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Effect of planting densities by the practice of twin rows on the agronomic and technological parameters of sugar cane in rainfed cultivation

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Abstract

With the aim of improving sugar cane productivity under rainfed conditions, a study of the effect of planting densities using paired rows on sugar cane yield parameters was carried out at the CNRA Ferkéssédougou station in northern Côte d'Ivoire.

The experimental design used was a Fischer block, comprising three repetitions of six treatments, designated T1 to T6.

The results revealed that treatments T1 and T2 improved cane yields, reaching 149±18.04 and 157±44.55 t/ha, respectively. Similarly, an increase in the number of usable stems per hectare of 207,726 ± 13144.44 and 216,468 ± 70412.15 was noted for treatments T1 and T2 respectively. Furthermore, the T6 treatment improved the technological parameters (Brix (22.4 ± 0.86 %); Fibre content (16.8 ± 0.11 %); Pol (19.4 ± 0.81 %) ; Purity of juice (86.7 ± 1.09 %) ; Saccharin content (14.9 ± 0.62 %); Extractable sugar (10.5 ± 0.52 %)). The study also identified three promising planting densities for village cane :1.1m and 1.3m row spacing at 0.4m and 1.3m row spacing at 0.5m.

In conclusion, the cultural practice of density in twin rows in sugar cane plantations in rainfed conditions allows an increase in agronomic and technological parameters. This cultivation practice could contribute to an increase in yield or even a substantial increase in sugar production.

Keywords: Village cane; Density; Double row; Village cane; Parameters; Yield; Agronomic; Technological

1. Introduction

Sugar cane (*Saccharum officinarum L.*) is a multipurpose tropical and subtropical herbaceous plant belonging to the Poaceae family [1,2]. It is mainly grown for its stalk, from which crystallisable sugar known as sucrose is extracted [3]. Industrial processing of the stalks into sugar and rum is its main use. But the plant's imposing mass can also be transformed into fuel energy, coal and biofuel, making it a veritable reservoir of molecules for the chemical industry [4]. The various sugar cane products namely sucrose, molasses and bagasse are used for human and animal consumption and for electricity generation. These products can also supply associated industries [5]. In Côte d'Ivoire, the sugar sector

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comprises a sub-sector of irrigated industrial sugar cane cultivation practised by sugar companies and a sub-sector of rain-fed village sugar cane cultivation practised by smallholders. It covers a total area of around 30,000 hectares, including 5,000 hectares of village cultivation. Total average annual sugar production is around 180,000t/year, compared with a requirement of at least 200,000t [6]. Sugar has become an essential part of society. It is present everywhere, in food and drink. The need to increase yields had already been envisaged by the first capitalist industrialists, for whom this need was a priority [7]. Growing sugar cane contributes to food security and generates foreign currency for the local population by creating jobs. Sugar cane production has more than just an economic purpose. It plays a major role in safeguarding our natural heritage and enhancing the environment. It helps to maintain the landscape and the quality of life in which we live, making it possible to occupy and make the best use of land. Cane effectively combats soil erosion and requires few plant protection products [8]. Despite the importance of this crop, the yield of rainfed sugar cane is very limited, with average production estimated at 40t/ha and 80t/ha for irrigated crops [9]. This poor performance is due to the high density of sugar cane plantations, the use of single rows, low-yielding varieties that are susceptible to disease and unsuitable for rainfed conditions, infertile soils and the high cost of agricultural inputs. The productivity of sugar cane plantations depends not only on promising, resilient varieties, but above all on good, innovative cultivation practices that characterise an appropriate technical itinerary and correspond to the ecological conditions of the village sugar cane production zone. These practices help to improve plot yields and substantially increase sugar production. They concern fertilisation, weed control and planting density, which is the subject of the study. It is within this framework that our research work on the effect of planting densities by the practice of twin rows on the agronomic and technological parameters of sugar cane in rainfed cultivation

2. Material and methods

2.1. Biological material and chemicals

The plant material used in the experiment was sugarcane (*Saccharum officinarum* L.) of the N21 variety (Figure 1). This is a commercial variety originating from Natal in South Africa. All other chemicals and reagents used were of analytical quality.

Figure 1 Sugar cane (*Saccharum officinarum*) cutting

2.2. Experimental set-up

The experimental set-up was a Fischer block with 3 replications and 6 treatments (Figure 2), with variations in row spacing and spacing between treatments. The trial was carried out on a new plantation production cycle (virgin crop) of sugar cane. The treatments compared were:

- Treatment 1 (T1) : E 0.4m/Int 1.1m/Im 1.5 m: Double line(DL) spacing 0.4m; DL interline 1.1m; Mitoyenne interline 1.5 m,

- Treatment 2 (T2) : E 0.4m/Int 1.3m/Im 1.7 m: Double line(DL) spacing 0.4m; DL interline1.3m; Mitoyenne interline 1.7 m,
- Treatment 3 (T3) : E 0.4m/Int 1.4m/Im 1.8 m: Double line(DL) spacing 0.4m; DL interline1.4m; Mitoyenne interline 1.8 m,
- Treatment 4 (T4) : E 0.4m/Int 1.5m/Im 1.9 m: Double line(DL) spacing 0.4m; DL interline1.5m; Mitoyenne interline 1.9 m,
- Treatment 5 (T5) : E 0.5m/Int 1.1m/Im 1.6 m: Double line(DL) spacing 0.5m; DL interline1.1m; Mitoyenne interline 1.6 m,
- Treatment 6 (T6) : E 0.5m/Int 1.3m/Im 1.8 m: Double line(DL) spacing 0.5m; DL interline1.3m; Mitoyenne interline 1.8 m.

The surface areas of the elementary plots (T1, T2, T3, T4, T5 and T6) were respectively 24.5; 27.5; 29; 30.5; 26.5; 29.5 m^2, i.e. a total of 167.5 m^2.

The surface areas of the useful elementary plots were 9.5; 10.5; 11; 11.5; 10.5; 11.5 m^2, i.e. a total of 64.5 m^2.

The total plot area was 44m x 26.3m, equal to 1157.2 m^2. The distances between blocks or replicates were 3m and those between treatments or elementary plots were 2m. The detailed plan of a treatment was represented by the different letters (a, b and c) (Figure 3).

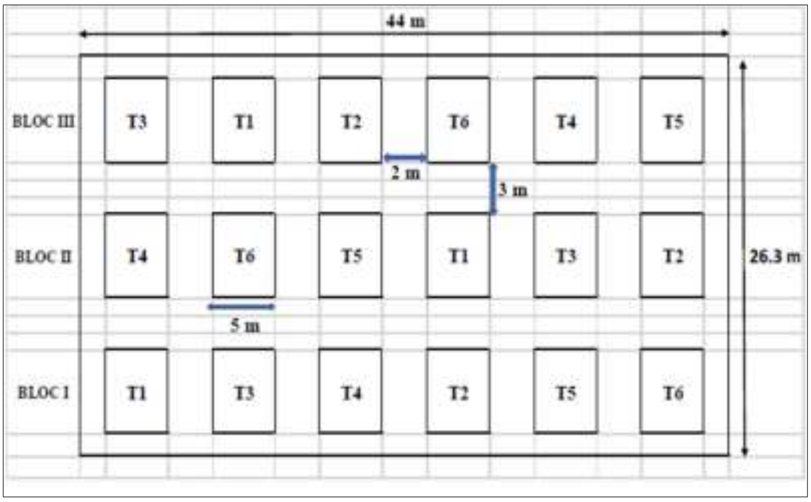

Figure 2 Layout of the experimental plot

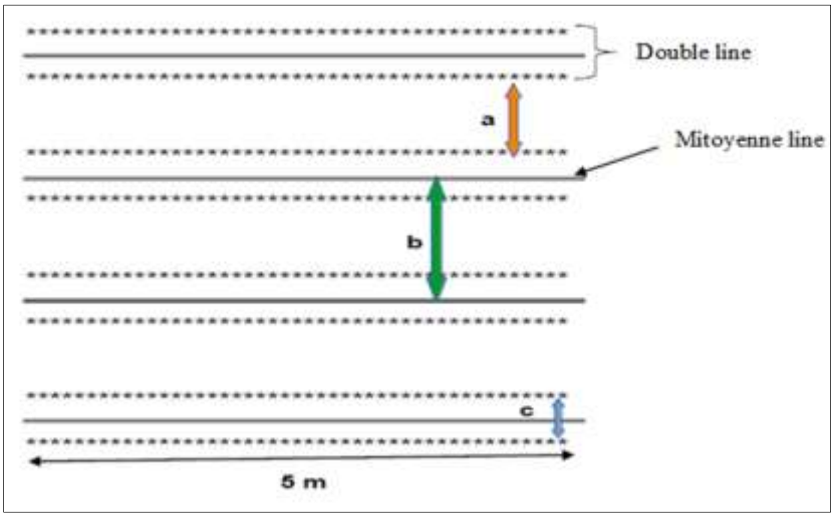

Figure 3 Details of a treatment

Surface area of the total plot: 1157.2 m^2.

Total area of elementary plots: 167.5 m^2.

Total area of useful elementary plots: 64.5 m^2.

- Line spacing between two double lines (1.1 m; 1.3 m; 1.4 m; 1.5 m)
- mitoyenne line spacing between two double rows (1.5 m; 1.6 m ; 1.7 m ; 1.8 m ; 1.9 m)
- Distance between double rows (40 and 50 cm)

2.3. Evaluation of agronomic parameters

Agronomic parameters were determined using the methods reported by [10] and [11]. Before and after harvest (16 months), samples of cane were taken from the useful lines (two central double lines) by treatment of the three replicates on the different plots (T1, T2, T3, T4, T5 and T6) to determine the different agronomic characteristics. Thus, the number of machinable stems was determined by counting. The diameter (mm) of the stems was measured at the collar using a caliper (Bochem). A tape measure (Stanley Tylon) was used to determine the length (cm) of a sample of 10 stems. The mass (g) of a sample of 3 machinable canes was determined using a scale (Ingco). The total mass of the canes was weighed using a 100g load cell (Nops) and reduced per hectare according to the following mathematical relationship:

$$\text{Cane yield (T/ha)} = \text{mass of cane} \times 10000 / \text{usable area}$$

The number of internodes and the number of internodes attacked by stem borers were determined by counting samples of 3 machinable stems. The number of stem stumps was counted on each usable line and reported per hectare.

2.4. Evaluation of technological parameters

A sample of three (3) sugar cane stems was taken from each micro plot and brought to the laboratory for the various analyses. Technological qualities were determined for each sample using the methods described by [9] and [10]. Each sugar cane stem was cut into three (3) pieces, retaining either a base, a middle or an end to form a secondary sample. This new sample was reduced to pulp by an electric grinder ("Jeffco" food and fodder cutter grinder, model 265B size 10, series L1710). The pulp was then subjected to a hydraulic press (pinette Emidecau Ind. 125). From the extract collected, the Brix degree (%) was measured using a refractometer (Schmidt+Haensch, model DURSW, series 29129) at 20°C. After filtration of the extract collected through WHATMAN n°91 paper, the juice's rotatory power (pol), which expresses the reducing sugar content, was measured using a polarimeter (saccharomat Z, series 29305). The purity (%) of the juice corresponding to the rate of rotatory power (pol) in the Brix degree was determined according to the following mathematical formula:

$$\text{Purity (\%)} = (\text{Pol juice (\%)} / \text{Brix (\%)}) \times 100$$

The fibre content (%) was determined using a correspondence table based on the mass of cake (100g) obtained after pressing the crushed material. The saccharin content (%) was determined by multiplying the Pol of the juice by a factor n read from a second table for a cake mass of 500g of cane pulp. The extractable sugar content (ES %) was determined using the following mathematical expression:

$$\text{ES (\%)} = [(0.84 \times \text{Pol \% C}) (1.6 - 60/\text{Purity}) - (0.05 \times \text{Fibre \% C})]$$

Finally, the extractable sugar yield (ESY), which considers the cane yield per hectare and the extractable sugar rate, was determined according to the following mathematical equation:

$$\text{E.S.Y (T/ha)} = (\text{ES \%} \times \text{CY}) / 100$$

- E.S.Y: Extractable sugar yield (T/ha)
- ES: Extractable sugar rate (%)
- CY: Cane yield (T/ha)

2.5. Statistical processing of data

All measurements were performed in triplicate. The means obtained were subjected to an analysis of variance followed by the LSD test (ANOVA 1 post-hoc test) at the 5% significance level using STATISTICA 7.1 software.

3. Results

3.1. Effect of density per paired row on agronomic parameters

The mean values of the agronomic characteristics observed at harvest for the N21 variety are given in Table 1. Statistical analysis showed non-significant differences (p>0.05) between treatments for agronomic parameters.

The treatments recorded an average high tillering of 186155 machinable stems per hectare. These values ranged from 161559 to 216468 machinable stems per hectare. Treatments T2 and T1 recorded the best results above 200000 stems, with 216468 and 207726 machinable stems respectively. Analysis of variance showed non-significant differences (p-value= 0.61) in the effect of treatments on the stem length parameter. Mean stem lengths varied from 169 to 188 cm.

The averages for the mass of the cane stems were identical, while the averages for the diameter of the stems varied from 20 to 23 mm depending on the treatment. As for the number of stumps, the averages ranged from 30 to 37 stumps per hectare. The number of internodes attacked by stem borers was 0 in the different treatments. Treatments T4 and T2 recorded high yields of 157 t/ha

Table 1 Agronomic parameters obtained by treatment

Treatments	NS/ha	SD (mm)	NUS/ha	CY (t/ha)	MS(g)	SL (cm)	NI (%)	NIA (%)
T1	37± 6.08a	22 ± 1.93a	207 726 ± 13144.44a	149 ± 18.04a	856 ± 164.43 a	188 ± 30.11a	16 ± 2.71a	0 ± 0.82a
T2	34± 4.04a	22 ± 2.53a	216 468 ± 70412.15a	157 ± 44.55a	800 ± 176.38a	181 ± 25.86a	17 ± 3.31a	1 ± 0.84a
T3	34 ± 3.79a	22 ± 3.70a	161 559 ± 15757.63a	116± 4.93a	811 ± 38.49a	182 ± 22.34a	17 ± 6.41a	1 ± 1.33a
T4	34 ± 1.53a	23 ± 2.35a	189 620 ± 35239.08a	157 ± 5.29a	789 ± 134.72a	179 ± 19.75a	16 ± 2.16a	0 ± 0.00a
T5	31± 4.58 a	20 ± 2.55a	181 421 ± 11266.87a	125 ± 8.49a	711 ± 126.20a	169 ± 26.38a	15 ± 2.17a	0 ± 0.00a
T6	30 ±3.79a	23 ± 2.41a	168 660 ± 21025a	120 ± 33.50a	856 ± 107.15a	188 ± 22.09a	18 ± 6.02	0 ± 0.41a
Mean	34 ± 4	22 ± 4	186155 ± 31982	137 ± 26	804 ± 122	181 ± 24	16 ± 4	0 ± 1
P	0.43	0.43	0.33	0.17	0.77	0.61	0.76	0.4

Means followed by the same lower case letter are not significantly different at the p=5% threshold; NS/ha: Number of stumps per hectare ; SD (mm): stem diameter ; NUS/ha: Number of usable stems/ha; CY(t/ha): Yield of canes per hectare ; MS (g): mass of stems, ; SL(cm): Stem length in centimetres, NI (%): Number of Internodes, NIA (%): Number of Internode attacked.

3.2. Effect of density per paired row on technological parameters

Statistical analysis showed non-significant differences (p>0.05) between treatments for technological parameters. The average technological characterisation values obtained for each treatment applied to the harvest of the N21 variety are given in Table 2. The brix content of all the averages for all the treatments was similar at around 22%. The average fibre content varied from 16 to 17% for the different treatments, while the sugar content (Pol) was around 19%. For these same treatments, the purity of the cane juice varied from 85.1 to 86.7%. Extractable sugar yields ranged from 11 to 16 t/ha.

Table 2 Technological parameters obtained by treatment

Traitements	Brix (%)	FC (%)	Pol (%)	PJ (%)	SC (%)	ES (%)	ESY/ha
T1	22 ± 0.27 a	16.7 ± 1.18 a	19 ± 0.51 a	86.3 ± 1.58a	14.6 ± 0.12 a	10.2 ± 0.20a	15.3 ± 1.18a
T2	22.4 ± 0.85a	17.1 ± 0.17a	19.2 ± 1.43a	85.9 ± 3.235a	14.7 ± 1.14a	10.3 ± 1.19a	15.3 ± 1.71a
T3	22.3 ± 0.51a	16.6 ± 0.40a	19 ± 0.45 a	85.1 ± 0.15a	14.6 ± 0.27a	10.2 ± 0.20a	11.8 ± 0.40a
T4	21.8 ± 0.17a	16.4 ± 0.87a	18.8 ± 0.33a	86.4 ± 1.59a	14.5 ± 0.42 a	10.2 ± 0.51a	16 ± 1.45a
T5	21.9 ± 0.5 a	16.7 ± 1.45a	18.8± 1.03a	85.6 ± 3.59a	14.4 ± 1.09 a	10.1 ± 1.19a	13.3 ± 1.08a
T6	22.4 ± 0.86a	16.8 ± 0.11a	19.4 ± 0.81a	86.7 ± 1.09a	14.9 ± 0.62a	10.5 ± 0.52a	12.6 ± 0.60
Mean	22.1 ± 0.5	16.7 ± 0.8	19 ± 0.8	86 ± 1.9	14.6 ± 0.6	10.2 ± 0.7	14 ± 2.7
P	0.72	0.72	0.72	0.96	0.98	0.99	0.35

Means followed by the same lower case letter are not significantly different at the p=5% threshold. ; FC: Fibre content; rate of rotatory power (pol) ; PJ: Purity of juice ; SC: Saccharin content; ES: Extractable sugar; ESY: Extractable sugar yield

4. Discussion

The study assessed the effect of paired row density on the agronomic and technological parameters of rainfed conditions sugar cane at the CNRA station in Ferkessédougou. The results of the analysis of variance showed no significant difference for each of the parameters evaluated. Despite this lack of difference, a high number of strains was observed in treatment T1. This could be explained by the fact that the number of stumps is influenced by the lowest density. The number of stems varied from 161559 to 216468 machinable stems per hectare, with an average of 186155 machinable stems. This variability could be due to the density effect and the practice of twin rows. It should be remembered here that the number of stems (tillers) is influenced by cultural and edaphic conditions [12]. The results obtained are in line with those of [10], whose work focused on sugar cane clones. The results obtained are in agreement with those of [10] whose work focused on sugar cane clones. High values of 188 cm and 23 mm were recorded respectively with averages of 181 cm and 22 mm for stem length and diameter. This finding was also reported in previous studies carried by [13] who worked on the row spacing of sugar cane. According to these same authors, spacing has no effect on stalk length or diameter. The present stem diameter values are contrary to those reported by [14]. These authors found high stem lengths (196.8-234.4cm) compared to our values obtained. For the sugar cane yield parameter, the N21 variety recorded a high yield of 157 t/ha with an average of 137 tc/ha in twin rows. It should be remembered here that the increase in sugar cane yield is linked to the production method (small-scale or industrial), the type of crop (rainfed or irrigated) and the implementation of appropriate farming techniques [14,15]. The N21 variety proved to be more productive with the paired-row planting density, in contrast to the growing conditions adopted by [16]. These authors found a cane yield of 85.5 t/ha for the N21 variety. Consequently, the variety could be recommended to farmers in rainfed double-row conditions.

The various stem samples taken in this study have a high number of internodes (18), with an average of 16 internodes. This observation is due to the fact that the plans are high (188cm). These results are similar to those of [17] and [18], who reported that long stems have more internodes and less internode spacing. Only the stems in treatments T2 and T3 showed internodes that were weakly attacked by the stem borer (Eldana saccharina). It should be remembered here that stem borer infestations are thought to be linked, on the one hand, to excess nitrogen inputs (optimum of 100kg/ha of NPK) and, on the other, to the burning of plots before cutting [19,9,20]. In addition, the number of internodes and the number of internodes attacked are not a function of planting density but of the characteristics of the sugarcane variety. The results obtained corroborate those of [16], who observed a high number of internodes and a low number of attacked internodes. This is why the N21 variety would be better suited to farmers for its resistance to diseases and pests under these same growing conditions. As far as technological parameters are concerned, the results of the trial show that N21 is a promising variety. It has a high sugar yield (14 t/ha) with a very good saccharin content (14.6 %) thanks to the double row planting density. According to [16], the high saccharin content is due to the high fibre content (16.7%). It should also be remembered that extractable sugar yield is the most relevant evaluation criterion among the technological parameters [9]. The results obtained are clearly superior to those mentioned by [16], who worked on sugarcane varieties, including the N21 variety, using single rows with 1.5 m row spacing in rainfed cultivation in the Ferkessédougou sugar fields in northern Côte d'Ivoire.

5. Conclusion

The aim of this research work was to study the impact of double row planting density on rainfed cultivation sugar cane yield parameters. At the end of this study, it emerged that the practice of double row density in rainfed sugarcane plantations increases the agronomic and technological parameters. This cultivation practice could contribute to an increase in yield and even a substantial increase in sugar production.

Compliance with ethical standards

Disclosure of conflict of interest

All authors declare that no competing interests were disclosed.

References

[1] Souza DRD, Stingel E, Almeida LCD, Munhae CB, Mayhe-Nunes AJ, Odair CB, Maria SDEC M. Ant diversity in a sugarcane culture without the use of straw burning in southeast, Sao Paulo, Brazil. American Journal of Agricultural and Biological Science. 2010; 5: 183-188.

[2] Traoré NB, Konaté ML, Mangara A. Floristic diversity of weeds in village sugarcane (*Saccharum officinarum* L.) plantations in the Ferkessédougou department., Côte d'Ivoire. Afrique science. 2023; 22(2) :17-28.

[3] Davina M. Evaluation of the fibrous and textile potential of sugarcane (*Saccharum officinarum* L.). University of Haute Alsace (Mulhouse-Colmar, France). PhD thesis; 2023. 196p.

[4] CIRAD. Sugar cane. https://www.cirad.fr/nos-activites-notre-impact/filieres-agricoles-tropicales/canne-a-sucre/plantes-et-usages. 2023. Consulted on 15/05/2023.

[5] Berndes G. Bioenergy and water - the implications of large-scale bioenergy production for water use supply. Global environmental change. 2002; 12: 253-271.

[6] CNRA. Sugar cane program 2020-2023. https://cnra.ci/wp-content/uploads/2021/12/05-Progr-canne-a-sucre-2020-2023-VF.pdf. 2021. Consulted on 20/O5/2023.

[7] Poser C. Influence of temperature on sugarcane phenology: consequences on the crop establishment phase in the Hauts de La Réunion. Agronomy. University of Reunion (Saint-Denis, France). PhD Thesis ; 2013. 188p.

[8] Lebreton G. Effect of sugar cane cutting time on grass cover and the biological cycle of weeds in Réunion, End-of-cycle dissertation, Practical School of Advanced Studies in Life and Earth Sciences (Réunion, France); 2010. 89 p.

[9] Kouamé Dk, Péné CB, Zouzou M. Screening of promising commercial sugarcane varieties in the Ferke 2 sugar perimeter in northern Côte d'Ivoire: optimization of selection time. Sciences & Nature. 2010; 7 (1): 97 – 106.

[10] Zadi M, Turquin L, Péné CB. Agronomic and technological evaluations of sugarcane (*Saccharum officinarum* L.) clones preselected at the line stage in Ferkessédougou, northern Côte d'Ivoire. Journal of applied sciences. 2017 ; 115 :11502-11512.

[11] Béhou YYM, Péné BC, Zézé A. Genetic variability of sugarcane clones preselected at the line stage in new plantations at Ferké (northern Côte d'Ivoire). Journal of Applied Biosciences. 2018; 127: 12832-12848.

[12] Konaté AK, Zougrana S, Kone S, Wonni I. Agronomic performance evaluation of aromatic rice varieties in Burkina Faso. International journal of Biological and chemical sciences. 2022; 16 (1): 42-53.

[13] Pouzet D, Martiné JF. Planting row spacing and sugarcane production. Summary of 4 years of trials under high-altitude tropical conditions. CIRAD ; 2000. 7 p.

[14] Sprumont J, Delahaye S. The sugarcane industry in Haiti: Technical information, suggestions for improvement, documentation, Camp Perrin School Workshop – Haiti; 2010. 171p.

[15] Ngoy KR, Tshomba KJ, Nkulu MFJ. Sugar cane production at Mulimi, Kabalo Territory, Tanganyika Province, Democratic Republic of Congo (RDC): Challenges and prospects, Challenges of industrialization. International Journal of Multidisciplinary and Current Research. 2020 ; 8 : 1-9.

[16] Péné CB, Boua MB, Ouattara YC. New varieties of sugarcane (*Saccharum officinarum*) adapted to rainfed conditions in the Ferke sugar fields in northern Côte d'Ivoire. Journal of Applied Biosciences. 2019; 134: 13702-13710.

[17] Ekpélikpézé OS, Agre P, Dossou AI, Adjatin A, Dassou A, Dansi A. Characterization of sugarcane (Saccharum officinarum L.) cultivars of Republic of Benin. International Journal Current Research. Biosciences and Plant Biology. 2016; 3 (5): 147-156.

[18] Babalakoun AO, Amoussou E, Bello S, Assaba EI, Yedomonhan H, Cledjo P, Zoundjihekpon J. Agromorphological characterization of sugar cane cultivar (Saccharum officinarum Linné.) grown in southern and central Benin. Révue Ecosystèmes et Paysages (Togo, Benin). 2022; 2 (02): 162-176.

[19] Goebel FR, Way MJ, Conlong D. Management of sugarcane borers, the environment and cultivation practices : summary of results and outlook. In : Proceedings of the Sugar Conference. ARTAS/AFCAS. Guadeloupe, AFCASARTAS. 2008. 12 p.

[20] Pene BC, Kouame DK, Dove H, Boua BM. Incidence des infestations du foreur de tiges Eldana saccharina (Lepidoptera, Pyralidae) en culture irriguée de canne à sucre selon la variété et la période de récolte en Côte d'Ivoire. Journal of Applied Biosciences. 2016; 102: 9687-9698