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AGRONOMIC EVALUATION OF LOCAL SOIL-LESS GROWING SUBSTRATES BASED ON RICE AND COCOA RESIDUES IN TOMATO CULTIVATION IN CÔTE D'IVOIRE

Agriculture

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ABSTRACT

Côte d'Ivoire, an agricultural country, rejects large quantities of crop residues and agro- industrial waste with agricultural potential into the environment every year. The purpose of this study is to study the effect of thirteen substrates mainly based on rice husks, sawdust and cocoa shell shreds on some agronomic parameters of tomatoes grown in soil-less conditions in Daloa using a completely randomized block design.

The main results revealed that the best agronomic performance was obtained with the soil (19.64 $t.ha^{-1}$). This performance is far from being achieved with the soil-less growing substrate produced. The best yield with those substrates was 10.76 $t.ha^{-1}$. The best growing substrates were RCJ711 and RCJ621 rice husks based ones. Cocoa shell substrates gave the lowest performance. When more than 30% cashew was associated with cocoa, the quality of the substrate was reduced. This research showed that it is possible to develop soil-less growing substrate in agriculture in order to sustainably increase production by dodging soil pests.

KEYWORDS

Carbonization, cocoa shells, rice husks, sawdust, substrates, tomato

1. INTRODUCTION

Agricultural practices based on a cultivation system without restitution to the soil, quickly lead to soil impoverishment. Most soils in tropical Africa and in Côte d'Ivoire, in particular, are in an advanced state of physical deterioration and lack nutrients and organic matter [1]. In addition, the removal of fallow land due to high population pressure has led to a decline in soil fertility [2]. This decline in soil fertility associated to high parasitic pressure on the soil leads to a decrease in crop production. Chemical fertilizers used to compensate for soil productivity are too expensive and their massive and continuous use causes many problems including soil acidification, physical degradation, declining organic matter and soil microbial biomass [3] and [4]. This situation increases farmers' poverty [5]. This problem is intensified in the market gardening context, which is highly dependent on fertilizers and soil quality. Indeed, with the displacement of populations towards cities and the concentration in areas favourable to cash crops, urban and peri-urban agriculture are gaining more and more ground on highly polluted soils [6]. Those soils conditions threaten the health of consumers and the sustainability of vegetable production.

Soil-less agriculture is expanding with exotic growing substrates that combine various nutrients requiring various equipment for their applications. Fertilization is generally carried out with nutritive fluids which are not always accessible and which, however, determine the success of this innovative production method. Its adoption in an agricultural country producing huge quantities of agricultural and industrial waste such as Côte d'Ivoire could be facilitated by revising the technology package so as to valorize local products with local means. In such a context, the valorization of agricultural waste products such as rice husks, cocoa residues, sawdust and cashew pelts could be an appropriate solution to improve vegetable production in Côte d'Ivoire [7] and [8]. Indeed, these waste products are accessible to Ivorian farmers. The Daloa region, located in the second cocoa zone, is an important center for the supply of vegetable produce, including tomatoes, despite the low level of the national production. Indeed, in Côte d'Ivoire, annual production fluctuates between 22,000 and 35,000 tons [9]. This weak productivity creates a structural deficit in product supply and only one-thirds of demand is fulfilled by local production [10]. This weak productivity is due not only to climate change and the misuse of pesticides, but is imputable to a decline in soil fertility and parasitic pressure caused by overexploitation in urban and peri-urban areas.

The purpose of this study is to assess the potential of local agricultural waste to develop soil- less substrates for tomato production. Specifically, this will involve determining physical and chemical properties of local substrates and evaluating the agronomic performance of these local substrates with respect to tomato productivity.

2. MATERIALAND METHODS

2.1 Study environment

This study was carried out in the department of Daloa located between north latitudes by 6°30 and 8° and between west longitudes by 5° and 8° (Figure 1). Main urban city in the Centre-Ouest of Cote d'Ivoire, Daloa is located at 140 km from the political capital Yamoussoukro and 420 km from the economic capital Abidjan. Soils are ferralitic ones. The texture and the high amount of organic matter predispose these soils to good agricultural production [11]. However, they are extremely fragile and contain toxic elements in the soil [12] and [6].

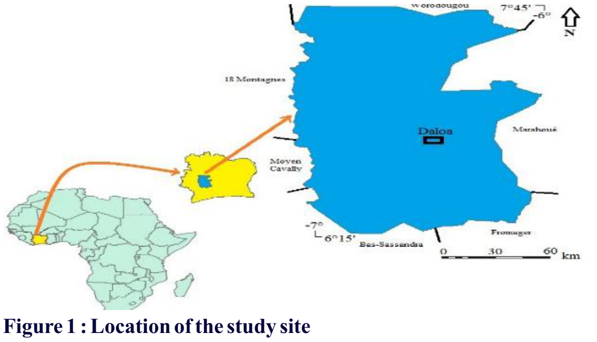

Figure 1 : Location of the study site

2.2 Equipment used

The plant material is composed of tomato plants obtained from F1 hybrid variety COBRA 26. Substrates are obtained from the combination of local agriculture sub-products such as rice husks, sawdust, crushed cocoa shells and cashew pelts. Rice husks, cocoa shells and sawdust are the main raw matter used. These sub-products are selected for their availability in the area and their agronomic potential. The technical equipment includes growing buckets; four charcoal ovens; a drip irrigation system; a pair of scissors; a precision scale; a 16-litres sprayer; 60 m of black tarpaulin; a caliper; a graduated ruler; a digital camera; a 50-metres roll; a machete, two hoes and a pickaxe; a tape measure; fertilizers and pesticides.

2.3 Methods of operation

2.3.1. Composition of substrates

Substrate production process

The carbonization of rice husks or sawdust is done in few stages (figure 2):

Step 1: Ignition

Set up a heap of material to be carbonized up to 200 – 240 kg Constitute a burner of flammable materials (twigs of wood, small branches) that can form embers at the top of the heap; light on the fire, and leave it burn until embers are produced.

Step 2: Combustion by smothering

Cover the embers with the material to be carbonized with the carbonizer, then pack the remaining material around so that to avoid air intakes at the base of the carbonizer. Keep it burning; Dampen the material by adding water if necessary Smother the flames by adding water if necessary;

Ensure that the flame does not reignite.

This step may take 8 to 12 hours depending on the quantity and quality of the substrate.

Step 3: Cooling

At the end of combustion, extinguishing the fire with water and allow carbonized material to cool down for 20 to 30 minutes before collecting the carbonized component.

The rate of carbonization varies according to the material. It is about 50% for rice and varies between 33 and 50% for sawdust.

Figure 2 : Substrate production steps.

a.Heap of material to be carbonized with burner on the top; b. Embers formation; c. Combustion by smothering; d. Cooling

2.3.2. Formulation of substrates

Calculate the different proportions needed in each matter considering the total capacity of the container. All pretreated or un-pretreated sub-products are weighed to form substrates. The composition of each substrate is given in table 1. The substrate container is filled at 4/5th of its capacity so that to provide a layer of approximately 22 cm depth to the roots.

Table 1 : Composition of the different substrates

Composition of substrates						
N°	Substrates	Rice husks (%)	Cocoa shells (%)	Cashew pelts (%)	Sawdust (%)	Mass (kg)
1	RCJ180	10	80	0	10	1,55
2	RCJ171	10	70	10	10	1,55
3	RCJ261	20	60	10	10	1,55
4	RCJ054	0	50	40	10	1,60
5	RCJ243	20	40	30	10	1,45
6	RCJ444	25	25	25	25	1,47
7	RCJ621	60	20	10	10	1,00
8	RCJ711	70	10	10	10	1,13
9	RCJ333	30	30	30	10	1,35
10	C100	100% cocoa shells crushing				1,69
11	B100		100% Carbonized sawdust			0,9
12	R100		100% Carbonized rice husk			0,85
13	Soil		Floor indicator light		-	

RCJ: Charred Rice husks - Cocoa shells - Cashew Pelts in this order, B: Sawdust,

2.3.3. Experimental tomato production system

The experience is conducted in a Complete Randomized Blocks Design (CRBD) with three replicates compting 39 elementary plots of 5 plants each. The elementary plot is rectangle with 1.5 m x 1 m.

2.3.4. Tomato plant nursery

The shaded nursery is made in alveolar plates, sowing one seed per hole. It is regularly watered and plantlets are gradually exposed to sun by reducing shade as an acclimation. They are completely discovered three (3) days before transplanting. Transplanting of the seedlings were down in potted substrates twenty-one (21) days after sowing. Only vigorous seedlings of 4 and 5 open leaves were transplanted at 0.3 x 1 m being 33'333 seedlings/hectare. The recovery of the plants was observed a week later and the dead seedlings were replaced only once.

2.3.5. Maintenance and monitoring of plot cultivation

The plots are regularly irrigated and fertilized three weeks with NPK (NPK 15-9-20) 3.8 S;

1.8 MgO; 0.02 Zn; 0.15 B; 0.02 Mn and nitrabor at flowering. Nine (9) to fifteen (15) g of those fertilizers were directly localized 5 cm from the stand in the substrate. Phytosanitary cares were made alternating insecticides and fungicides. Staking carried out before flowering ensures that the plant could resistant to the weight of fruits and allowed it to keep an upright growth habit.

2.3.6. Measured parameters

Tomato growth parameters

The survival rate of the plants was observed six (6) days after transplanting by counting plants that survived by substrate. The height of the plants was determined from the collar to the base of the terminal bouquet, using a ruler graduated twice a month from the 10th day after transplantation to 90th day. The diameter was determined with a caliper at full flowering.

Flowering parameters

Dates of appearance of the first floral buds, flowers and first fruits were noted in d.a.s. The count of flower buds, flowers and fruits was regularly carried out each six days from the date of first appearance.

2.3.7. Yield parameters

The fruit was harvested as soon as the first ripen fruits were harvested each three (03) days. Rotten fruits are quantified and separated from the lots. The number of fruits and the mass of each fruit were determined by plant. Weighing made it possible to calculate the yields (t.ha-1) according to the following formula:

2.3.8 Statistical analysis of data

To assess the differences between treats for each variable, an ANOVA is applied using SAS Vers. 9.4 software. The T-test classified substrates for a given variable when significant differences were observed. Graphics were created with Origin 5.0.

$$Fruit\ Yield\ (Kg.m^{-2}) = \frac{Fruit\ Weight\ (Kg)}{\text{Area harvested } (m^2)}$$

3. RESULTS

3.1 Physico-chemical characteristics of substrates

3.1.1 Organic matter (MO)

The organic matter content calculated from the carbon content varied from 2.40 to 5.88%, and is generally good for substrates. The highest OM values were recorded with 100 % cocoa shell treats (5.88%). Carbonized rice husk substrates had the lowest OM rate levels followed by RCJ621 and RCJ711 with 2.4% and 2.9% respectively.

3.1.2 Water retention capacity

Table 2 presents the water retention capacity of substrates. It was lower in sawdust (10%) compared to other substrates with 27.5% in 100 % cocoa shells, 65% in 100 % rice and 55% in 100 % cashew. Composite substrates improved water retention, reaching 72.5% in RCJ333 substrate. However, when high cocoa were associated with low cashew proportion, water retention decreases.

3.1.3 pH of the substrates

The pH of the different substrates varied from 5.6 (slightly acidic) to 7.9 (quite basic). Three classes had been identified: quit acid pH class ($5.6 \leq pH \leq 6.2$); neutral pH class ($6.5 \leq pH \leq 7.1$) and finally the somewhat basic pH class with a single substrate RCJ171 (7.9) with 70 % cocoa shell.

3.1.3 Nitrogen and phosphorus

Results in table 2 indicates that all substrates had good nitrogen level and well supplied with phosphorus. Cocoa shell mill treats have the highest nitrogen rates at 1.7 and 1.8% in substrates C100 and RCJ054 respectively.

3.1.5 Cationic Exchange Capacity (CEC) and Saturation Rate (V)

The CEC varies from good (21.8 $cmol.kg^{-1}$ for sawdust) to very good (151.3 $cmol.kg^{-1}$ in cocoa) in substrates. The rice husk had a CEC of

28.5 cmol.kg^{-1} while it is 9.12 cmol.kg- 1 for the soil (check).

The saturation rate of the adsorbent complex is higher in the control plot than in composite substrates (table 2). These rates ranged from 2.86 (RCJ711) to 5.78% for substrates, while the rate was 27.73% for the control soil. In general, cocoa shell substrates showed low saturation compared to carbonize rice husk substrates.

The substrates appeared to have no major biological activity except for treats with at least 70% cocoa shell shreds and more than 30% cashew pelts. The substrate C100 had even been colonized by a fungus whose genus has not been determined.

Table 2 : Properties of the different substrates

							Absorbent complex (cmol.kg-1)				
Substrates	**CRE(%)**	**pH**	**C(%)**	**N(%)**	**P(%)**	**K^+**	**Ca^{2+}**	**Mg^{2+}**	**CEC**	**MO (%)**	**V (%)**
B100	10	6,5	1,6	0,4	0,19	0,207	0,61	0,14	21,88	2,8	4,35
Cao100	27,5	7,0	3,4	1,7	0,21	3,383	0,68	0,44	151,32	5,88	3,723
R100	65	6,8	1,8	0,4	0,23	0,627	0,1	0,1	28,54	3	3,05
RCJ054	30	6,0	2,3	1,8	0,18	1,843	0,52	0,32	86,34	3,9	4,07
RCJ171	35	7,9	3	1,3	0,21	1,986	0,71	32	95,83	5,1	4,23
RCJ180	37,5	7,0	3,1	1,3	0,2	1,785	0,45	0,3	82,36	5,3	3,97
RCJ243	22,5	7,1	2,6	1,7	0,19	2,204	0,39	0,35	98,18	4,4	3,74
RCJ261	37,5	6,7	3,3	1,0	0,2	1,18	0,57	0,33	61,48	5,69	4,83
RCJ333	72,5	6,0	2,1	1,3	0,21	1,55	0,43	0,19	71,43	3,7	3,04
RCJ444	45	6,9	2,2	1,4	0,28	1,396	0,14	0,18	59,681	3,8	2,89
RCJ621	27,5	5,6	1,4	1,4	0,21	0,611	0,5	0,27	37,15	2,4	5,78
RCJ711	65	6,0	1,7	0,6	0,2	0,885	0,04	0,13	36,91	2,9	2,86
Soil	-	6.2	1,47	0,11	0,87	0,113	1,86	0,49	9,12	2,52	27,73

CRE: Substrate water retention capacity; **CEC:** Cation exchange capacity; **MO:** Organic matter; **V: Saturation rate**

3.2 Effect of treatments on the growth and development of tomato plants

The plant recovery or survival rate and 90-day post-seeding diameter (DAS) are presented in table 3. Statistical analysis indicates a highly significant difference ($p<0.001$) for the recovery rate and very significant difference ($p<0.0001$) for height and diameter at flowering.

3.2.1 Survival rate

The survival rate varied with high significance (P 0;001) from 53% (RCJ054) to 100% on 100% sawdust, 100% rice husks and composites combining rice husks, cocoa shell shreds, cashew skin and sawdust in the same proportions. The highest mortality rate was observed in the RCJ054 composite.

3.2.2 Diameter of the seedlings at 90 DAS

The collar diameter (table 3) of tomato plants varied with very high significance (P 0.0001) from 0.43 to 0.94 cm depending on the substrate composition. The substrate (RCJ621) with 60% rice husks, 20% cocoa shell shreds and 10% cashew skin obtained the largest collar diameter (0.94 cm), an increase of 3.28% over the control (Sol). The plants with the smallest collar diameters were obtained on RCJ333.

Table 3: Recovery rate (%) and average diameter (cm) of tomato plants at 90 DAS

Substrates	**Recovery rate (%)**	**Diameter at the collar (cm)**
B100	100^{a}	0.78^{dc}
R100	100^{a}	0.47^{fg}
RCJ711	93.33^{ab}	0.51^{fg}
RCJ621	60^{cd}	$0,94^{a}$
RCJ444	100^{a}	0.85^{abc}
RCJ333	73.33^{bcd}	$0,43^{g}$
RCJ243	93.33^{ab}	0.68^{de}
RCJ054	$53,33^{d}$	0.56^{ef}
RCJ261	86.67^{ab}	0.81^{bc}
RCJ171	86.67^{ab}	0.81^{bc}
RCJ180	80^{abc}	0.86^{abc}
Cao100	60^{cd}	0.85^{abc}
Soil	100^{a}	0.91^{ab}
CV	**36,84**	**21,86**
PPDS	**24,92**	**0,124**
Effect	**	***

CV: Coefficient of variation; **PPDS**: Smallest significant difference at 5%. **RCJ**: Rice -cacao- cashew; **B**: Wood; **R**: Rice. The averages followed by the same letter do not differ significantly at the 5% threshold. (**): Highly significant; (***): Very highly significant.

3.2.3 Height of plants

No significant differences were observed from the beginning of growth to 30 DAS. However, from the 45th das onwards, there was very high significant variation ($P<0.0001$) that continued until flowering. Two (02) substrate groups could be defined with respect to the height of plants. These two groups were formed by the substrate RCJ054 with dwarf plants, opposite all others including substrate that gave normal growth. The control and carbonized rice husk treats (RCJ711 and RCJ621) offered the highest plants after the soil (figure 3).

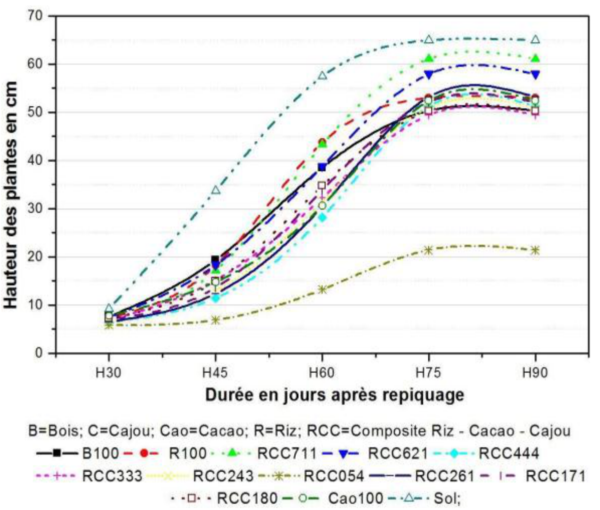

Figure 3: Evolution of the height of tomato plants according to the type of substrate.

3.3 Mineral deficiency effect

The deficiency effect was observed for two minerals: nitrogen (N) and magnesium (Mg^{2+}). Nitrogen deficiencies were manifested by chlorosis of the foliage (light green or even yellow tint) and reduced growth. Magnesium deficiencies were manifested by thickening and intermediate chlorosis of the leaves. N deficiencies were very significant ($p<0.0001$) between culture substrates. This effect was very marked on RCJ054 treatment plants with 25 to 50% of the plot covered with symptoms. The Mg^{2+} deficiencies observed are not significantly different (p 0.05) according to the treats. However, RCJ444 had a deficiency rate between 1% and 25%.

3.4 Tomato productivity on growing substrates

3.4.1 Floral parameters

The average number of flower buds per plant is shown in figure 4a. Soil cultivation favored more flower buds compared to substrates ($p<0.0001$). Composites RCJ621 and RCJ444 produced more flower buds. The average number of flowers obtained per plant is illustrated in figure 4b. R100, RCJ711 and RCJ621 produced more flowers after the soil. The RCJ054 treat recorded the lowest number of flower buds and flowers over the entire cycle. The average number of fruits harvested varied between 1.53 and 18.27 per plant. Plants grown on soil (check) with 18.27 fruit harvested/plant was the best substrate followed by R100 and RCJ621 with 11.53 and 11.20 fruit, respectively. RCJ054 and C100 were the worsts substrates with 1.53 and 6.93 fruits harvested respectively (figure 4c). All those parameters are highly different ($p<0.0001$).

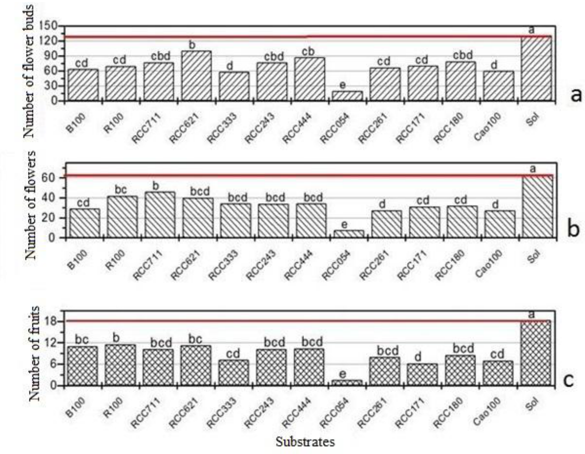

Figure 4: Average number of flower buds, flowers and fruits produced according to substrates. Averages follow by the same letter are not different at the 5% probability threshold

3.4.2.Earliness effect

The statistical analysis showed high significant difference for the first fruiting date and a very high significant difference for the first flowering date. Substrates RCJ621 and RCJ333 favored earlier f lowering and fruiting, while these two phenomena were delayed in RCJ444 (1/4 of each by-product) and RCJ054 (50% cocoa, 40% cashew and 10% sawdust) treats. The flowering-fruiting period was shorter for this last treatment.

3.4.3. Fruit yield

Figure 5 shows a variation in tomato fruit yield by substrate. It varied from one substrate to another with a highly significant difference ($P=0.0004$). However, the highest yield was obtained on the soil (1st group) with 19.84 $t.ha^{-1}$, compared to 10.76 $t.ha^{-1}$ for the best substrate. The yield of the best substrates evolved around 10 $t.ha^{-1}$ and five substrates (B100, RCJ621, RCJ711, RCJ444 and RCJ243) formed the second group in the ranking. Tomato production on RCJ054 substrate was lowest at 1.56 $t.ha^{-1}$ (group 4), while the other substrates in group 3 had intermediate yields between 5 and 10 $t.ha^{-1}$.

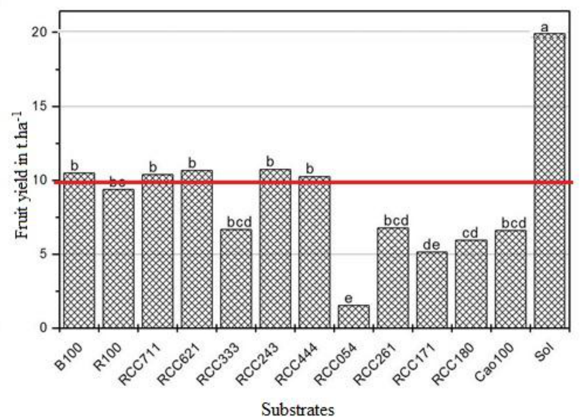

Figure 5: Average fruit yield per substrate ($t.ha^{-1}$).

Averages followed by the same letter are not significantly different at the 5% probability threshold.

4. DISCUSSION

4.1 Quality of the substrates

The carbonized materials showed good water retention and appropriate pH skills. Rice husk has coarse texture but had good water retention compare to cocoa and sawdust. Those two substrates behaved as sandy soil for lack of binding substance associated to their inner structure. Thick cocoa shells and slim sawdust could be characterized by bad porosity. In fact, rice husk seemed to be the best because of their good porosity described by [13]. Its inner structure could offer swelling possibilities responsible for water retention. Thus, a high proportion of rice husk will tend to be more permeable than cocoa shell shreds substrate more compacting because of a sticky fluid flowing from cocoa shells. The poor water retention capacity of cocoa shell shred substrates could also be explained by the uniformity and the large size of the particles favoring mass curing. Sawdust has a low retention capacity in relation with its coarse lamellar texture. It behaved like a sponge. The addition of small proportions of cashew to these substrates tends to improve water retention if the sawdust, cocoa and cashew pills balance each other. Substrates porosity, in link with water retention tends to contrast with [14] who argued that porosity is inversely proportional to the mass of the substrate. The retention capacity of substrates containing carbonized rice husks varied from 27 to 65%. It did not differ fundamentally from the results obtained by [15] with coco fibers (25-40 %), an organic substrate, and includes vermiculites (45-50 %) and perlites (35-50 %), both mineral substrates. pH of rice husks, sawdust and shredded cocoa shells are suitable for good agricultural production. On the other hand, the cashew shells, even at 20%, reduced the pH to plunge the composite substrate into a higher acidity class. These results are similar to those of [16] and are comparable to the pH of coco fiber (5.4 to 6.7). Cashew shells are acidic and transmit this acidity to the substrate even in a small proportion in opposition to [17] for whom it is the rice husk that lowers the pH of the soil or the substrates with which it is combined. It can be deduced that the pH of a composite substrate is a function of its content.

With the exception of the 100% carbonized sawdust substrate, the tested substrates had a very high CEC, reflecting a very high cation binding potential overall. Cocoa shell shreds showed highest CEC values (59.68 to 151.32 $cmol.kg^{-1}$) comparable to the CEC of perlite-based substrates (60 to 140 $cmol.kg^{-1}$) [18]. Indeed, the cation exchange capacity is inversely proportional to the particle size due to a larger specific surface area. Although cocoa did not have good physical property, it has the best chemical potentialities. Substrates based on carbonized organic materials have CECs (21.88 to 37.15 $cmol.kg^{-1}$) that are slightly similar to the 27 $cmol.kg^{-1}$ of vermiculite-based substrates reported by [15].

4.2 Substrate productivity

The survival rate of seedlings was strongly influenced by the nature of the substrate. Indeed, acidic substrates caused the death of plants that necessarily led to replacements that do not survive any more. pH of the substrates were found to be harmful to plants, confirming the results of [19] and [20]. This action is reinforced by the excess water provided by cashew and cocoa grind. Cashew seemed to be very acidic when integrated to any composite. The lack of emergence predestines these substrates for a reduced number of individuals at harvest and will impact yield [21]. The high acidity reduces the water assimilation observed by [13] in cocoa nurseries and led plantlets to disaster before the flowering stage. Growth is low on substrates relative to the soil. Plants on substrates dominated by rice husks with no more than 20% cocoa or cashew residue grew well and plants were vigorous in comparison with [22] and [23]. This takes into account the nitrogen content and pH. Indeed, the pH of all carbonized substrates varied from between 5.5 to 6.8 which is the optimal pH zone for tomatoes [24]. In addition to improving the pH of substrates, carbonized material provided better water retention in substrates, thus promoting harmonious plant development. These carbonized substrates have direct and indirect physical effects on plant growth by contributing to better water and air availability in the root zone [17]. Lower growth level was observed on treats with at least 30% cashew shell in relation to its acidic character that limits plant growth. RCJ621 substrate (60% rice husk, 20% cocoa shell and 10% cashew shells) gave the best plant development followed by RCJ180 and C100 substrates. This growth reflects good chemical dispositions certainly linked to an evolution of the substrate. Raw cocoa residues created conditions for biological activity causing bad smell that limit its domestic use despite the good apparent chemical properties. Cocoa shells, rich in nutrients with biological activity, can be classified and used as organic fertilizers [25] and [26]. A nitrogen deficiency was observed on tomato plants grown on substrate RCJ054 (50% raw cocoa shell residue and 40% cashew shells). This expression of deficiency could be attributed to the physico-chemical properties of the substrate. Indeed, this substrate, had a moderate water retention capacity (30%) and an acidic pH. The substrate is compacted in the presence of water, modifying its porosity and nutrients assimilation by plants. Similar results were obtained by [27] in pineapple production. The presence of cashew is a factor limiting plant growth in substrates.

The first inflorescences were observed on substrates dominated by charred rice husks and then on those based on cocoa crushes. This early maturity is due to the good availability of nutrients, including phosphorus. Indeed, according to [28], the contribution of phosphorus in an assailable form favors the formation of flowers and fruits and increases precocity. [29] confirm the precocity of plants developed on organic substrates compared to conventional production.

Soil productivity was higher than that on substrate and the national average of 10 $t.ha^{-1}$ [30]. The best substrates are at the level of the national average production of 10 $t.ha^{-1}$ [31]. Those substrates performances could be explained by the depressive effects of some components. The cocoa shell shreds and cashew shells created conditions of root asphyxiation and bad pH. But in general, the uniform watering of substrates with different water retention capacities influenced productivity. This could explain why, despite the chemical qualities and good vegetative development, substrate productivity is lower, unlike [32] who reported an increase in fruit yields of tomatoes and peppers on carbonized organic substrate from lemon tree wood. The predominance of non-inert organic cocoa residues makes the substrates used, more predisposed to play the role of organic fertilizer, gradually making nutrients available to plants. Indeed, [33]-[34]-[23]-[35] and [36], observed beneficial effects of adding organic substrates to the soil as organic amendment in corn and cassava production. Further studies should look for irrigation rate according to each substrate.

5. CONCLUSION

In this study, substrates based on local agricultural sub products have a strong agronomic potential due to their water retention capacity and their chemical properties. The study found that rice husk substrates had a good water retention capacity with an average of 52.5% compared to an average of 33% for cocoa shell shreds which otherwise have high CEC. The best agronomical substrate should contain at least 50% rice husks, almost 10% cashew and the remaining proportion in sawdust or cocoa shells; more cashew (raw matter) would deteriorate its quality.

Rice husks, sawdust and cocoa residues are available in the Haut-Sassandra region and constitute raw material of interest. Cashew pelts are also available in the central regions in Cote d'Ivoire. Those materials can be valorized and improve the production environment. However, while sawdust and rice husks have been carriers with a certain inertia promoting plant growth with a potential for sustainability, cocoa shell shredder seemed to evolve rapidly over time and would give poorer crop. Some improvements in the structure of rice husks, cashew pills and sawdust would help to improve their performance.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

[01] Pieri, C. (1989) Fertility of savannah lands, assessment of thirty years of agricultural research and development south of the Sahara, Ministry of Cooperation and Development. CIRAD, Paris, 444 p.
[02] Tra Bi, C.S. (2013) Diversité spécifique et dégâts des termites dans les cacaoyères (Theobroma cacao L., 1753) de la région d'Oumé en côte d'ivoire, Thèse de l'Université Félix Houphouët-Boigny, UFR Biosciences, n° d'ordre: 787/2013 ; 287 p.
[03] Boga, J.P., Kouassi, P. Yapi, A. Tahiri, A. Tano, Y. (2000) Influence of termitic materials on some agronomic parameters of two food crops in the savannah of Côte d'Ivoire. *African Agronomy*, 12(1), 1-10.
[04] Boli, Z. Roose, E. (2000) The role of short-term fallow in restoring the productivity of soils degraded by continuous cultivation in the humid Sudanian savannah of North Cameroon. *In*: Floret Ch. and Pontanier R. La jachère en Afrique tropicale. John Libbey Eurotext Edition, Paris (France), 149-154.
[05] Compaoré, E. Sedogo, P.M. (2002) Influence of agricultural practices on soil phosphoric fertility in Burkina Faso. FRSIT communication from 11 to 18 May 2002: 173-180.
[06] Zro, F.G.B. Guéi, A.M. Nangah, Y.K. Soro, D. and Bakayoko, S. (2016) Statistical approach to the analysis of the variability and fertility of vegetable soils of Daloa (Côte d'Ivoire). African Journal of Soil Science, Vol. 4 (4), pp. 328-338.
[07] Gurpreet, S. Jolata, S.K. Yadvinder, S. (2007) Manuring and residue management effects on physical properties of a soil under the rice - Wheat system in Punjab.India. Soil and Tillage Research, 94 pp.
[08] Tejada, M. Gonzalez, J.L. (2007) Influence of organic amendments on soil structure and soil loss under simulated rain. Soil and Tillage Research 93, pp. 197-205.
[09] Sangare, A. Koffi, E. Akamou, F. Fall, C.A. (2009) Status of Plant Genetic Resources for Food and Agriculture: Second National Report. National Report on the State of Plant Genetic Resources for Food and Agriculture (Cote d'Ivoire), 65 p.
[10] Soro, S. Doumbia, M. Dao, D. Andres, T.B. Girardin, O. (2007) Performance of six tomato cultivars *Lycopersicon esculentum* Mills. Against leaf yellows, bacterial wilt and root- knot nematodes. Sciences & Nature, 4(2): 123-130.
[11] Soro, D. Ayolié, K. Bakayoko, S. Dao, D. Kouadio, Y.J. Gnakri, D. (2014) Can Kponan yam (*Dioscorea cayenensis*) full season tuber sprout if planted? Journal of Agricultural Science and Technology, 4(4): 312-320.
[13] Kouassi, K.G. (2012) Evaluation of different fertilizers on the growth and development of cocoa tree nurseries (*Theobroma cacao* L.) grown on different substrates. Final thesis for the Diploma of Advanced Agronomy (DAA) from the National Polytechnic Institute of Yamoussoukro (Cote d'Ivoire), 75 p.
[14] Clauzel, J.M. (1997) Physical analysis of the substrate, an unknown tool for the Soil-less producer. Laboratory for analysis and agronomic advice, Bordeaux, France. Newsletter, 3p.
[15] Morel Ph., Poncet L. et Rivière L.M. (2000) Les supports de culture horticoles. INRA Editions 87p.
[16] Titouna D. (2011) Etude numérique de la solution nutritive dans un milieu poreux : cas de la laine de roche floriculture et expert. Thèse de doctorat, UNIVERSITE EL HADJ LAKHDAR BATNA, 123p.
[17] Badji, A. (2011) Effects of biochar on soil microbiological activities under high nitrogen inputs (market gardener). Master's thesis from Cheikh Anta Diop University in Dakar, 61 p.
[18] Moinereau, J. Hermann, P. Favrot, J.C. River, L.M. (1985) Inventory substrates. Characteristics, resources. In Soil-less crops. Edition the a.t.p. of INRA, Paris (France), 15-77.
[19] Comtois, M. Legare, M. Limoges, C.M. Martineau, C. Mongeau, B. (2004) Fertilization of woody plants grown in containers. *Document prepared as part of the Horti-2002 Program, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation,* Québec (Canada)*:* 57 p.
[20] Hannah, J. (2006) Good cultivation practices in forest nurseries. Practical guidelines for research incubators. *Manuel Technique World Agroforestry Centre (ICRAF),* 3, 93 p.
[21] Egle, K. (1992) Study of the variability of the components of cassava yield (*Manihot Esculenta Crantz* var. 312-524) as a function of soil fertility. Thesis as an agricultural engineer at the École Supérieure d'Agronomie de Lomé (Togo), 122 p.
[22] Sara, L. (2015) Effect of biochar amendment of organic soils for a greenhouse tomato crop: nutrient retention, organic activities, and fertilization management. Advances in Agronomy, 59-14.
[23] Kouassi, N.J. Kouamé, N. Koffi, A.M. N'guessan, N.A. Yatty, K.J. (2017) Influence of activated charcoal and seeding rate on the evolution of some growth and development parameters of a local variety of okra (*Abelmoschus caillei*). *International Journal of Biological and Chemical Sciences,* 11(4), 1829-1839.
[24] Shankara, N. Marja, de G. Martin, H. Barbara, V.D. (2005) Tomato cultivation: production, processing and marketing. Edition agromisa foundation and CTA (Catalase). Barbara van Dam (Netherlands), 105 p.
[25] Chenu, C. (2003) How to characterize soil organic matter? Soil fertility and cropping systems. Proceedings of the 6th meeting of reasoned fertilization and soil analysis, 18-19.
[26] Kouadio, K.P. (2007) Effect of crushed oyster and snail shellfish on soybean growth and production. DEA's brief. University Nangui Abrogoua (Côte d'Ivoire), 33p.
[27] Folliot, M. Marchal, J. (1990) Influence of the culture medium on the growth rate of vitro pineapple plants in the acclimatization phase. Fruits, 45(4), 367-378.
[28] Kolev, N. (1976) Market gardening in Algeria. Volume I: Fruit vegetables. Edition Ministry of Agriculture and Agrarian Reform: 06-33.
[29] Mouria, B. Ouazzani, T.A. Douirav, A. (2010) Agronomic valuation of compost and its extracts on tomato cultivation. *Revue Ivoirienne de Sciences et Technologie*, 16, 165 - 190.
[30] Minagra (1993) Agricultural Development Master Plan 1992-2015. Ministry of Agriculture, Abidjan (Côte d'Ivoire): 257 p.
[31] Soro, S. Yeboué, N.L. Tra Bi, C.S. (2015) Contribution of tomato cultivation (*Lycopersicon esculentum* mill. Solanaceae) to the conservation of the Tanoe-Ehy Marsh Forest (Côte d'Ivoire). Journal of Animal & Plant Sciences, 26 (2): 4072-4080.
[32] Graber, E.R., Harel, Y.M. Kolto, M. Cytryn, E. Silber, A. David, D.R. Tsechansky, L. Borenshtein, M. Elad, Y. (2010) Biochar impact on development and productivity of pepper and tomato grown in fertigated soilless media. Plant and Soil, 337, 481-496.
[33] Abobi, A.H.D. Angui, T.K.P. Kouadio, Y.J. (2014) Influence of cocoa shell fertilization on the chemical parameters of a ferralsol and on the growth of maize (*Zea mays* L.) in Oumé, Côte d'Ivoire. *Journal of Applied Biosciences*, 82,7359 - 7371.
[34] Lele, N. (2016) Potential for improving the fertility of sandy and acidic soils in Kinshasa (DRC) through the use of charcoal (biochar), plant biomass and mineral fertilizers. Doctoral thesis of the Regional Postgraduate School of Integrated Management of Tropical Forests and Territories of the Democratic Republic of Congo, 243 p.
[35] Lévesque, V. (2017) Bio-tank amendment: Effects on the activity and structure of microorganisms and on yields of greenhouse tomatoes and peppers. PhD thesis in agri-food microbiology at Laval University in Quebec City (Canada), 253 p.
[36] Kouadio, K.P. Yoboué, K.E. Touré, N. Beugré, C.M. Aka, K.F. Kouakou, K.J. Yao, K.A. (2018) Effect of cocoa bean teguments on the chemical fertility of a ferralsol and some cassava growth parameters, in Ahoué, South-East Côte d'Ivoire. Journal of Applied Biosciences, 121, 12144-12156.