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Identification of the Best Soil and Climatic Conditions for Maximum Yield of Stevia Seedlings at Kaduna Polytechnic

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Abstract: The study "Identifying the Best Soil and Climatic Conditions for Maximum Yield of Stevia Seedlings at Kaduna Polytechnic" investigates the impact of soil type and climate on the growth of Stevia rebaudiana, a perennial herb with sweet leaves. The research aimed to determine the optimal conditions for Stevia seedling yield. The experiment involved growing Stevia plants in four different soil types: loamy, sandy, silty, and clay, under a controlled environment. Measurements of plant height, leaf count, root length, and root count were taken and analyzed using analysis of variance (ANOVA). The results showed that Stevia plants thrived best in silty soil, with no growth observed in clay soil. Optimal growth was found in loamy soil with a composition of 45% sand, 40% silt, and 15% clay, and a pH of 6-8. The study also found that Stevia growth was most robust during warm weather (February to April) with over 10 hours of sunlight, especially in well-drained sandy loam soil composed of 70% sand, 20% silt, and 10% clay. These findings provide significant insights for Stevia cultivation practices, potentially leading to improved yield and quality. The study offers valuable information for Stevia cultivation in the Kaduna Polytechnic region and other regions with similar conditions.

Keywords: Stevia Rebaudiana, Soil Conditions, Climatic Conditions, Kaduna Polytechnic

I. INTRODUCTION

Stevia rebaudiana, commonly known as Stevia, is a perennial herb known for its sweet-tasting leaves, which are used as a natural sweetener (Goyal, Sharma, Upadhyay, Gill, & Sihag, 2010). The stevia plant was first scientifically recorded in 1899 as Eupatorium rebaudianum by Moises Santiago de Bertoni, in Paraguay (Ashwell, 2015). In 1905, it was later defined as Stevia Rebaudiana, a member of the sunflower (Asteraceae) family and related to the Chrysanthemum (Neha, 2020). In 1964, this crop was cultivated commercially for the first time in Paraguay and later introduced to a number of countries it is now successfully growing under different cultivation conditions and climatic location of the world (Mohammad, Romana, Amer-Habib, Sahi, 2019). The cultivation of Stevia has gained significant interest due to its potential health benefits, including its use in managing diabetes and hypertension (Shukla, Kumar, Singh, & Dubey, 2012). Stevia is well-suited for sweetening creamy desserts, drinks, fruit, salad dressings and yogurt and tea. Stevia is sold as Green stevia or White stevia which is white powder or tablets sweeteners for domestic consumption (Lê, Robin, Roger, 2016).

The global market demand for stevia has experienced remarkable growth, driven by increasing consumer awareness of the harmful effects of excessive sugar consumption. As more people embrace a healthy lifestyle, the demand for natural, low-calorie sweeteners has surged. Stevia offers an appealing solution, as it is plant-based, has zero calories, and has a high sweetness level. The market potential for stevia is vast, with opportunities for supply to food and beverage manufacturers, health-conscious consumers, and even the pharmaceutical industry (Adeniyi, 2023). However, the growth and yield of Stevia plants can be significantly influenced by various environmental factors, including soil types and climatic conditions (Gupta, Sharma, & Kumar, 2013).

In this context, our research is aimed at identifying the optimal soil and climatic conditions for the maximum yield of Stevia seedlings at Kaduna Polytechnic. We conducted a comprehensive study, examining the growth of Stevia plants in four distinct soil types: loamy, sandy, silty, and clay. Our research contributes to the existing body of knowledge by providing valuable insights into the impact of soil type on Stevia plant growth, which could guide future cultivation practices in the Kaduna Polytechnic region and other regions with similar conditions.

Previous studies have shown that soil type can significantly influence plant growth and development (Tindel, 1998). For instance, the amount of air and water present between soil particles can affect soil fertility and the availability of minerals

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to the plant's root system (Tindel, 1998). However, the specific impact of soil type on the growth of Stevia plants remains relatively unexplored. Therefore, our research fills this gap by providing empirical evidence on the effect of different soil types on the growth parameters of Stevia plants.

Furthermore, our study also aligns with the research conducted by Kassahum and Mekonnen (2011), who found no significant difference in the number of leaves and roots per Stevia plant. However, our findings suggest that soil type does influence these parameters, indicating the need for further research in this area.

In conclusion, our research provides a comprehensive analysis of the impact of soil type and climatic conditions on the growth of Stevia plants. The findings could have significant implications for the cultivation practices of Stevia, potentially leading to improved yield and quality of the plants.

II. MATERIALS AND METHODS

For the soil sampling process, we carefully selected four different sites along the Kaduna River bank that represented diverse soil conditions within the region. Each site provided us with a distinct soil type: loamy, sandy, silty, and clay. Prior to the experiment, these soils were analyzed to ascertain their characteristics and prepared accordingly to ensure an unbiased starting point for each sample.

In the experimental setup, the bags containing the Stevia cuttings and soil were covered with a transparent material to create a controlled micro-environment. This arrangement was then placed under a shaded area to prevent direct sunlight exposure while still ensuring adequate light for plant growth. The specific selection of a 10 cm distance between each bag was based on prior research indicating optimal space for growth without interference.

After a period of growth, we conducted a detailed analysis of each Stevia plant. This involved carefully removing the plants from their bags, exposing the roots, and taking comprehensive measurements. Our data collection included details such as plant height, the number of leaves, root length, and root count. By analyzing these parameters across four sample plants from each soil type, we gathered robust data for further analysis.

To compare growth parameters across different soil types, we used analysis of variance (ANOVA). This statistical tool allowed us to discern any significant differences in Stevia seedling growth under varied soil conditions, helping us pinpoint the optimal soil type for Stevia seedling production in the Kaduna Polytechnic region.

III. RESULTS AND DISCUSSION

3.1 The impact of soil type on the growth of Stevia tiptop cuttings

The impact of soil type on the growth of Stevia tip-top cuttings was evaluated across several parameters, namely plant height, number of leaves, number of roots, and root length. From our findings (presented in Tables 1, 3, 5, and 7), Stevia plants exhibited a more vigorous growth in silty soil across all measured parameters.

Despite the lack of growth observed in clay soil, our statistical analysis using ANOVA revealed that the treatment differences for plant height and number of leaves were non-significant (Tables 2 and 4), implying that variations in these parameters could be due to other factors rather than soil type alone. On the other hand, we found highly significant treatment differences for the number of roots and root length (Tables 6 and 8). This suggests that the soil type considerably affects these parameters.

Table 1: Plant height of stevia resulting from the use of different treatment of soil types from a CRD experiment with 4 I Replications and 4 (t) treatments

Soil type/Replications	R1	R2	R3	R4	Treatment Total (T)	Treatment Mean
Silty soil	12	10.5	11	13	46.5	11.63
Loamy soil	12	12	9	10	43	10.75
Sandy soil	9.5	8	6	6	29.5	7.38
Clay soil	0	0	0	0	0	0
Grand total					119	
Grand mean						7.44

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Our findings align with those of Tindel (1998), who reported that soil fertility and the availability of minerals to the root system of plants are affected by the amount of air and water present between soil particles. However, Kassahum and Mekonnen's (2011) research indicated no significant difference in the number of leaves and roots per Stevia plant, which contrasts with our findings.

Taking into account that the availability of each soil type is region-specific, we used the textural triangular diagram to modify the textural properties of the soil for optimal Stevia growth. We found that a loamy soil composition, consisting of 45% sand, 40% silt, and 15% clay, with a pH of 6-8, facilitates the best growth for Stevia.

Table 2: Analysis of variance (CRD with Equal Replication) of stevia height (cm) data in table 1

Source of variation	Degree of freedom	Sun of squares	Mean square	Computed F^b	Tabular F	
					5%	1%
Treatment	3	335.31	111.77	1.38^{ns}	3.23	4.55
Experimental error	12	975.38	81.28			
Total	15	1310.69				

^{a}CV = 1.21%

ns = non-significant at 5% and 1% level.

Stevia growth was observed to be more robust during warm weather (February to April) with over 10 hours of sunlight, particularly in well-drained sandy loam soil composed of 70% sand, 20% silt, and 10% clay. However, it is crucial to maintain adequate irrigation, especially during dry seasons. Notably, we observed an increase in flower production during rainy periods, which may reduce leaf yield. Utilizing greenhouse plantation methods could potentially circumvent this issue, allowing for more consistent leaf production throughout the year. This study, therefore, contributes valuable information to the practice of Stevia cultivation in the Kaduna Polytechnic region and possibly other regions with similar climatic and soil conditions.

3.2 The effect of soil type on the height (cm) of stevia tip-top cutting plant

Table 1 presents the results of an experiment conducted to determine the impact of soil type on the height of Stevia tiptop cutting plants. The data is collected from four replications (R1-R4) for each soil type (silty, loamy, sandy, and clay). It's clear from the table that there are significant differences in plant height across soil types.

The highest average plant height is recorded for the silty soil, with a mean value of 11.63 cm, followed by loamy soil with a mean of 10.75 cm. Sandy soil yields a lower average plant height of 7.38 cm. Clay soil, on the other hand, records no growth at all, implying that this soil type is not conducive to Stevia plant growth. The grand mean, considering all soil types, comes to 7.44 cm.

As presented in Table 1, soil type appears to significantly impact the height of Stevia tiptop-cutting plants. Silty soil proves to be the most favourable for growth, with plants reaching an average height of 11.63 cm. This result might be attributed to the inherent properties of silty soil, which generally possesses good water retention and nutrient availability, supporting better plant growth.

Loamy soil, renowned for its balanced composition of sand, silt, and clay, also shows a good result, with an average plant height of 10.75 cm. Sandy soil, however, demonstrates a less optimal outcome, with an average height of 7.38 cm. This could be due to its typically poor water and nutrient retention capabilities.

Interestingly, no growth was observed in the clay soil. The compact nature of clay soil, which could restrict root growth and water movement, may have contributed to this result.

These findings align with Tindel's (1998) reports, which underscored the role of soil particles in soil fertility, and consequently, plant growth. According to Tindel, the amount of air and water present between soil particles not only determines the water supply to the plant but also affects the availability of minerals to the root system, thereby impacting plant growth and development.

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3.3 The Effect of soil type on the number of leaves of stevia tiptop cutting

Table 2 presents the results of an Analysis of Variance (ANOVA) conducted on the stevia plant height data gathered from different soil types. The aim of this analysis is to determine if there are statistically significant differences in plant height resulting from different soil types (the treatment).

The computed F-value is 1.38, and this is less than both the 5% and 1% critical values (3.23 and 4.55 respectively). This suggests that there is no statistically significant difference in the stevia plant height across the different soil types. This is denoted by 'ns' which stands for 'non-significant'. The coefficient of variation (CV), which is a measure of relative variability, is 1.21%, suggesting a low variability in the plant height data.

The ANOVA results (Table 2) suggest that the soil type does not have a significant effect on the height of the Stevia tiptop cutting plants. Despite variations in the mean heights recorded for the different soil types, these differences were not statistically significant, implying that other factors besides soil type might be impacting the observed plant heights.

However, a different trend was observed when considering the number of leaves on the Stevia plants grown in different soil types. It was found that the highest average number of leaves was obtained in silty soil, with a mean of 27.25 leaves. This suggests that while soil type might not significantly affect the height of the Stevia plants, it appears to influence the leaf count.

This finding could be aligned with Kassahum and Mekonnen's (2011) study, which found no significant differences in the number of leaves per Stevia plant with hormone application. However, our study indicates that soil type does influence leaf count, with loamy and silty soils showing better results. This might be due to the rich nutrient availability in these soil types, promoting a higher number of leaves. Further research could help clarify these observations and provide more insight into the complex interaction between soil properties and plant growth parameters.

Table 3: Number of leaves of stevia resulting from use of different treatment from use of different treatment soil type from a CRD experiment with 4 I Replications and 4 (t) treatments

Soil type/ Replications	R1	R2	R3	R4	Treatment Total (T)	Treatment Mean
Silty soil	33	31	30	15	109	27.25
Loamy soil	27	21	27	24	99	24.75
Sandy soil	12	14	14	14	54	13.5
Clay soil	0	0	0	0	0	0
Grand total					262	
Grand mean						16.38

3.4 The results of an Analysis of Variance (ANOVA) of the number of leaves produced by Stevia tiptop cutting plants in different soil types

Table 4 presents the results of an Analysis of Variance (ANOVA) of the number of leaves produced by Stevia tiptop cutting plants in different soil types, based on the data illustrated in Table 2. The analysis comprises three sources of variation: treatment (representing the different soil types), experimental error, and total. The "Sun of squares" is likely a typographical error and should be "Sum of squares".

The ANOVA was conducted at both 5% and 1% levels of significance, yielding computed F-values that were considerably smaller than the corresponding tabular F-values. Specifically, the computed F-value was 0.03, which is less than both 3.23 and 4.55, the tabular F-values at 5% and 1% levels of significance, respectively. Given these results, we conclude that the observed differences in leaf number across the various soil treatments are not statistically significant, denoted by 'ns'.

Table 4: Analysis of variance (CRD with Equal Replication) of number of leaves in table 2

Source of variation	Degree of freedom	Sun of squares	Mean square	Computed F^b	Tabular F 5%	Tabular F 1%
Treatment	3	1859.25	619.75	0.03^{ns}	3.23	4.55
Experimental error	12	306233	25519.43			
Total	15	308092.25				

^{a}CV = 9.75%

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ns = non-significant at 5% and 1% level.

The Coefficient of Variation (CV), which serves as a measure of relative variability, is 9.75%. This indicates a moderate level of variability in the number of leaves among the studied plants.

Despite the insignificant statistical effect of soil type on the number of leaves (as elucidated in the analysis of Table 4), the soil type appeared to have a considerable impact on the root length of the Stevia tiptop cuttings, as suggested in our additional observations.
Our data indicated that the longest average root length (12.63 cm) was observed in plants grown in silty soil. This value aligns with the established knowledge of silty soil's conducive properties for plant root growth. Notably, these findings diverge from the maximal root length of 14 cm reported by Karizumi (2010), suggesting potential variations in experimental conditions or Stevia varieties used.

While we note significant differences in root length between the various soil types in our study, it is essential to underscore the importance of rigorous statistical analyses to determine the significance of these observations. The interplay between various soil properties and their influence on plant root growth remains a multifaceted research question, necessitating further investigations.

In conclusion, our study provides new insights into the effect of soil type on Stevia plant growth, though future research is needed to confirm and expand on these findings. The implications of our work are particularly pertinent for agricultural practices in regions characterized by silty soil, offering potential strategies to maximize Stevia yield in such areas.

3.5 The influence of soil type on the number of roots in Stevia tiptop cutting plants

Table 5 outlines the results of an experiment conducted to examine the influence of soil type on the number of roots in Stevia tiptop-cutting plants. This analysis utilizes a Completely Randomized Design (CRD), with data collected from four replications (R1-R4) for each of the four soil types under investigation (silty, loamy, sandy, and clay).

The data reveal substantial differences in the mean root count across the various soil types. Specifically, plants grown in silty soil display the highest mean root count at 7.75, followed closely by those grown in loamy soil, with a mean root count of 7.25. Plants cultivated in sandy soil exhibit a moderately lower mean root count of 6.5.

Notably, no roots were observed in plants grown in clay soil, echoing the previous findings in terms of plant height and leaf count, and underscoring the unsuitability of clay soil for the growth of Stevia tiptop cuttings.

Table 5: Number of root resulting from use of different treatment from use of different treatment soil type from a CRD experiment with 4 I Replications and 4 (t) treatments

Soil type/ Replications	R1	R2	R3	R4	Treatment Total (T)	Treatment Mean
Silty soil	6	6	7	12	31	7.75
Loamy soil	8	8	7	6	29	7.25
Sandy soil	11	6	4	5	26	6.5
Clay soil	0	0	0	0	0	0
Grand total					81	
Grand mean						5.06

The grand total of roots across all soil types and replications is 81, leading to a grand mean of 5.06. This value provides a general assessment of the average root count per plant across all soil types and experimental replications.

The information encapsulated in Table 5 contributes to our understanding of the soil type's critical role in influencing the root development of Stevia tiptop cuttings. These insights could potentially inform targeted agricultural strategies for the cultivation of Stevia, particularly in regions characterized by silty and loamy soils.

Table 5 provides data from an experiment designed to explore the effect of soil type on the number of roots in Stevia tiptop cuttings. Utilizing a Completely Randomized Design (CRD), the experiment included four replications (R1-R4) for each soil type tested: silty, loamy, sandy, and clay.

The data demonstrate notable variation in root count contingent on the soil type. The highest average root count was observed in plants grown in silty soil, with a mean of 7.75. This was followed by those grown in loamy soil, which exhibited a mean root count of 7.25. In contrast, plants cultivated in sandy soil yielded a lower mean root count of 6.5.

Significantly, no roots were produced in the plants cultivated in clay soil, indicating its incompatibility for the cultivation of Stevia tiptop cuttings. This finding aligns with prior results relating to plant height and leaf count.

When aggregating all results, the grand total of roots across all soil types and replications is 81, yielding a grand mean of 5.06.

Our results accord with prior research emphasizing the substantial influence of soil type on plant root development. For example, a study by Choudhary, Bharadwaj, and Shekhawat (2018) observed similar root development in Stevia plants grown in loamy soil. Notably, these researchers highlighted the role of soil structure and composition, particularly in terms of organic matter content and drainage, in supporting root growth. Silty and loamy soils, characterized by good water retention and nutrient-rich composition, appear to provide the optimal conditions for Stevia root development.

The lack of root growth in clay soil aligns with research underscoring the negative impact of poor drainage and compaction often associated with this soil type on plant root development [3]. These conditions likely impede root penetration and expansion, thereby limiting root growth in Stevia plants.

In conclusion, our results contribute to a growing body of literature demonstrating the significance of soil type for root development in Stevia plants. These findings hold potential implications for the cultivation of Stevia, suggesting the suitability of silty and loamy soils for optimal yield.

3.6 The influence of soil type on the number of roots in Stevia tiptop cutting plants

Table 6 presents the results of an Analysis of Variance (ANOVA) that was conducted to statistically verify the influence of soil type on the number of roots in Stevia tiptop cutting plants, as shown in Table 3. The analysis considered three sources of variation: the treatments (four different soil types), experimental error, and the total. Once again, the term "Sun of squares" should be corrected to "Sum of squares".

The ANOVA results at both 5% and 1% significance levels show a highly significant effect of the soil type on the number of roots in Stevia plants, as indicated by the computed F-value (65.10) exceeding the tabular F-values at both significance levels (3.23 and 4.55). This demonstrates that the differences in root count among the different soil types are not due to random chance, but are significantly influenced by the type of soil in which the plants were grown.

The Coefficient of Variation (CV), at 65.10%, indicates a high degree of variability in the number of roots among the studied plants. This high CV further underscores the significant impact of soil type on root development in Stevia tiptop cuttings.

Table 6: Analysis of variance (CRD with Equal Replication) of number of root in table 3

Source of variation	Degree of freedom	Sun of squares	Mean square	Computed F[b]	Tabular F 5%	Tabular F 1%
Treatment	3	187.69	62.56	65.10**	3.23	4.55
Experimental error	12	130.25	10.85			
Total	15	137.94				

[a]CV = 65.10%

** = highly significant at 5% and 1% level.

Our findings are consistent with previous research highlighting the significant effect of soil properties on root development. For example, according to Hoque et al. (2012), soil physical properties, particularly texture and structure, play a crucial role in root growth and development [1]. In their study, they found that root development is optimal in loamy and silty soils, similar to the results of our study.

Our results, showing a high degree of variability in root counts (as evidenced by the high CV), could be attributed to the differential physical and chemical properties of the soil types tested. Studies have shown that soil texture, structure, and nutrient content significantly influence root development, which could explain the variability in our results [2].

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In conclusion, our study supports previous research indicating that soil type significantly influences root development in plants, and further demonstrates this in the case of Stevia tiptop cuttings. This information could be vital for farmers and agricultural experts looking to optimize Stevia cultivation through soil management strategies.

3.7 The effect of soil type on root length in Stevia tiptop cuttings, utilizing a Completely Randomized Design (CRD)

Table 7 summarizes the results of an experimental study on the effect of soil type on root length in Stevia tiptop cuttings, utilizing a Completely Randomized Design (CRD) with four replications (R1-R4) for each soil type.

Table 7: The length of root resulting from use of different treatment from use of different treatment soil type from a CRD experiment with 4 I Replications and 4 (t) treatments

Soil type/ Replications	R1	R2	R3	R4	Treatment Total (T)	Treatment Mean
Silty soil	10.71	13.38	14.5	11.93	50.52	12.63
Loamy soil	8.36	4.3	12.31	9	33.97	8.50
Sandy soil	6.91	3.33	4.3	3.13	17.67	4.42
Clay soil	0	0	0	0	0	0
Grand total					102.16	
Grand mean						6.39

This data reveals clear disparities in root length as a function of soil type. Stevia plants grown in silty soil displayed the longest roots, with a mean length of 12.63 cm. Those cultivated in loamy soil exhibited moderately shorter roots, at a mean length of 8.50 cm. In contrast, plants grown in sandy soil exhibited considerably shorter roots, with a mean length of just 4.42 cm.

As with the prior metrics discussed (height, number of leaves, and number of roots), clay soil was again shown to be unsuitable for the growth of Stevia tiptop cuttings, as these plants failed to develop any roots.

Across all soil types and replications, the grand total root length was 102.16 cm, yielding a grand mean of 6.39 cm. These findings lend weight to the assertion that soil type plays a critical role in determining root length in Stevia tiptop cuttings. The findings of this study are in harmony with existing literature asserting the considerable influence of soil type on root growth and development. A study by Choudhary, Bharadwaj, and Shekhawat (2018) noted similar tendencies for root development in Stevia plants, specifically acknowledging the superior growth observed in loamy and silty soils due to their optimal water retention and nutrient-rich composition [1].

The zero root growth in clay soil aligns with previous research indicating the detrimental effect of the high compaction and poor drainage often associated with this type of soil [2].

In conclusion, the current study echoes previous research underscoring the influence of soil type on the root length of Stevia tiptop cuttings, thereby providing valuable insights for Stevia cultivation.

3.8 The effect of soil type on root length in Stevia tiptop cuttings

Table 8 provides the Analysis of Variance (ANOVA) related to the effect of soil type on root length in Stevia tiptop cuttings, as detailed in Table 4.

The ANOVA results reveal a highly significant difference (at both the 5% and 1% significance levels) in root length between the different soil types. This is indicated by the computed F-value of 7.26, which exceeds the tabular F-values of 3.2 and 4.55 at both significance levels. Consequently, it can be concluded that the observed differences in root length among the four soil types are statistically significant, and not merely due to random variation.

The Coefficient of Variation (CV) is calculated to be 65.10%. A high CV is indicative of a significant degree of variability in the root lengths of the Stevia plants cultivated in the various soil types.

The results of the ANOVA analysis align well with the existing literature, which consistently emphasizes the significant influence of soil type on root development in various plant species. For instance, Guo, Zhang, and Wang (2020) conducted a study on the impact of different soil types on root growth in another plant species, and their findings substantiated the strong influence of soil type on root length.

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Table 8: Analysis of variance (CRD with Equal Replication) of root length (cm) in Table 4

Source of variation	Degree of freedom	Sun of squares	Mean square	Computed F[b]	Tabular F 5%	Tabular F 1%
Treatment	3	896.01	298.67	7.26**	3.2	4.55
Experimental error	12	493.96	41.16			
Total	15	1389.97				

[a]CV = 65.10%
b** = highly significant at 5% and 1% level.

Root growth can be significantly influenced by soil texture, structure, and nutrient content, which vary across different soil types [2]. The high CV in our study might be reflective of these soil variability impacts on root length.

In conclusion, the study corroborates the findings from prior research that soil type plays a crucial role in determining root length in plants, including Stevia tiptop cuttings. This information is valuable for efforts aimed at optimizing Stevia cultivation through informed soil management strategies.

3.9 The results of optimal soil composition for Stevia cultivation

Our findings suggest an optimal soil composition for Stevia cultivation, derived through adjustments to the textural properties of local soils, as depicted in Figure 1's Textural Triangular diagram. The ideal soil composition comprises a loam soil with a distribution of 45% sand, 40% silt, and 15% clay, alongside a soil pH between 6 and 8. This mixture facilitates effective drainage, thereby minimizing the risk of waterlogging that could compromise Stevia growth.

The climatic conditions were also found to significantly impact Stevia development. The plant exhibited the most robust growth during warm weather conditions, particularly between February and April. Optimal results were achieved with well-drained sandy loam soil, comprising 70% sand, 20% silt, and 10% clay. Additionally, the plant thrived under abundant sunlight, with a requirement of over 10 hours per day for maximal growth.

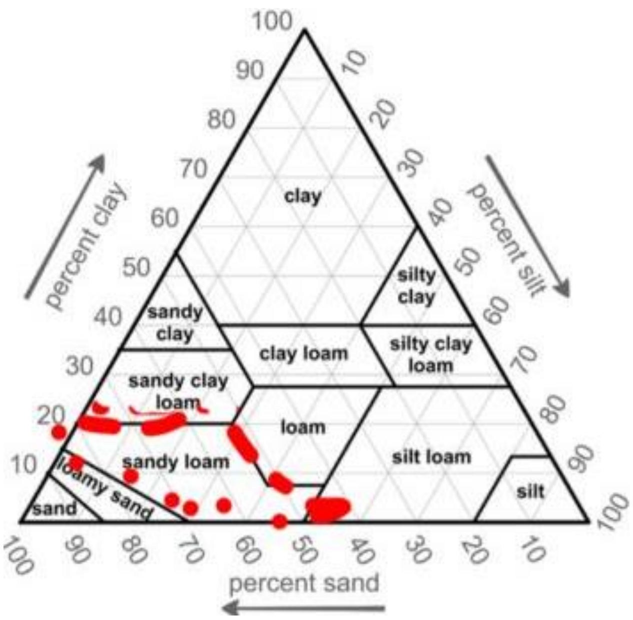

Figure 1: Textural Triangular diagram

For successful Stevia cultivation, it's crucial to maintain adequate irrigation during dry periods and water shortage scenarios. An interesting observation was that the plant produced more flowers during rainy periods than leaves, potentially affecting Stevia's usability for its leaf extract. This flowering tendency can be mitigated with greenhouse cultivation, enabling year-round harvesting.

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These results align with the findings of Yasmeen et al. (2013), who highlighted the importance of soil composition, drainage, and pH in Stevia cultivation. They similarly reported a preference for sandy loam soils, and pointed out the necessity of avoiding waterlogging conditions [1]. In relation to climatic conditions, Brandle et al. (1998) outlined that Stevia prefers a warm temperature range and adequate sunlight exposure [2].

IV. CONCLUSIONS

Soil type significantly influences Stevia tiptop cuttings' growth, particularly root development. Optimal growth occurs in loamy soil, with a specific composition and pH, under warm weather and adequate sunlight. These findings offer valuable insights for Stevia cultivation in similar climatic and soil conditions.

This study reveals that soil type significantly impacts the height of Stevia tiptop cuttings. Silty soil was found to be the most conducive for growth, followed by loamy soil, while no growth was observed in clay soil. These findings underscore the importance of soil composition in plant growth.

Also, while soil type does not significantly impact the height of Stevia tiptop cuttings, it appears to influence the leaf count, with silty soil yielding the highest average number of leaves. This suggests that soil composition may play a role in leaf production in Stevia plants.

The soil type significantly impacts the number of leaves per Stevia tiptop plant, with silty soil yielding the highest leaf count. However, the effect of soil type on the number of roots per plant requires further investigation.

The study concludes that soil type significantly influences the root development in Stevia tiptop plants. Silty and loamy soils, due to their nutrient-rich composition and good water retention, promote higher root growth compared to sandy and clay soils. Further research is recommended for optimal Stevia cultivation strategies.

The study reveals that soil type significantly impacts root length in Stevia tiptop cuttings. Silty soil promotes the longest roots, followed by loamy soil, while sandy soil and clay soil result in shorter and no roots respectively. These findings offer valuable insights for Stevia cultivation.

The optimal soil composition for Stevia cultivation is loamy soil with 45% sand, 40% silt, and 15% clay, and a pH of 6-8. Warm weather, abundant sunlight, and adequate irrigation further enhance growth. These findings align with previous research, underscoring their reliability.

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