Agronomic valorization of digestates from anaerobic digestion from cow dung in the Faranah Administrative Region (Republic of Guinea)

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ABSTRACT

In order to promote local natural resources in maize fertilization and to minimize the negative impact of high doses of chemical fertilizers on farms in the Faranah administrative region, a fertilization test on the effect of digestates from cattle dung on maize was carried out in the experimental station of the Higher Agronomic and Veterinary Institute of Faranah, from June 18 to October 11, 2018. The site of study has a slightly acid ferralitic soil of 6.25, poor in nutrients with 1.99% organic matter. The analyzes revealed that the digestate of the methanization and the dung of Faranah dung have the highest dry matter and ammonia contents and those of Dinguiraye have the lowest. As for the pH, it is slightly acidic for Faranah and strongly acidic for Dinguiraye. The variation in the crude fiber content is higher between digestates and lower between minerals. Moisture, dry matter, fat and protein show intermediate fluctuations between them. The experimental device used is the Randomized Full Block with 4 repetitions. The plant material used is the "hope" corn variety from Burkina Fasso. The treatments studied are: absolute control (To), Digestat Faranah (DFa), Dabola (DDa) and Dinguiraye (DDi) all made at a rate of 12.5 t/ha. Statistical analyzes made with the Genstat 12 software, showed that the studied parameters (average growth rate, average height of the plants at harvest and weight of 1000 grains) showed a non-significant difference between the digests; the average number of rows per ear and yield showed a significant difference between digests while the average ear length and the average number of seeds per row showed a highly significant difference between treatments. In terms of yield, Dabola (4.67 t/ha) and Faranah (3.39 t/ha) digests gave the best with no significant difference between them and that of the lowest yielding control (1.62 /ha).

Key words: *Digestate, Bovine excrement, Agronomic valorization, Region, Faranah.*

1. Introduction

Waste management represents a major challenge for sustainable environmental management. Whether inert, organic or toxic, it is about implementing the most appropriate management strategies. The methanization of waste is in full expansion. The production of energy and the conservation of nutrients are important assets of this sector, to limit the risks that populations can incur. To do this, one of the most beneficial options for the predominantly peasant target populations is the agronomic valorization of this waste for the improvement of crop yields and the production of biogas [1].

The use of animal excreta to maintain or increase soil productivity is a secular practice and the terms "manure" and fertilizer are almost synonymous. Due to the use of firewood in many countries, sun-dried cow dung is burned so that it loses its fertilizing value, hence the biogas [2]. Biomethanation transforms volatile organic matter into energy, while preserving its fertilizing potential, both from the point of view of organic matter and mineral elements. This bioprocess offers a solution for biomass energy recovery which, far from being in competition with agronomic imperatives, is on the contrary in synergy with them. It aims to transform the carbon of organic matter into methane.

The residual material resulting from the process, which can represent 70 to 80% of the initial mass is called digestate [3]. The digestate or secondary coproduct of the biomethanation is the wet residual material rich in partially stabilized organic matter obtained after the anaerobic digestion. It is an organic fertilizer rich in mineral nitrogen and mineral elements, it can be used in the solid state (methacompost) as an integral part of the culture substrates, or spread, as they can be used directly in the liquid state as fertilizing agricultural soils, even fertilizing above ground [4]. The digestate represents the digested material leaving the biomethanation process, these characteristics depend on the type of methanization plant and the digested substrates. The conditioning of this digestate makes it possible to obtain a solid digestate, called methacompost and a liquid digestate, called process juice. Whatever its composition, it is admitted that the digestate is a fertilizer because of its richness in N, P and K [5, 6].

Fertility is the ability of a soil to produce crops according to its intrinsic qualities and the cultivation techniques used in a continuous manner. Plants take the mineral elements from the soil to produce the organic compounds. Only 16 elements are needed for the normal operation of the biochemical machine of the plant. These elements must be present in the soil in a form that can be assimilated by plants [7]. According to [8], in promoting new sources of fertilizer, the agricultural world has the opportunity to develop new fertilization routes in the coming years. Among these, the production of digestate on the basis of the methanization represents an interesting opportunity and contributes to meeting the requirements of the organic fertilization of the cultivated plants. Managing soil fertility is a problem in most farms around the world. On the other hand, in the Republic of Guinea in general and in Faranah in particular, cultivated soils are degraded and livestock available cannot cover manure requirements. The test of alternative fertilization systems is therefore necessary for economic, health and environmental aspects [9, 10].

The objectives of fertilization are to obtain the best possible yield considering the other factors that contribute to it (soil quality, climate, water supply, genetic potential of crops, means of exploitation), as well as the best quality, and this at the least cost. In addition, there is the goal of preserving the quality of the environment. Maize is the only cereal that is absolutely dependent on humans for its survival. Sown in spring, it flowers in summer to be harvested in autumn. It is a cereal grown in various agroecological zones, alone or in association with most crops. In many countries, maize is the staple food of many human and animal populations. Corn grain is used in many forms (cooked, grilled, salad, soup). Corn in Guinea is used in many forms. Green, it is eaten grilling or boiled. The importance of these products varies from one region to another. Since production is produced from acreage by yield, the overarching question of concern to the world is how to increase this output by maintaining the invariable area since the world population is increasing year by year [11]. It is within this framework that the present research falls.

2. Materials and Methods

2.1 Materials

The administrative region of Faranah is the central part of Guinean territory which represents the transition zone between Middle Guinea, Upper Guinea and Forest Guinea. It is located at 8 ° 50 and 12 ° north latitude and 9°15 and 11°29 west longitude. It includes four prefectures: Dabola, Dinguiraye, Faranah and Kissidougou subdivided into 42 municipalities including four (4) urban and 38 rural. The region covers an area of 40,122 km2 and has a population of 1,035,162 including 538,535 women according to the RGPH3 for an average density of 26 inhabitants per km2 (2017 census). The climate as a whole is Guinean Sudano type with the alternation of two seasons: dry and rainy.

The average annual rainfall varies between 1200mm and 2300mm of water from North to South. Temperatures are high and oscillate between 24 and 30 ° C on average. Relative atmospheric humidity ranges between 69 and 85% on average and the prevailing winds are theharmattan and the monsoon [12]. The trial was carried out in the experimental field of the ISAV Agriculture Department in the Faranah Urban Commune, on a four-repeater Randomized Complete Block. The digestates used were obtained from Faranah, Dabola and Dinguiraye. These digests were used at a uniform dose of 12.5t / ha and at three months of their production, the tested variants are: Control without digestate (T0), Digestat Faranah (DFa), Digestat Dabola (DDa) and Digestat Dinguiraye (DDi). The soil of the test field is ferralitic with sandy-clay-silty texture.

2.2 Methods

The methodology adopted for this research is based on theoretical and experimental approaches. We used several techniques for: physicochemical and agrochemical characterization of the soil of the site, dung manure, digestate resulting from methanization of cow dung, biometric evaluation and biochemical analysis of grains [13, 14, 15, 16, 17]. The following phenophases were observed: emergence, three-leaf stage, paniculation, heading and maturation; the beginning of each phenophase was noted when 10% of the plants showed it and the end when 75% did so. The following parameters were determined: the daily growth rate, the height of the plants at harvest, the average number of rows per ear, the number of seeds per ear, the weight of 1000 grains and the yield. The weather reports were taken at the Faranah ISAV automated station located in the experimental field. Genstat version 12 software was used for statistical analysis (analysis of variance). The comparison of averages was made by the test of the smallest significant difference at the 5% threshold. The different stages of this research are illustrated by the following pictures 1 to 9 (Figure 1).


Picture 1: Determination of NPK and pH


Picture 2: Biodigester


Picture 3 : Digestate for spreading


Picture 4: Preparation of the experimental soil


Picture 4: 15 days after semi


Picture 6: 40 days after semi


Picture 7: Phase de maturation


Picture 8: Samples elementary plot


Picture 9: Ears

Figure 1: pictures at different experimental stages

3. Results and discussion

The various results obtained during this research are illustrated in the tables from 1 to 6. They are also illustrated by Figures 2 and 3.

3.1Physicochemical and agrochemical characteristics of the soil of the site

The physicochemical and agrochemical characteristics of the experimental soil are given in Tables 1 and 2 respectively.

Table 1: Physicochemical analyzes of the experimental soil

Horizons/Samples	Granulometry (%)					Texture	Density (g/cm^3)		pH (H_2O)	Porosity (%)
	A	L_f	L_g	S_f	S_g		Related	Real		
A	15.6	6.0	6.0	28.8	43.0	S. L	1.41	2.50	6.6	43.60
B	31.6	4,0	6.0	23.0	35.0	L.A	1.90	2.39	5.0	20.50
Comp A	17.6	4,0	6.0	23.8	43.0	L.S	1.97	2.13	6.7	7.51
Comp B	23.6	2,0	2.0	28.8	43.0	L.A. S	2.0	2.33	5.8	14.16

This table shows that the soil of the test has a high bulk density in all samples except for horizon A where it is relatively low, the texture is sandy-loamy in A and loam-clay in B, the porosity is low and the soil has a strong, deep and light acidity in the superficial horizons. There is an average clay content in the B horizon.

Table 2: Agrochemical analyzes of experimental soil samples

Horizons/Samples	Nitrogen NO_3 ($mg.kg^{-1}$)	Phosphorus P_2O_5 ($mg.kg^{-1}$)	Potassium K_2O (eq/100g)
A	4.00	-	0.22
B	12.00	6.60	
Comp A	8.00	61.58	
Comp B	4.00	10.99	

The results of agrochemical analyze prove that the soil is poor in assimilable Nitrogen, Phosphorus and Potassium except for the composite sample of the A horizons.

3.2 Physicochemical and agrochemical characteristics of cow dung manure and digestate from anaerobic digestion

The physicochemical and agrochemical characteristics of cow dung manure and digests from the three (3) prefectures (Dabola, Faranah, Dinguiraye) are given in Table 3 respectively.

Table 3: physicochemical analyzes of manure and digestate

Parameters	Dabola		Faranah		Dinguiraye	
	Fumier	Digestat	Fumier	Digestat	Fumier	Digestat
Humidity (%)	77.04	70.01	76.73	50.55	78.98	72.59
Dry matter (%)	22.96	29.99	23.27	49.45	21.02	27.41
Ammoniac NH_3 (gN/g)	1.53	0.09	2.87	0.11	1.89	0.08
pH	6.80	6.07	6.47	3.86	7.30	6.62
Temperature (°C)	27.6	27.5	27.30	27.50	27.4	27.30

Table 3 shows that digestate and manure from Faranah have the highest levels of dry matter and ammonia while those from Dinguiraye have lower values. The pH is slightly acidic except for the digestate of Faranah where it is strongly acidic. Dinguiraye manure is slightly alkaline.

3.3 Agrochemical characteristics

The agronomic effect of digestates produced from cattle dung from the three prefectures was observed through certain parameters of growth and production of the crop. The averages of these parameters are shown in Figures 2 and 3.

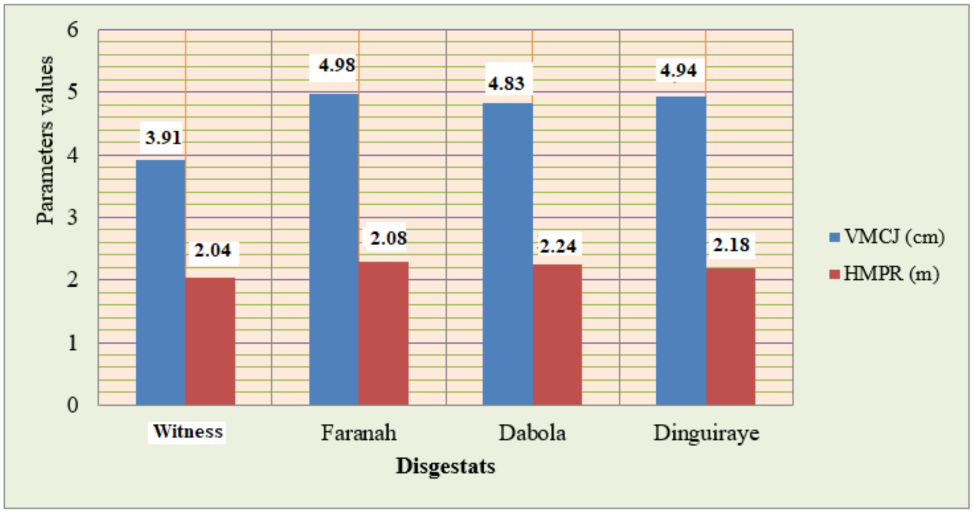

Figure 2: Effect of digests on growth rate and plant height at harvest

This graph shows that the Faranah digestate shows a higher growth compared to the control (4.98 cm/day against 3.91 cm/day) and the other digests gave the intermediate values. As for the height of the plants, the Faranah digestate yielded larger plants (2.28 m) and the others gave smaller plants (2.04 to 2.24 m).

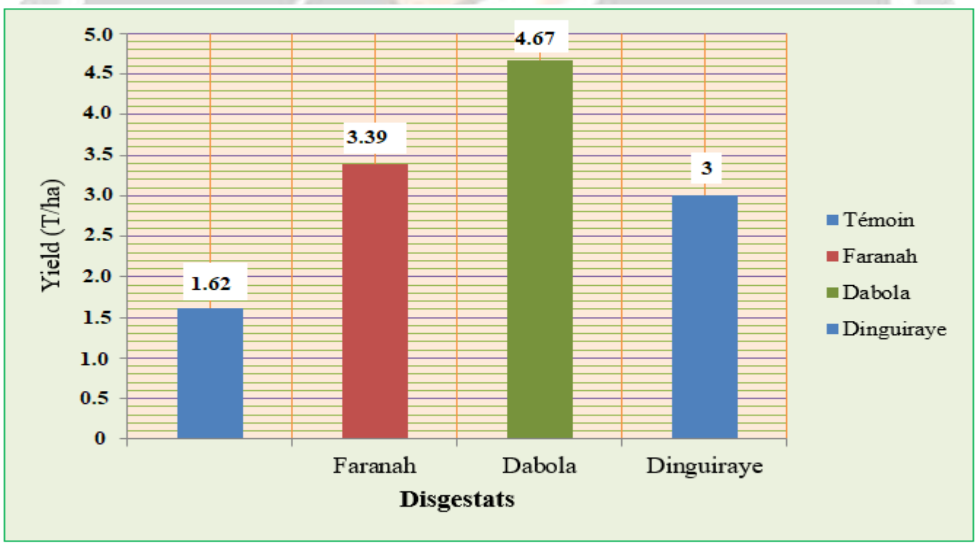

Figure 3: Average yield in t/ha.

From this chart, we note that the highest yield was provided by the Digestat from Dabola (4.67 t/ha) followed by that of Faranah (3.39 t/ha) and Dinguiraye (3 t/ha). The control gave the lowest yield (1.62t / ha).

3.4 Synthesis of the analysis of variance of the studied parameters

The synthesis of the analysis of variance of the parameters studied appears in Table 4.

Table 4: Summary of Analysis of Variance

Source of variation	Ddl	F calculated							F theoretical	
		VMCJ	HMPR	LME	NMGR	NMRE	PMG	Rdt	5%	1%
Repetition	3	0.76 NS	2.33 NS	0.37 NS	1,81 NS	0.10 NS	1.31 NS	1.37 NS	3.86	6.99
Digestat	3	3.80 NS	3.06 NS	22.39**	40.49**	6.40*	2.09 NS	6.16*	3.86	6.99
Residually	9									
CVM (%)		11.2	5.5	9.1	2.51	1.07	8.4	31.9	-	-

F: Fisher's Criterium; VCJD: Average Daily Growth Rate; HMPR: Average Height of Plants at Harvest; LME: Average Length of Ears; NMGR: Average Number of Grains per Row; MEPS: Average Number Ranked by Thick; PMG: Thousand Grains weight; Yield: Yield; NS: Not significant; (*) Significant; (**) highly significant.

This table shows that at the level of repetitions the difference is not significant for all the parameters studied, which proves that the soil is homogeneous from the point of view of fertility. At the level of the treatments (digestates) the non-significant difference for the VCJD, the PMG and the HMPR, significant for the MEPS and the Yield and highly significant for the LME and the NMGR. This proves that the digestate from cattle dung of different origin applied at a dose of 12.5 t/ha has positively influenced the fertility of the soil. With a coefficient of variation that varies between 1.07 and 31.9%, ie an average of 9.95% (less than 15%), it can be said that the test is of good precision.

3.5 Comparison of means by the SDPP test

Comparison of means by the SDPP test is recorded in Table 5.

Table 5: Comparison of averages

Digestat	VMCJ (Cm)	HMPR (m)	LME (cm)	NMGR	NMRE	PMG (g)	Rdt (t/ha)
Witness	3.91[a]	2.04[a]	9.96[a]	19.25[a]	11.97[a]	175.30[a]	1.62[a]
Faranah	4.98 [b]	2.28[b]	16.56[b]	28.80[b]	13.76[b]	199.40[a]	3.39[b]
Dabola	4.83[b]	2.24[a]	15.94[b]	29.93[b]	13.38[b]	196.40[a]	4.67[b]
Dinguiraye	4.94[b]	2.18[b]	16.20[b]	28.90[b]	13.78[b]	199.50[a]	3.00[a]
PPDS 0,05	0.829	0.187	2.124	2.513	1.073	25.849	1.613

PPDS: Smallest Significant Difference; a: class a; b: Class b.

This average comparison table shows that the origin of the digestates has influenced all the components of yield (average ear length, average number of grains per row, average number of rows per year), except for the weight of one thousand grains where it does not. There was no significant difference between digests. As for growth parameters (average daily growth rate, average height of plants at harvest) and yield, digests showed significant effects depending on their source.

3.6 Biochemical analyzes of grains

The results of the biochemical analysis of the grains are given in Table 6.

Table 6: Biochemical grain analyzes

Variants	Humidity (%)	Dry matter (%)	Protein (%)	Fat Matter (%)	Mineral matter (%)	Crude fiber (%)
T0	6,61	93,39	5,70	0,71	1,43	4,91
DFa	6,67	93,33	6,03	0,92	1,49	3,77
DDa	6,63	93,37	6,60	0,91	1,48	4,68
DDi	6,95	93,05	5,70	0,77	1,50	4,23

T0: Control without digestate; DFa: Digestat Faranah; DDa: Digestat Dabola; DDi: Digestat Dinguiraye.

The fluctuation of the crude fiber content is greater between the variants than that of the mineral content. The other parameters (moisture, dry matter and fat) show intermediate fluctuations.

In general, the results obtained during this research, allowed us to have information on the effects of the experimental variants on the growth and production parameters of the variety " Hope " of maize in edaphoclimatic

conditions. of Faranah. The meteorological data recorded during the trial were favorable to the growth and good development of the variety. The minimum temperature (24.04°C) is above that reported by [18] which indicates that the minimum temperature for corn development is 19°C. The average temperature during the test is 24.39°C slightly lower than that given by [18], which indicates that corn generally grows well under a temperature that varies from 25 to 30°C.
During the 90 days of the test, the amount of rainfall (1240.12 mm) is sufficient for the water requirements of corn, namely 500 mm of water well distributed for a 90-day corn. The pH of the soil (6.25) is greater than that of digestate (5.52) and lower than that of manure (6.86), which justifies the contribution of digestate to improve the chemical properties of the soil and favor the growth and development of maize, the basic substances of organic matter and humid substances are beneficial against acidification of the soil and stabilize it chemically [18, 19].
The levels of NPK assimilable elements in the soil are low (0.00022-0.0159 g/kg DM), very high for digests (1.06 - 6.13 g/kg DM). The sums of exchangeable bases between 10.7 to 14.6 meq/100g of soil and 7.80 to 8.25 meq/100g of digestate are excellent. Cation exchange capacities ranging from 13.5 to 18.1 meq/100g of soil and 0.22 to 0.35 meq/100g of digestate are respectively low and medium. The vegetative cycle varied from 84 to 94 days for the control and Faranah respectively and is consistent with the data sheet which indicates 80 to 95 days [20]. The average number of rows per epi 12 is confirmed by some authors. The average weight of 1000 grains is 192.65g is greater than that given by [21], which states that the weight of 1000 grains in small-caliber hybrids is 100 to 150 g, and it is lower than that given by [21] which varies from 250 to 350g.The average yields obtained proved that the digestate Dabola was the best (4.67 t/ha), which is consistent with the idea of [22], which says that the average yield varieties selected by the research is 2 to 5 t / ha, which states that for a yield of 4.86 t/ha of maize, 12 tons of well-decomposed organic manure are needed. The three digests used had a positive effect on maize yield, which confirms the idea of [22] which explains that the use of organic amendments at doses of 2, 6, 9 and 12 t/ha improves maize yield by up to 28%.

4 Conclusion

As a result of this research, it was found that bovine digests from Faranah, Dinguiraye and Dabola prefectures improved the yield of "Hope" corn. The physical and chemical characteristics of the experimental study soil revealed that it is feralitic poor in nitrogen, phosphorus and potassium assimilable. This justifies the contribution of nutrients to meet the needs of the plant.
Chemical quality, manure and digestate showed that the digestate and manure of Faranah have the highest levels of dry matter while those of Dinguiraye have the lowest levels. The ammonia content of the digestate and manure is higher in the Faranah digestate. The pH is slightly acidic except for Faranah digestate where it is strongly acidic and slightly basic for Dinguiraye manure.
The yield evaluation obtained from the variants shows that the Dabola digest gave the highest yield (4.67 t/ha) followed by that of Faranah (3.39 t/ha) and the Control gave the lowest yield (1, 62 t/ha). For the analysis of the biochemical quality of maize kernels, the fluctuation of the crude fiber content is greater between the variants than that of the mineral content. The daily increase of maize plants in the beginning of vegetation until the end was remarkable for the control variant and less remarkable for the other variants. Improving the chemical, physical and biological characteristics of soils with organic amendments creates better growing conditions for plants.

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