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Effect of organic amendments on *Aloe vera* growth in nursery in Daloa, Côte d'Ivoire

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***Abstract*— *In the face of climate change, the optimization of crop diversification policy in Côte d'Ivoire must go through research and promotion of crops of interest that require little water, including Aloe vera. However, in view of its slow growth in nursery, the improvement of growth substrate fertility by the supply of nutrients is necessary. Thus, this study aims at assessing the effects of six organic matter formulations on Aloe vera growth in nursery. To this end, a completely randomized block experimental design comprising six treatments and three replications was carried out. The amendments tested were cow dung, chicken droppings, charcoal, banana tree stems and ripe plantain and dessert bananas. The results showed substrate pH variability (6.67 to 7.87) depending on the amendments. Leaf emergence speed increased with cow dung from the 80th day after planting. Similarly, the highest number of leaves was obtained with cow dung (9.33 leaves). With 22.89 cm in average length and 1.65 cm in average width, the leaves generated with cow dung were also the longest and widest. This study showed that cow dung promotes rapid Aloe vera growth in nursery.*

***Keywords*— Climate change, Crop diversification, Aloe vera, Nursery, Organic matter**

I. INTRODUCTION

Côte d'Ivoire has based its economy since its independence on agriculture. This agriculture is dominated by cash crops such as coffee, cocoa, oil palm, cotton and rubber (Sangaré *et al*., 2009). Alongside these cash crops, there are food crops such as bananas. With an annual yield estimated at 1.6 million tons (Nindjin *et al*., 2003), it ranks third in terms of food production. It is an important source of income, employment and export earnings (Foure & Tezenas, 2000). Moreover, food crops contribute to local and regional economic development, ensuring regular income for producers.

However, the rapid growth of the Ivorian population, which rose from 2630000 in 1950 to 21295000 in 2015 (Kouakou *et al*., 2018) has a significant impact on agriculture. Indeed, this population growth has led to strong anthropogenic pressure on arable land and a strong reduction in the area occupied by forests. This situation has been exacerbated in recent years by insufficient and irregular rainfall, subjecting crops to water stress, which seriously limits their growth as well as plant productivity (Zerrad *et al*., 2008). Consequently, farmers are faced with a drop in their agricultural yield and therefore in their income. Faced with this observation, the optimization of crop diversification policy through research and the promotion of crops of interest and requiring little water is necessary. *Aloe vera*, which appears to be an interesting alternative, fits in this perspective.

Indeed, *Aloe vera* is a succulent plant that can grow with low or irregular water availability (Svjetlana *et al*., 2020). Moreover, the presence of bitter anthraquinones and other polyphenolic components makes the plant unattractive to pests and pathogens (Gharib, 2021). *Aloe vera* is mainly cultivated for its leaves from which juice and gel are extracted, which give rise to the development of products with diversified uses to such an extent that the plant has now become a marketing strategy (Onyinyechi *et al*., 2021). The main producing countries are Mexico, Venezuela and the Dominican Republic. In this regard, the American continent alone produces 60% of *Aloe vera* gel sold in the world, while the remaining 40% comes from Asia and Australia (Michayewicz, 2013). In these countries, Aloe vera is grown to meet the ever-increasing international demand. According to IMF estimates, the *Aloe vera* market could bring in more than $3.3 billion dollars by 2026 (Anonymous 1, 2022). For Africa and other developing countries, this could therefore become a major financial windfall.

In West Africa, Nigeria is the leading *Aloe vera* producer. However, its yield is intended for the local market (Michayewicz, 2013). In Côte d'Ivoire, *Aloe vera* is an unknown plant that is mainly grown as an ornamental plant on degraded soils. Its cultivation is preferably done vegetatively because of the rapid growth of suckers compared to propagation through seeds. These can be cut from the mother plant when they reach 15-20 cm in length, and can be cultivated in nursery in the first year (Michayewicz, 2013). However, growth in nursery lasts a year or more due to the slow growth of this plant which can give vigorous plants to be transplanted to the field. Thus, any attempt to promote this plant must think about improving growth substrate fertility by providing nutrients to boost its cultivation.

To date, it is difficult to find works devoted to the search for standard amendments for a sustainable and large-scale *Aloe vera* yield. The hypothesis we put forward is that the contribution of organic matter to the soil would positively influence *Aloe vera* growth parameters. Thus this study, which was carried out in Daloa in west central Côte d'Ivoire, aims at assessing the effects of six organic matter formulations on *Aloe vera* growth in nursery. The organic matter used in this study were composed of plant and animal waste from the Daloa region.

II. MATERIAL AND METHODS

Study site

This study was conducted on an experimental plot at the University Jean Lorougnon Guédé (UJLoG) located in the department of Daloa (West central Côte d'Ivoire). It is bounded by the West longitudes 6.48° and 6.41° and the North latitudes 6.91° and 6.84° (Adjiri *et al*., 2018). The climate of this region is of the subequatorial Attiean type (Adjiri *et al*., 2020) with two seasons, namely a dry season and a rainy season. The dry season extends over four months (November to February). As for the rainy season, it lasts eight months and extends from March to October. The wettest months are April, August and September when an average of 103.58 mm of rain is recorded each year. Furthermore, the average annual temperature is 26.3°C and the months of November and May are the driest with average temperatures of 26.2 and 27.9°C, respectively (Dro *et al*., 2020). The soils in this area are generally ferralitic, moderately leached on firm land and sandy hydromorphic (Zro *et al*., 2018).

Methodology

Trial set up

The trial was set up in December 2020 and lasted four (04) months. The plant material used in this study consisted of *Aloe vera* suckers with a size between 15 and 20 cm (Michayewicz, 2013). These all-comer suckers were collected from different districts of Daloa near homes.

The organic amendments tested included:

- Cow dung (1);
- Chicken droppings (2);
- Charcoal (3);
- Banana tree stems or banana stipes (4);
- Ripe plantain (5);
- Ripe dessert banana (6);

The soil used as substrate was collected from the experimental plot of UJLoG. The organic matter tested were mixed with soil in 15-cm high pots with a surface area of 0.0176 m^2.

For each pot the height was divided into three (03) of which 2/3 were filled with soil and 1/3 with the amendment except for the pots containing the bananas. Indeed, at this point, the pots were completely filled with soil and then holes were made in each banana which, subsequently, were buried in the ground at the rate of one banana per pot. In each pot, the suckers were buried so that only the roots were covered with the substrate except for dessert bananas and plantains where the suckers were buried in the holes made inside them and then covered with substrate. The control was made up of a pot filled entirely with soil collected from the experimental plot. The Experimental Design was a completely randomized block with 3 replications (Fig. 1). Plant monitoring consisted of watering as needed when the surface of the substrate was dry. Also, regular cleaning was carried out in order to avoid any competition of weeds with *Aloe vera* plants.

Substrate 1	Substrate 2	Substrate 5
Substrate 5	Substrate 4	Substrate 3
Substrate 3	Substrate 7	Substrate 2
Substrate 6	Substrate 1	Substrate 4
Substrate 2	Substrate 6	Substrate 7
Substrate 7	Substrate 3	Substrate 1
Substrate 4	Substrate 5	Substrate 6
Block 1	**Block 2**	**Block 3**

Fig 1: Experimental design

Substrate 1: Control; Substrate 2: Soil + cow dung; Substrate 3: Soil + chicken droppings; Substrate 4: Soil + charcoal; Substrate 5: Soil + banana stipes; Substrate 6: Soil + ripe plantain; Substrate 7: Soil + ripe dessert banana.

Parameters measured

The observations focused on substrate growth parameters and pH monitoring. Substrate pH, determined by the electrometric method with a pH meter (Alla *et al.*, 2018) was measured every 20 days. The probe was pushed, after cleaning with a cloth, into the substrate about 10 cm followed by the reading one (01) minute later. This operation was repeated three times at different locations of the substrate contained in each pot in order to calculate the average for result reliability.

The growth parameters concerned leaf emergence speed, the number of emerged leaves, leaf length and width over time. Thus, a leaf was considered new when its length reached 4 cm (Yosser, 2012). The length of the new generated leaves as well as their width were taken every 20 days using a graduated ruler.

Statistical analysis of data

The data collected was subjected to statistical tests using Statistica 7.1 software. An analysis of variance made it possible to assess the effects of amendments on *Aloe vera* sucker growth. The hypothesis of equality of averages was assessed at α risk = 5%. If this last hypothesis was rejected, the Newman-Keuls multiple comparison test (at α risk threshold = 5%) made it possible to classify the averages into homogeneous groups.

III. RESULTS AND DISCUSSION

3.1. Results

3.1.1. pH of the different substrates

The measured pHs varied from 6.67 to 7.87 and are shown in Table 1 and Fig. 2. The pH values showed a significant difference (P<0.05) regarding substrates.

Compared to the pH of the control which was 7.87 and which represented the starting pH of the substrates, the input of amendments led to a drop in the pH of the substrates. A very significant reduction was obtained with cow dung, ripe plantain, chicken droppings and charcoal amendments. However, these pH remained basic with the exception of the substrate amended with charcoal powder which was acidic (6.67).

Table 1: Average pHs of the studied substrates

	S 1	S 2	S 3	S 4	S 5	S 6	S 7	P
Average pH	7.87^{a}	7.36^{b}	7.59^{ab}	6.67^{c}	7.69^{ab}	7.49^{b}	7.73^{ab}	0.00

The averages on the same line followed by different letters are significantly different at 5% threshold.

S1: reference**; S2**: Soil + cow dung; **S3**: Soil + chicken droppings; **S4**: Soil + charcoal; **S5**: Soil + banana stipes; **S6**: Soil + ripe banana plantain; **S7**: Soil + ripe dessert banana; **P**: Probability

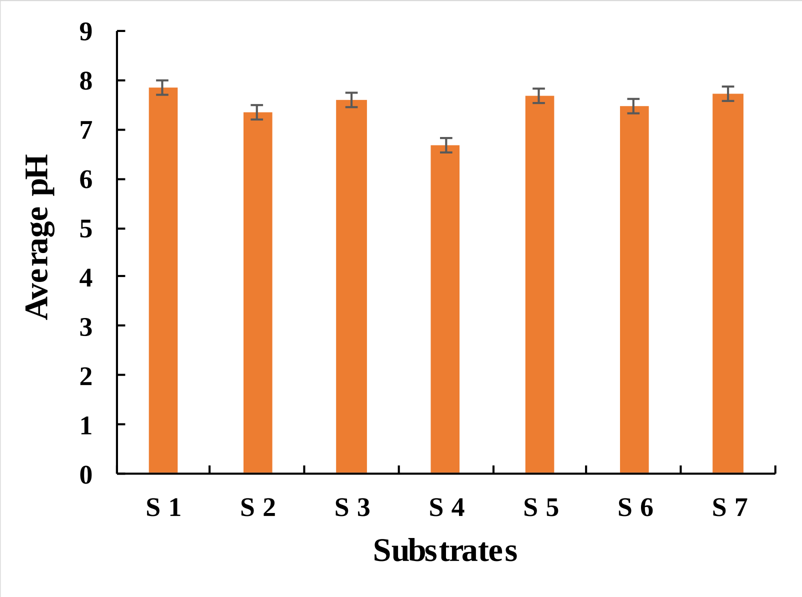

Fig. 2 : Average pHs depending on the substrates

S 1: Control**; S 2:** Soil + cow dung**; S 3:** Soil + chicken droppings**; S 4**: Soil + charcoal**; S 5:** Soil + banana stipes; **S 6:** Soil + ripe plantain**; S 7:** Soil + ripe dessert banana

3.1.2. Leaf emergence speed

Leaf emergence speed followed the same evolution regardless of the type of substrate (Fig. 3). The analysis of variance of the data shows that the amendments used did not significantly influence ($P > 0.05$) new (Table 2). However, Figure 3 shows a slight increase in leaf emergence speed from the 80th day after planting on substrate 2 (cow dung) and from the 100th day after planting on the substrate amended with chicken droppings (substrate 3).

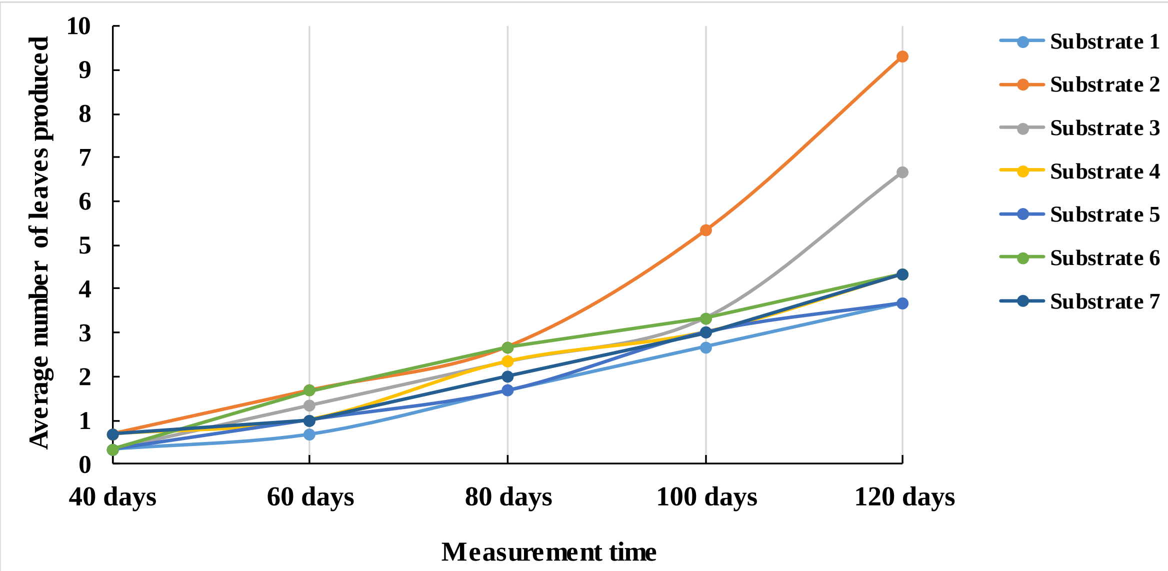

Fig. 3 : Evolution of the average number of leaves generated on the substrates depending on time

Table 2: Average number of leaves generated on the substrates

	S 1	S 2	S 3	S 4	S 5	S 6	S 7	P
40 days	0.33ª	0.67ª	0.33ª	0.67ª	0.33ª	0.33ª	0.67ª	0.93
60 days	0.67ª	1.67ª	1.33ª	1.00ª	1.00ª	1.67ª	1.00ª	0.33
80 days	1.67ª	2.67ª	2.33ª	2.33ª	1.67ª	2.67ª	2.00ª	0.34
100 days	2.67ª	5.33ª	3.33ª	3.00ª	3.00ª	3.33ª	3.00ª	0.17
120 days	3.67ª	9.33ª	6.67ª	4.33ª	3.67ª	4.33ª	4.33ª	0.17

The averages on the same line followed by different letters are significantly different at 5% threshold.

S1: reference; **S2**: Soil + cow dung; **S3**: Soil + chicken droppings; **S4**: Soil + charcoal; **S5**: Soil + banana stipes; **S6**: Soil + ripe banana plantain; **S7**: Soil + ripe dessert banana; **P**: Probability

3.1.3. Number of emerged leaves

The number of emerged leaves on the different substrates is illustrated by Fig. 4. Organic fertilizers increased the number of emerged leaves except banana tree stems which generated a number (3.67 leaves) identical to that of the control (3. 67 leaves). The highest number of leaves was obtained on substrates 2 (9.33 leaves) - cow dung-based - and 3 (6.67 leaves) - chicken dropping-based -, respectively. However, statistical analysis revealed no significant difference (P > 0.05).

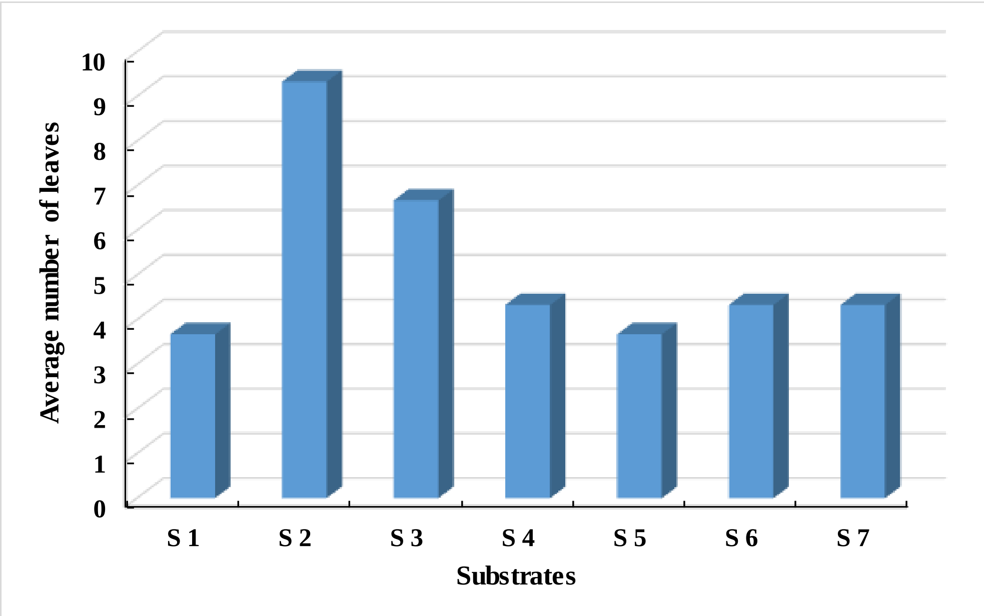

Fig. 4 : Number of leaves generated depending on the substrates

S 1: Control**; S 2:** Soil + cow dung**; S 3:** Soil + chicken droppings**; S 4**: Soil + charcoal**; S 5:** Soil + banana stipes; **S 6:** Soil + ripe plantain**; S 7:** Soil + ripe dessert banana

3.1.4. Effect of amendments on the length of new generated leaves

Fig. 5 shows that the average length of generated leaves on amendeded substrates increased with time. However, the leaves generated on the amended substrates were longer than those generated on the non-amended control. Thus, significant differences (P<0.05) were observed from the 80th day (Table 3I). Substrate 2, with cow dung, was the one that produced the longest leaves from the 40th day after planting (8.50 cm) to the 120th day (22.89 cm). It was followed by the one with chicken droppings even if on the 120th day after planting no significant difference was observed between substrates 2, 3 and 4. The same was true for substrates 1,5,7 where no significant difference was observed although the average lengths of generated leaves on substrates 5 and 7 were greater than those of the leaves generated on the control from the 100th day.

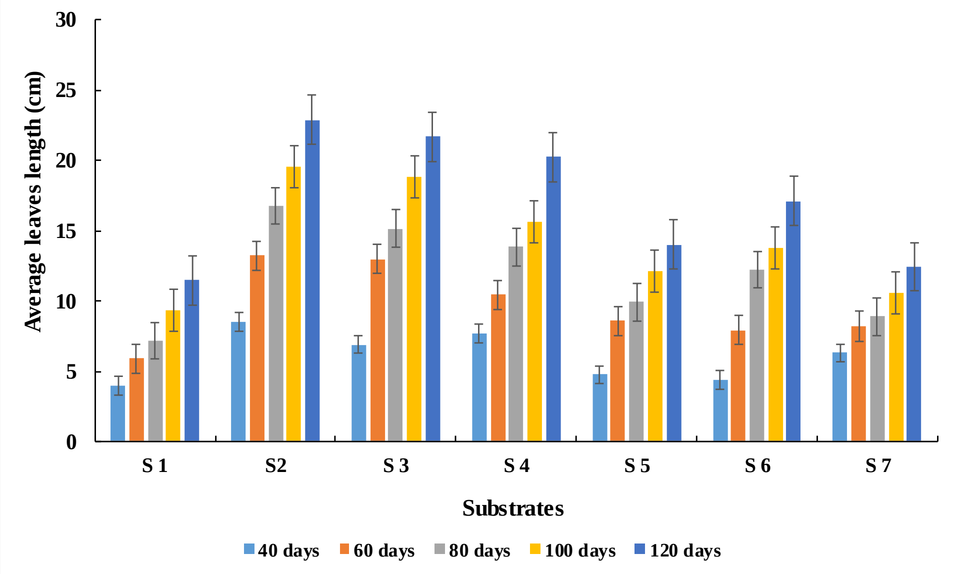

***Fig. 5** : Evolution of the average length of leaves generated on the substrates depending on time*

S1: Control; S2: Soil + cow dung; S3: Soil + chicken droppings; S4: Soil + charcoal; S5: Soil + banana stipes; S6: Soil + ripe plantain; S7: Soil + ripe dessert banana

Table 3: Average length of leaves generated on substrates

	S 1	**S 2**	**S 3**	**S 4**	**S 5**	**S 6**	**S 7**	**P**
40 days	4.00^{a}	8.50^{a}	6.90^{a}	7.70^{a}	4.75^{a}	4.40^{a}	6.30^{a}	0.38
60 days	5.90^{a}	13.25^{a}	13.00^{a}	$10,45^{a}$	8.60^{a}	7.90^{a}	8.20^{a}	0.37
80 days	7.16^{c}	16.78^{a}	15.16^{ab}	13.84^{abc}	9.92^{abc}	12.22^{abc}	8.88^{bc}	0.00
100 days	9.38^{b}	19.60^{a}	18.83^{a}	15.66^{ab}	12.08^{b}	13.79^{ab}	10.53^{b}	0.00
120 days	11.49^{b}	22.89^{a}	21.71^{a}	20.24^{a}	14.00^{b}	17.12^{ab}	12.43^{b}	0.00

The averages on the same line followed by different letters are significantly different at 5% threshold.

S1: reference; **S2**: Soil + cow dung; **S3**: Soil + chicken droppings; **S4**: Soil + charcoal; **S5**: Soil + banana stipes; **S6**: Soil + ripe banana plantain; **S7**: Soil + ripe dessert banana; **P**: Probability

3.1.5. Effect of Amendments on center width of new generated leaves

Fig. 7 shows the average width of *Aloe vera* leaves of measured on the different substrates. Significant differences ($P < 0.05$) between the substrates were observed on the 80th day after planting (Table 4). The amended substrates all favored good leaf width growth compared to the control. The substrates amended with cow dung and chicken droppings induced better *Aloe vera* leaf width growth. However, cow dung promotes leaf width growth better than chicken droppings. Indeed, the highest average width was obtained with cow dung (1.34 cm). On the 100th day after planting, cow dung and chicken droppings generated the largest leaves with averages of 1.43 cm and 1.39 cm, respectively. After 120 days of planting, the widest leaves were still those obtained on substrates amended with cow dung (1.65 cm) and chicken droppings (1.61 cm). The lowest averages were obtained with the control substrate even if between the 100th and 120th day after planting, the leaves obtained on substrate 5 had the same average width as those obtained on the control.

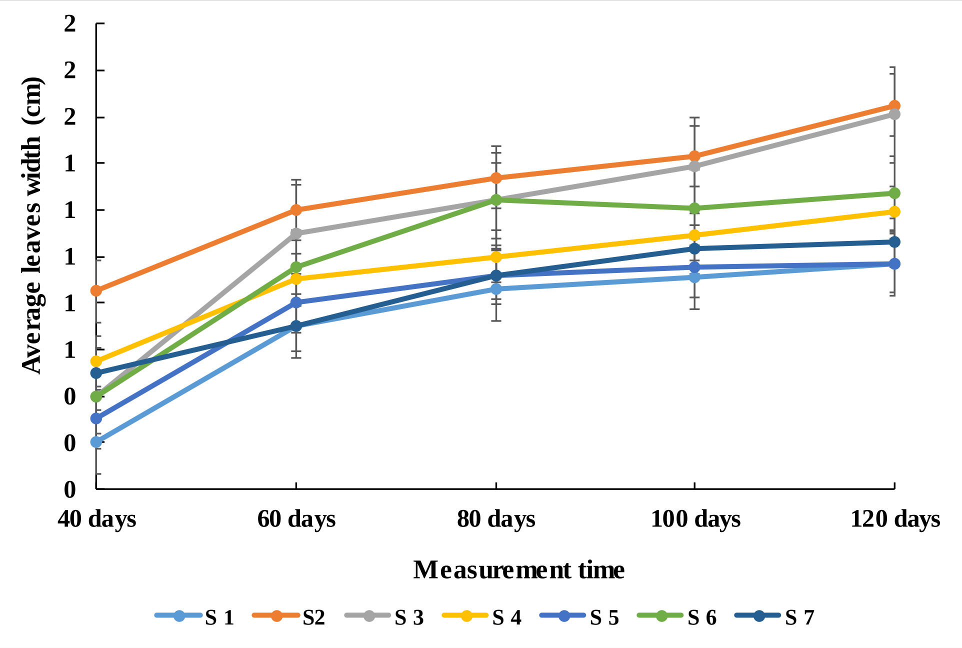

Fig 6: Evolution of the average width of the leaves generated on the substrates depending on time

S1: reference; S2: Soil + cow dung; S3: Soil + chicken droppings; S4: Soil + charcoal; S5: Soil + banana stipes; S6: Soil + ripe banana plantain; S7: Soil + ripe dessert banana

Table 4: Average width of the leaves generated on substrates

	S 1	**S 2**	**S 3**	**S 4**	**S 5**	**S 6**	**S 7**	**P**
40 days	0.20ᵃ	0.85ᵃ	0.40ᵃ	0.55ᵃ	0.30ᵃ	0.40ᵃ	0.50ᵃ	0.68
60 days	0.70ᵃ	1.20ᵃ	1.10ᵃ	0.90ᵃ	0.80ᵃ	0.95ᵃ	0.70ᵃ	0.06
80 days	0.86ᵇ	1.34ᵃ	1.24ᵃᵇ	1.00ᵃᵇ	0.92ᵃᵇ	1.24ᵃᵇ	0.92ᵃᵇ	0.01
100 days	0.91ᵇ	1.43ᵃ	1.39ᵃ	1.09ᵃᵇ	0.95ᵇ	1.21ᵃᵇ	1.03ᵇ	0.02
120 days	0.97ᵇ	1.65ᵃ	1.61ᵃ	1.19ᵇ	0.97ᵇ	1.27ᵇ	1.06ᵇ	0.00

The averages on the same line followed by different letters are significantly different at 5% threshold.

S1: reference; **S2**: Soil + cow dung; **S3**: Soil + chicken droppings; **S4**: Soil + charcoal; **S5**: Soil + banana stipes; **S6**: Soil + ripe banana plantain; **S7**: Soil + ripe dessert banana; **P**: Probability

3.2. Discussion

The pH of *Aloe vera* growth substrates evolved differently depending on the types of amendment ranging from 7.87 to 6.67. The organic amendments supplied therefore did not have the same influence on the modification of soil pH. The variability of pH takes into account the nature of organic amendments (Koulibaly, 2011). Charcoal input resulted in an acidic pH while other inputs kept the soil at a basic pH. This result is in contradiction with the results which tend to show that charcoal, due to its adsorbent properties, tends to increase soil pH (Bio, 2016). We could explain our results by the quality of charcoal used or the management of the crop. For example, poorly controlled irrigation can lead to excessive drainage, loss of bases and Ca^{2+} at depth, resulting in acidification of the surface (Koulibaly, 2011). However, the variation in pH was not an obstacle to the cultivation of aloe in nurseries. These results are in agreement with some authors who have shown that *Aloe vera* is generally cultivated on soils whose pH varies between 6.0 and 7.20 and can even tolerate high pHs (Anonymous 2, 2022; Gharib, 2021).

Leaf generating speed and total number of generated leaves, although improved by the input of organic fertilizers, were not statistically different from one substrate to another before 80 days after sowing. One could conclude that the examination of the comparative rhythms of emergence of *Aloe vera* leaves is first of a genetic order. As a result, it provides information both on the size of the leaf system and on the number of leaves up to the adult stage of the plant (Vincourt, 1984). However, these genetic characteristics can be influenced by the cultivation environment. Indeed, at 80 and 100 days after planting, it was noted the intensification of leaf emergence on the substrates amended with cow dung and chicken droppings, respectively. In fact, these organic constituents have, in the meantime, been mineralized to be made available to the plant for its development (Segnou *et al*., 2012; Etter, 2017).

The amendments supplied have relatively improved *Aloe vera* leaf growth in length and width. According to Djéké *et al*., (2011) and Useni *et al*., (2013), the decomposition of organic fertilizers raises the levels of soil nutrients available to plants. These results would therefore result from a favorable action of the nitrogen and humus contained in these organic amendments, in particular cow dung and chicken droppings (Dembele, 2014). Indeed, according to Eleiwa *et al*. (2012), plant vegetative growth is positively correlated with nutrient absorption, in particular nitrogen which plays an important role in the increase in leaf area index and generation as well as photosynthetic activity. In addition, the results obtained in plants that received chicken droppings could be explained by the essential role that assimilable phosphorus, released into the soil by this manure, plays in growth and development, as well as in plant metabolism and energy transport (Ouedraogo *et al*., 2014). Similarly, according to Kouassi *et al*. (2017), charcoal contributes to nitrogen immobilization. In fact, adding charcoal to heavily weakened tropical soils improves their physical, chemical and biological properties. As a result, these soils can acquire good cation exchange capacities (CEC) and better abilities to retain and recycle nutrients over long cultivation periods. These results would therefore be attributable to this capacity possessed by charcoal. Through the effects due to banana, it seems that nitrogen assimilation by plants is favored by the strong presence of potassium and phosphorus in banana peel, as thought by Leikam *et al*., (1983). According to them, adequate phosphorus and potassium nutrition can increase the crop's growth response to nitrogen. The results obtained, in connection with substrate 5, show a low quantity of nitrogen in banana tree stems, which would justify the weak growth of the plants having evolved on this substrate compared to other fertilizers. Indeed, nitrogen is the most important nutrient for good growth of *Aloe vera* plants (Michayewicz, 2013). This observation is confirmed by Harry *et al*. (2011) who claim that the concentrations of total nitrogenous matter in banana tree stems are low and close to a straw.

IV. CONCLUSION

Cow dung, chicken droppings, charcoal, banana stipes, ripe plantain, and ripe dessert banana were used to determine and compare their effects on *Aloe vera* sucker growth in nursery. The results show that the pH of the substrates depends on the type of amendment supplied. This pH varied from 6.67 to 7.87. Regarding growth parameters, thanks to its richness in nitrogen, cow dung intensified leaf emergence speed. Moreover, with 9.33 leaves generated, 2.89 cm average leaf length and 1.65 cm average leaf width, it favored the rapid growth of *Aloe vera* suckers. Thus, for the establishment of an *Aloe vera* nursery, the use of cow dung could be recommended to promote good and rapid growth of suckers.

REFERENCES

[1] Adjiri, O., Assoma, T.V., Soro, G., Aka, N., Bengaly, I. and Soro, N. (2020). Evaluation of the suitability of natural spring waters for agriculture using hydrochemical techniques: the case of the departments of Daloa and Zoukougbeu, Ivory Coast. *Africa Science*, 16 (1): 204-217.

[2] Adjiri, O., Kouamé, V., Niangoran, C.K., Soro G. and Biémi, J. (2018). Toxic waste dumping in Ivory Coast: following the effectiveness of the clean-up operation based on residual pollution indicators. *Environment, Risks & Health*, 2 (17): 147-154.

[3] Alla, K.T., Bomisso, E.L., Ouattara, G. and Dick, A.E. (2018). Effects of plantain peel by-product fertilization on agromorphological parameters of the F1 Eggplant variety kalenda (Solanum melongena) in Bingerville locality, Ivory Coast. *Journal of Animal & Plant Sciences*. Vol.38, Issue 3: 6292-6306.

[4] Anonymous 1 (2022). Mexico big producer of the beauty scrunchie [online]. https://www.actulatino.com/2021/08/16/l-aloe-vera-the-mexico-big-producer-of-scrunchie-beauty/ (Consulted on 03/09/2022).

[5] [5] Anonymous 2 (2022). What type of soil for Aloe vera? [online]. https://plantsguide.com/what-type-of-soil-for-aloe-vera/ (consulted on 25/01/2023).

[6] Bio, S. (2016). Growing differently: local examples of agro-ecological techniques. 21 p.

[7] Dembele, A. (2014). Response of maize (*Zea mays* L.) to compost or manure on soils amended with fragmented twigs of *Piliostigma reticulatum* (D.C.) Hochst. DEA thesis. University of Polytechnic of Bobo-Dioulasso. Burkina Faso, 64 p.

[8] Djéké, D.M., Angui, K.T.P. and Kouadio, Y.J. (2011). Decomposition of cocoa shells in ferralitic soils of the Oumé area, west-central Ivory Coast: effects on soil chemical characteristics. *Biotechnology Agronomy Society and Environment*. 15 (1), 109 - 117.

[9] Dro, B., N'goran, K.D., Coulibaly, S., Salla, M., Amon, A.D.E and Kouassi, K.H (2020). Floristic Diversity of the Lianas of the Forest Classified as Bouaflé, Centre West of

Ivory Coast. *European Scientific Journal*. Edition Vol.16, No.27 ISSN: 1857 - 7881.
[10] Eleiwa, M.E., Brahim, S.A. and Mohamed, M.F. (2012). Combined effect of NPK levels and foliar nutritional compounds on growth and yield parameters of potato plants (*Solanum tuberosum* L.) *African Journal of Microbiology Research*, 6 (24) : 5100-5109.
[11] Etter, A. (2017). Organic fertilizers: yield and quality. Review UFA 10/ 2017, 2 p.
[12] Foure, E. and Tezenas, D.M. (2000). Banana production: a major economic challenge for food security. *Newsletter of the regional cooperation for the development of horticultural products in Africa*, 1 (8) : 23-28.
[13] Gharib, K. and Ben, Z.S. (2021). Investigations on Antimicrobial, Antifungal and Antiviral Properties of *Aloe vera*. Master thesis, University Brothers Mentouri Constantine 1, 48p.
[14] Kouakou, A.C.A., Coulibaly, B., Kaba D., Anoh, K.P and Courtin, F. (2018). Settlement dynamics and landscape modification in the Marahoué National Park (Ivory Coast). *TROPICULTURA*, 36(2): 206-216.
[15] Koulibaly, B. (2011). Characterization of soil acidification and fertility management of cotton agrosystems in Burkina. Thesis at the University of Ouagadougou Option Applied Sciences Speciality: Agro-pedology. 183 p.
[16] Leikam, D.F., Murphy, L.S., Kissel, D.E., Whitney, D.A. and Mserh, H.C. (1983). Effect of nitrogen and phosphorus chorus application and nitrogen source in winter wheat grand yield and leaf tissue phosphorus. *Soil. SCI. AMG*: 530-535.
[17] Michayewicz, N. (2013). Aloe vera, a medicinal plant traditionally and widely used for thousands of years, with numerous therapeutic properties. Miracle plant? Doctoral thesis, University of Lorraine, France, 148p.
[18] Nindjin, K.A.G., Agbo, N.G. & Otokore, O.D. (2003). Varieties of yams (*Dioscorea spp*) found on markets in Ivory Coast and their culinary preference Post-harvest, 32 p.
[19] Onyinyechi, C., Amobi, A.A., Cynthia, E., Chineye, L., Nneka, M.U.C., Simeon, O., Chidimma, C., Kelechi, M.O.F. and Chukwuebuka, O. (2021). In vivo study of antiplasmodium and histological activity of *Garcinia kola* and *Aloe vera* extracts against Falciparum malaria. *Journal of Medicinal Plants Research*, 15 (5) : 18-195.
[20] Ouédraogo, J., Nacro, H.B., Ouédraogo, E., Youl, S. and Sedogo, M. (2014). Improving phosphorus availability through soil macrofauna management: case of a lixisol in the semi-arid zone of Burkina Faso. *Int. J. Biol. Chem. Sci*. 8(4): 1838-1846.
[21] Sangare, A., *Koffi, E.M., Akamou, F.M. & Fall, C.A. (2009).* National Report on the State of Plant Genetic Resources for Food and Agriculture. Republic of Ivory Coast. Ministry of Agriculture. The State of Plant Genetic Resources for Food and Agriculture: Second National Report. 63 p.
[22] Segnou, j., Akoa, A., Youmbi, E. and Njoya, J. (2012). Effect of mineral and organic fertilization on fruit yield of chilli (*Capsicum annuum* l.; solanaceae) in lowland forest zone in Cameroon. 10 p.
[23] Svjetlana, Z., Parađiković, N., Davidović, J., Gidas, E. and Vujošević, A. (2020). The effect of water extract of *Aloe vera* (L.) burm.f. on germination and growth of scarlet sage; *Proceedings of the XI International Scientific Agricultural Symposium Agrosym* , 12 (7) : 262-267.
[24] Useni, S.Y., Chukiyabo, K.M., Tshomba, K.J., Muyambo, M.E., Kapalanga, K.P., Ntumba, N.F., Kasangij, A.K.P., Kyungu, K., Baboy, L.L., Nyembo, K.L. and Mpundu, M.M. (2013). Use of recycled human waste for increasing maize (Zea mays L.) production on a ferralsol in southeastern DR Congo. *Journal Applied Biosciences*. 66: 5070 - 5081.
[25] Vincourt, P. (1984). Relationships between leaves appearance rhythm, total number of leaves and flowering precocity in maize. *Agronomy*, 4 (8), pp.795-800.
[26] Yosser, B.Z. (2012). Behaviour of Aloe vera planted on two different textured soils and subjected to saline treatment. End of study project. Mograne High School of Agriculture, 49 p.
[27] Zerrad, W., Maataoui, B.S., Hilali, S., El Antri, S. and Hmyene, A. (2008). Comparative study of biochemical mechanisms of resistance to water stress in two varieties of hard wheat. *Lebanese Science Journal*, 9(2). 27-36.
[28] Zro, B.F.G, Soro, D. and Abobi, D.H.A (2018). Comparative analysis of the effects of two organic amendments on the organo-mineral status and productivity of a sandy soil. *Journal of Applied Biosciences* 124: 12416 - 12423.