 4.23 a*
T2 – Distilled Water (pH ±5.5)	31.11 ± 6.06 a
T3 – Kangen Water (pH ±9.5)	32.20 ± 2.28 a
F-Test	0.68
CV (%)	12.27

*column means followed by the same letter are not significantly different (P>0.05, Tukey Test)



Note: T1: - Tap water, T2: – Distilled water, T3: – Kangen water

Figure 3. Effects of different water pH level on the plant height increment

Table 2 shows the mean height of seedlings after 13 weeks. Tap Water recorded the highest mean height (32.43 ± 4.23 cm), followed closely by Kangen Water (32.20 ± 2.28 cm). ANOVA analysis (F (2,6) = 0.68, p = 0.54, η^2 = 0.12) again showed no significant effect. However, seedlings under neutral to slightly alkaline conditions (T1 and T3) tended to perform marginally better, aligning with findings from Mengel and Kirkby (2001) that moderate pH values support balanced nutrient uptake.

Figure 3 illustrates the weekly increment in plant height across the three water treatments during the 13-week period. All treatments showed steady and gradual increases in height, with seedlings irrigated using Kangen Water (T3) and Tap Water (T1) exhibiting slightly higher increments compared to Distilled Water (T2). The most distinct differences appeared between weeks 6 and 10, corresponding to the active vegetative growth phase. This visual pattern aligns with the mean height data presented in Table 2, confirming that although no statistically significant differences were detected (p > 0.05), neutral-to-slightly-alkaline irrigation water tended to sustain more consistent vertical growth rates. These findings are consistent with earlier studies by Mengel and Kirkby (2001) suggesting that moderate alkalinity buffers soil acidity and supports steady growth in nursery conditions.

Although no significant effects were detected, the trend favouring alkaline water could be related to its buffering capacity against acidic soil conditions, potentially improving calcium and magnesium retention. Similar findings were reported by Chen *et al*. (2013), who observed that alkaline irrigation water mitigates acidity effects and maintains better root-zone stability. Nonetheless, it is important to interpret these observations cautiously, as statistical insignificance means the observed differences could be due to natural variation.

CONCLUSIONS

This 13-week study found no statistically significant differences in cocoa seedling growth (height and stem diameter) under different irrigation water pH levels. However, slight numerical advantages were observed under alkaline water (Kangen Water). These results suggest potential long-term benefits worth investigating under extended trials and varied soil conditions. Given the additional cost of Kangen Water, practical implementation should be balanced against economic feasibility. Future research should include longer observation periods, additional growth parameters, and diverse cocoa genotypes to validate these preliminary findings.

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