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Effects of organic fertilizers and tillage on yield and its components of three varieties of *Corchorus olitorius* L. produced in South Benin

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Abstract

The intensive use of chemicals is depleting the soil in Benin, limiting crop yields in general, but in particular vegetable crops and more specifically *Corchorus olitorius*. This study aims to evaluate the influence of organic fertilizer and tillage on the agro-morphological characteristics of three varieties of corete. A split plot device in 02 repetitions, the main factor of which is the dose of organic fertilizer at 08 levels, was installed at two different sites, one of which is frequently plowed and the other of which has not been exploited during the last 5 years. The data collected during the trial were entered and processed in the Excel 2016 spreadsheet and subjected to various analyses including descriptive statistics, and analysis of variance with the Statitica software. The principal component analysis was performed with R 4.2.1 software and identified characters that are controlled by the treatments applied. The performance of the different varieties was assessed in the different study environments. The results show that soil amendment with varying doses of organic fertilizers associated with soil types improves the agro-morphological parameters of the plant. This combination makes the nutrients available. Thus, organic fertilizer is a significant fertilizer capable of improving soil fertility. The use of organic fertilizers contributes to the improvement of soil status and crop yields through organic fertilization.

Keywords: Amendment, Corchorus olitorius, organic fertilizer, performance, agro-morphological

Introduction

The majority of the world’s population now uses the various nutrients (vitamins, minerals, antibiotics, and fiber) found in vegetables (Ahmed 2021; Soro et al. 2012). These include *C. olitorius*), also known as Jute, or the Jew's mallow, or Jute mallow, discovered by Linn in 1753 (IPNI 2020). It grows in Africa, Egypt, the Middle East, the Philippines, Thailand, India, and Nepal (Ali et al. 2006). The genus Corchorus belonging to the family Malvaceae (formerly under Tiliaceae) is distributed in all tropical and subtropical regions of the world (Alissou 2011). The young leaves and green shoots of this fast-growing vegetable are chosen for cooking. They add taste and a viscous texture to soups and stews. Its seeds are used as a flavor, and infusions are prepared from its dried leaves. Most pharmaceutical, health, and nutraceutical benefits have been attributed to the presence of bioactive compounds, including ascorbic acid, carotenoids, and phenolic compounds in their leaves (Kaboré et al. 2021). Due to the richness of its leaves in nutritional substances (vitamin C, provitamin A, mineral salts, proteins), *Corchorus olitorius*, could be a "powerful weapon" against nutritional deficiencies, especially in developing countries (Kiebre et al. 2016).

So, to promote the various virtues that many ignore, it is essential to take appropriate steps to introduce them to humanity. However, it does not always yield the expected yields, thus requiring fertilization to maintain or improve soil fertility through nutrient input (Ognalaga et al. 2017). In tropical hot zones, for example, the quantity and quality of production are generally and essentially affected by several constraints, including soil infertility.

Mineral fertilization using chemical fertilizers (Kitabala et al. 2016), organic fertilization (Kaho et al. 2011), crop combinations, crop rotations, and crop rotation (Nyembo et al. 2013; Kitabala et al. 2016), and varieties tolerating soil infertility of certain nutrients can be used to address declining crop yields. In addition, excessive use of chemical fertilizers pollutes groundwater and hampers soil nutrient availability and product quality with adverse effects on human, animal, and plant health (Tchaniley et al. 2020). Thus, the agronomic value of organic matter consists not only in its ability to provide nutrients to plants but also in its ability to improve soil properties conducive to the growth of plants and soil microorganisms (Kitabala et al. 2016). Thus, frequent inputs of organic fertilizers are needed to improve soil properties in a sustainable way (Mulaji 2011). Organic manures are rich in nitrogen and their organic matter content makes the soil friable, and loose with a high porosity allowing good water infiltration (Ngoyi et al. 2020). It nourishes and harbors a large number of soil-useful organisms, such as earthworms and microorganisms, that continually work to improve fertility and soil structure (Tchaniley et al. 2020), hence the importance of using poultry manure and poultry droppings as organic fertilizers. Organic fertilizers increase soil organic matter content, and improve food exchange capacity, with increasing soil water conservation favoring soil aggregates and protecting the soil from acidity, alkalinity, salinity, pesticides, and toxic heavy metals (Tchaniley et al. 2020).

Moreover, good root development of crops is an essential factor in their good productivity and, above all, in their tolerance to climatic hazards (Kuelo et al. 2012). Thus, one of the key roles of tillage is to facilitate root growth. Through used soil, it reduces the resistance of the soil to root penetration through an improvement of its physical properties. Used soil makes the soil loose, increases its porosity, thus facilitating soil infiltration and water retention, and root penetration. Thus, tillage conditions the dynamics of organic matter (Ngoyi et al. 2020; Tchaniley et al. 2020).

To evaluate the effect of organic fertilizers and tillage on *C. olitorius* performance, this study aims to contribute to the improvement of the productivity of *Corchorus olitorius* L.

Study site

The experiments are being carried out in Benin in the municipality of Abomey-Calavi, Ouedo district belonging to the agroecology zone of the barred lands. It is characterized by a Sudano-Guinean climate with two rainy seasons alternating with two dry seasons.

Study material

Plant material

The plant material used is made up of 3 varieties of *Corchorus olitorius* L including an improved variety V1 and two local varieties such as the local 5-finger toothed variety, and the local mono variety obtained from the seed structures.

Two types of fertilizers were used for the experiment, namely organic fertilizer based on poultry manure and cow dung.

Methods

Experimental design

The experiments were carried out in the Commune of Abomey-Calavi, Ouedo District belonging to the Agro-ecology Zone of the Barred Land. It consists of three factors and is installed in a split-plot design with 03 repetitions. The primary factor is tillage with two (02) variants: Used soil and Untilled Soil (NLS); the secondary factor is the dose of organic fertilizer at eight levels: F0 = absolute control (without fertilizer); F1 = 2 kg/m² cow dung; F2 = 2.5 kg/m² cow dung; F3 = 3 kg/m² cow dung; F4 = 0.5 kg/m² poultry dung; F5 = 0.7 5 kg/m² of poultry manure; F6 = 1 kg/m² of poultry manure; F7 = 2 kg/m² of cow dung + 0.5 kg/m² of poultry manure and the third factor is the varieties constituted by one improved et two local varieties. Forty-eight treatments constituted the experiment. Each experimental unit occupied an area of 2 m². The seedling lines were arranged over the lengths of the experimental units with a spacing of 20 cm between the line and seedlings (it means a density of 25 seedlings/m^2 with 1 seedling/hole). The elementary plots are separated from each other by footrests 40 cm wide and the distance between the repetitions is 1 m. Treatments were randomized at each repetition level as were varieties within blocks.

Conduct of the experiment

The soil preparation consisted of clearing land, collecting plant debris, working, picketing, and making up the manure boards.

Indeed, since the boards were made, the experimental site was disinfected by the use of a biological product called "Controlphyt Cu" at a rate of 50 ml in 15 liters of water. The nursery of the varieties was made in line spaced by 20 cm each on a board 1 meter long and 6 meters wide each. The seedlings were transplanted 22 days after seeding in the nursery at the rate of one plant per seed pot. The seedlings were 10-15 cm tall and had 3-5 true leaves.

Data collection

A total of eight quantitative variables were collected 30 days after transplanting and included plant height, neck diameter, leaf length and width, petiole length, leaf number per plant, and weight of fresh and dry biomass. The measurement of the yield parameters was carried out during the cutting of the corete which took place approximately 44 days after subculturing. Fresh biomass was obtained just after cutting. After 96 hours in an oven at a temperature of 60° C., the dry biomass was recorded for each variety resulting from each treatment.

Statistical analysis of data

The data collected during the trial were entered and processed in the Excel 2016 spreadsheet. These data were subjected to various analyzes including descriptive statistics, and analysis of variance with the Statitica software. The analysis of Variance was performed with R 4.2.1 software and identified characters that are controlled by the treatments applied. Graphs were also produced using the Excel 2016 spreadsheet to compare the performance of varieties in different assessment environments. The three (03) varieties of *C. olitorius* used are V1=Improved variety; V2=Toothed local variety; and V3= Mono local variety.

Results

Descriptive analysis of the agro-morphological characters studied

The quantitative characteristics measured during the application of the different treatments to the corete varieties allow minimum and maximum values to be recorded in both assessment environments (farmed and unfarmed soil) (**Table 1**). A high degree of variability was observed between varieties for all traits measured at both the assessment medium and combined assessment levels. On untapped land (uncultivated for at least 5 years), the coefficient of variation of the characters varies from 12.78 % for the length of the leaf (LL) to 45.58 % for the weight of the fresh biomass (PBF). In this environment, the greatest variations were observed with seedling height (HP), leaf width (LW), and dry biomass weight (DBW), which showed coefficients of variation greater than 20%. Similar observations are made with the harvested medium (daily range) where the coefficient of variation varies from 7.91% for the length of the leaf (LL) to 22.24% for the weight of the fresh biomass. The greatest variations in this environment are obtained with LaL, FBW, and DBW for a CV greater than 20%. The evaluation of the mean values obtained from the combined data from the two media shows a wide variation in plant height (PH), leaf width (LW), leaf number per plant (LNP), fresh biomass weight (FBW), and dry biomass weight (DBW). A comparison of the mean values of the different characters from one medium to another associated with the combined data makes it possible to note that the lowest mean values are recorded with the soil used (**Table 1**).

Table 1a: Description of the characters measured in the two production media

	Unexploited					**Exploited**				
	Moy.	**Min.**	**Max**	**St. dev.**	**CV (%)**	**Moy.**	**Min.**	**Max**	**St. dev.**	**CV (%)**
PH (cm)	58.85	39.03	86.80	12.394	21.06	41.96	29.93	58.30	8.206	19.56
SD (mm)	7.21	4.53	9.97	1.203	16.70	5.90	4.48	9.28	1.061	17.99
PL (cm)	4.97	3.08	7.76	0.941	18.92	4.37	3.42	5.80	0.561	12.83
LL (cm)	9.51	7.50	12.46	1.216	12.78	8.34	6.68	9.48	0.659	7.91
LW (cm)	4.31	2.83	8.74	1.357	31.45	3.69	2.71	5.91	0.750	20.33
LNP	68.33	50.33	84.33	10.454	15.30	52.11	38.00	75.00	9.916	19.03
FBW (kg)	1.43	0.59	3.39	0.654	45.58	0.88	0.48	1.29	0.196	22.24
DBW (kg)	0.49	0.12	0.85	0.187	38.28	0.24	0.14	0.34	0.053	21.89

PH: plant height; SD: stem diameter; PL: petiole length; LL: leaf length; LW: leaf width; LNP: leaf number per plant; FBW: fresh biomass weight; DBW: dry biomass weight, St. dev.: Standard deviation, cm: centimeter, mm: millimeter, kg: kilograms, %: percentage

Table 1b: Description of the characters measured in the combined treatments

	Combined treatments				
Characters	**Mean**	**Min**	**Max**	**St. dev.**	**CV (%)**
PH (cm)	50.40	29.93	86.80	13.468	26.72
SD (mm)	6.55	4.48	9.97	1.307	19.94
PL (cm)	4.67	3.08	7.76	0.827	17.71
LL (cm)	8.92	6.68	12.46	1.139	12.76
LW (cm)	4.00	2.71	8.74	1.135	28.34
LNP	60.22	38.00	84.33	13.005	21.60
FBW (kg)	1.16	0.48	3.39	0.555	47.90
DBW (kg)	0.36	0.12	0.85	0.184	50.68

PH: plant height; SD: stem diameter; PL: petiole length; LL: leaf length; LW: leaf width; LNP: leaf number per plant; FBW: fresh biomass weight; DBW: dry biomass weight, St. dev.: Standard deviation, cm: centimeter, mm: millimeter, kg: kilograms, %: percentage

Analysis of variance of the measured characters

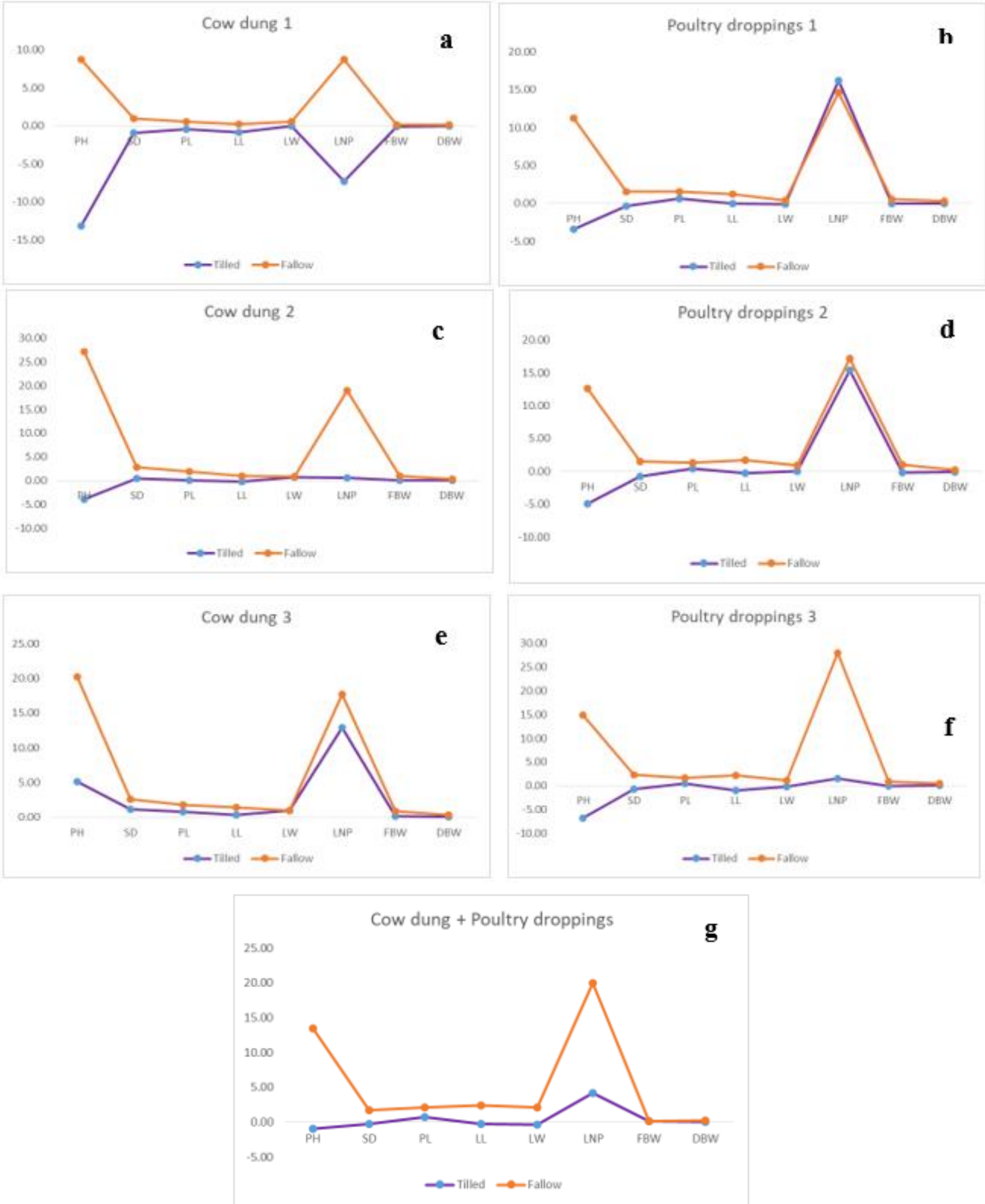
The multi-factor variance analysis performed on the different measured traits shows that there is a significant difference between varieties, different fertilizers, and soil types (on- and off-farm) for each of the traits considered. The interaction between the applied fertilizers and the soil type is significant for the eight characters measured indicating that the responses from the application of fertilizers are under the control of the action of the soil types. The assessment of the interaction between fertilizers and soil types also indicates a significant interaction justifying fertilizer expression due to soil type for all the traits measured. As for the interaction between varieties and soil type, the significant difference was observed for all traits except stem diameter (DT), petiole length (LP), and leaf length (LL). Similarly, the interaction between fertilizers and varieties is significant for all traits. Although there were no significant differences in the interaction between soil type and varieties for some traits, the interaction between soil type, fertilizers, and varieties was significant for all traits assessed (**Table 2**). The interaction between variety and soil type showed no significant difference in stem diameter (SD), leaf length (LL), and petiole length (PL). Following the analysis of these significant differences, selections can be made at each site and for each fertilizer. Figure 1 shows the expression of the traits in the presence of fertilizer application on both soils. The application of different doses of cow dung (2 kg/m², 2.5 kg/m²; 3 kg/m²) to help improve the growth of *Corchorus olitorius* plants (Figure 1 a, c, and e) on the unexploited part. The application of the different doses of poultry droppings (0.5 kg/m², 0.75 kg/m², 1 kg/m²) further contributed to the improvement in the growth of the characters evaluated with values essentially positive on the (Figure 1b, d and f) on the unexploited part. Thus, the treatment carried out by the combination of cow dung and poultry droppings at respective doses of 2 kg/m2 and 0.5 kg/m2 allowed an improvement of the eight characters (Figure 1g) compared with the single doses of cow dung (Figure 1a) and poultry droppings (Figure 1f).

Table 2: Analysis of the Variance of the Characters During the Different Processes

Source		Model	Soil	Fert.	Variety	Sol*Fert.	Soil*Variety	Fert.*Variety	Sol*Fert.*Variety
DDL		1	1	7	2	7	2	14	14
	SC	243885.6	6848.4	2234.3	4695.6	1646.4	345.2	529.4	854.7
PH (cm)	MC	243885.6	6848.4	319.2	2347.8	235.2	172.6	37.8	61.0
	F	148163.9***	4160.5***	193.9***	1426.3***	142.9***	104.8***	23.0***	37.1***
	SC	4120.911	41.265	41.704	10.786	16.683	0.787	25.020	13.048
SD (cm)	MC	4120.911	41.265	5.958	5.393	2.383	0.393	1.787	0.932
	F	15300.73***	153.21***	22.12***	20.02***	8.85***	1.46 NS	6.64***	3.46***
	SC	2095.585	8.625	24.631	7.286	5.195	0.803	8.726	5.387
PL (cm)	MC	2095.585	8.625	3.519	3.643	0.742	0.402	0.623	0.385
	F	22991.21***	94.63***	38.60***	39.97***	8.14***	4.41NS	6.84***	4.22***
	SC	7645.651	33.318	17.397	16.572	21.027	1.307	14.443	12.371
LL (cm)	MC	7645.651	33.318	2.485	8.286	3.004	0.654	1.032	0.884
	F	54141.81***	235.94***	17.60***	58.68***	21.27***	4.63NS	7.31***	6.26***
	SC	1538.508	9.278	10.884	62.911	14.862	7.669	5.635	7.801
LW (cm)	MC	1538.508	9.278	1.555	31.455	2.123	3.834	0.402	0.557
	F	22800.24***	137.50***	23.04***	466.16***	31.47***	56.83***	5.96***	8.26***
	SC	348124.6	6310.4	3691.2	1696.0	2231.3	35.8	1083.2	844.9
LNP	MC	348124.6	6310.4	527.3	848.0	318.8	17.9	77.4	60.3
	F	95153.32***	1724.84***	144.13***	231.79***	87.13***	4.89***	21.15***	16.50***
	SC	128.7372	7.3317	4.1042	1.2557	4.7557	0.7669	5.8818	4.3178
FBW (kg)	MC	128.7372	7.3317	0.5863	0.6278	0.6794	0.3835	0.4201	0.3084
	F	7574.167***	431.354***	34.496***	36.938***	39.971***	22.561***	24.718***	18.145***
	SC	12.71670	1.46520	0.57533	0.14251	0.31123	0.03111	0.33596	0.36016
DBW (kg)	MC	12.71670	1.46520	0.08219	0.07125	0.04446	0.01555	0.02400	0.02573
	F	57585.08***	6634.89***	372.18***	322.66***	201.33***	70.43***	108.67***	116.49***

PH: plant height; SD: Stem Diameter; PL: petiole length; LL: leaf length; LW: leaf width; LNP: leaf number per plant; FBW: fresh biomass weight; DBW: dry biomass weight; Fert: Fertilizer, cm: centimeter, mm: millimeter, kg: kilograms, %: percentage, ***: highly significant at 1% level, NS: non-significant

Figure 3: Effects of fertilizers on parameters measured in different soils



PH: plant height; SD: Stem Diameter; PL: petiole length; LL: leaf length; LW: leaf width; LNP: leaf number per plant; FBW: fresh biomass weight; DBW: dry biomass weight

Agronomic performance of *C. olitorius* and effect of fertilizers on different assessment soil

The evaluation of the performance of each of the varieties on the different soils in the presence of fertilizers shows results specific to each of the varieties through the expression of their agronomic performance. Thus, following the specific interaction between soils and varieties, specific selections can be made for the identification of the performance variety according to each of the traits studied. The analysis of variance (ANOVA) therefore indicates that the V2 variety showed the best performance for seedling height (PH) and leaf width (LW) with mean values of 49.2±7[a] and 4.44±0.689[a] respectively on cultivated soil. This variety also performed poorly for all the other traits evaluated. No significant differences in performance were observed between V1 and V3 varieties. SD and PL characters showed no significant difference between the performance of the local varieties studied (**Table 3**). On uncultivated soil, there were no significant differences between the varieties for fresh biomass weight (FBW), dry biomass weight (DBW), and stem-to-collar diameter (SD). In contrast to the commonly used site, the local variety V3 showed better agronomic performance for leaf length (LL) (10.14±1.16[a] cm), and number of leaves per plant (LNP) (72.9±11.265[a]) (**Table 3**). In this medium, the variety V2 has, in addition to the characters PH (71.39±9.042[a] cm) and LW (5.86±1.261 [a] cm), a better performance at the level of PL (5.47±1.081 [a] cm). LL and LNP indicated low values for V2 while the local variety V1 was the least effective in evaluating the length of the petiole (4.59±0.796[b] cm).

In addition to determining the best-performing varieties on each soil, the high significance of the soil fertilizer interaction makes it possible to identify the fertilizer that has produced better performance of the varieties following the evaluation of the measured characteristics. The three doses of cow dung applied showed significantly different results for the expression of the different characters except the weight of the fresh biomass, the effect of which was different compared with the effect of poultry droppings (**Table 4**). On the other hand, with droppings, the expression is not significant for the characters PH, SD, PL, and LW. In general, the fertilizer F3 (3 kg/m2 of cow dung) performed better in terms of height of the plants, diameter at the collar, length of the petiole, length of the leaf, and width of the leaf with respective averages of 50.63±3.68[a] cm, 7.26±0.7[a] cm, 4.82±0.503[a] cm, 8.93±0.162[a] cm, and 4.56±0.90 9[a] cm. The lowest performances for these same traits were obtained with the fertilizer F1 (2 kg/m2 of cow dung). The best expression of the number of leaves per plant is obtained with the fertilizer F4 for an average value of 62.89±11.008[a] cm and the lowest expression is recorded with the fertilizer F1. Assessment of biomass through determination of fresh and dry weight shows best expression with the respective application of F7 fertilizer consisting of a mixture of cow droppings and dung and F6 fertilizer consisting solely of poultry droppings.

Analysis of the expression of these different traits in the presence of the same fertilizer doses on untapped soil also shows diversified responses. In contrast to the cultivated soil, the plot with no fertilizer showed the lowest performance regardless of the character evaluated (Table 5). Also, the best performance is recorded with the application of F2 for the height of the plants (PH) and the diameter at the collar (SD) with a respective average of 72.45 ± 10.965^{a} cm and 8.33 ± 1.022^{a} cm. The F7 fertilizer mixture induced better performance at PL (5.74 ± 1.385^{ab} cm), LL (10.61 ± 0.628^{ab} cm), and LW (5.59 ± 2.286^{ab} cm). The best performance in LNP (80.72 ± 4.548^{ab}) and DBW (0.65 ± 0.037^{ab} kg) is obtained with F6 (1 kg/m^2 of poultry droppings) whereas F5 (0.75 kg/m^2 of poultry droppings) made it possible to record a good performance for FBW with an average of 1.91 ± 0.465^{ab} kg. It should be noted that the different doses of fertilizer applied to this soil from the droppings (0.5 kg/m^2, 0.75 kg/m^2, 1 kg/m^2) indicated no significant differences between them. Significant differences were recorded in plots subjected to the application of the doses of cow dung with the best results obtained with F2 (2.5 kg/m^2 of cow dung) or F3 (3 kg/m^2 of cow dung) depending on the character. Finally, the F7 mixture (2 kg/m^2 of cow dung + 0.5 kg/m^2 of poultry droppings) indicated performances similar to those obtained only with poultry droppings (Table 5).

Table 3: Agricultural performance of local varieties

Soil	Variety	PH (cm)	SD (cm)	PL (cm)	LL (cm)	LW (cm)	LNP	FBW (kg)	DBW (kg)
Cultivated	**V1**	38±6.69.86^{b}	5.68±1.022^{a}	4.15±0.403^{a}	8.51±0.397^{a}	3.26±0.478^{b}	54.88±11.243^{a}	0.83±0.177^{b}	0.22±0.043^{b}
	V2	49.2±7^{a}	6.34±1.138^{a}	4.61±0.723^{a}	7.86±0.737^{b}	4.44±0.689^{a}	46±19.6.567^{b}	0.98±0.155^{a}	0.27±0.038^{a}
	V3	37.98±5.54^{b}	5.67±0.934^{a}	4.35±0.436^{a}	8.64±0.539^{a}	3.39±0.413^{a}	55.27±9.073^{a}	0.83±0.225^{b}	0.23±0.06^{b}
Uncultivated	**V1**	52.18±9.223^{b}	6.76±1.178^{a}	4.59±0.796^{b}	9.49±1,219^{ab}	3.48±0.515^{b}	69.52±10.202^{a}	1.16±0.307^{a}	0.42±0.165^{a}
	V2	71±39.9.042^{a}	7.68±1.128^{a}	5.47±1.081^{a}	8.9±0.989^{b}	5.86±1,261^{a}	62.56±7.228^{b}	1.54±0.632^{a}	0.55±0.161^{a}
	V3	52.99±7.919^{b}	7.18±1.191^{a}	4.86±0.738^{ab}	10.14±1.16^{a}	3.61±0.315^{b}	72.9±11,265^{a}	1.6±0.852^{a}	0.5±0.215^{a}

The means with the same letter in a column were not significantly different at 5% threshold. PH: plant height; SD: Stem Diameter; PL: petiole length; LL: leaf length; LW: leaf width; LNP: leaf number per plant; FBW: fresh biomass weight; DBW: dry biomass weight; Fert: Fertilizer, cm: centimeter, mm: millimeter, kg: kilograms

Table 4: Effect of fertilizers on yield and its components in the cultivated soil

Fertilizer	PH (cm)	SD (cm)	PL (cm)	LL (cm)	LW (cm)	LNP	FBW (kg)	DBW (kg)
F0	45.46±9.093^{a}	6.08±1.095^{ab}	4.03±0.284^{bc}	8.61±0.275^{ab}	3.55±1^{b}	46±6,67.088^{bc}	0.9±0.233^{ab}	0.23±0.067^{bcd}
F1	32.25±2.724^{b}	5.12±0.348^{b}	3.6±0.119^{c}	7.76±0.729^{b}	3.55±0.403^{b}	39±39.1,255^{c}	0.75±0.22^{ab}	0.18±0.045^{d}
F2	41.59±9,501^{ab}	6.55±1.592^{ab}	4.13±0.331^{abc}	8.41±0.484^{ab}	4.29±0.612^{ab}	47±22.6344^{bc}	0.89±0.126^{ab}	0.22±0.044^{cd}
F3	50.63±3.68^{a}	7.26±0.7^{a}	4.82±0.503^{a}	8.93±0.162^{a}	4.56±0.909^{a}	59.56±3.195^{a}	1.03±0.164^{ab}	0.28±0.014^{ab}
F4	42.06±4.906^{ab}	5.7±0.339^{b}	4.64±0.393^{ab}	8.63±0.812^{ab}	3.47±0.401^{b}	62.89±11.008^{a}	0.86±0.156^{ab}	0.23±0.036^{bcd}
F5	40±48.7,522^{ab}	5.3±0.526^{b}	4.42±0.343^{ab}	8.34±0.409^{ab}	3.53±0.64^{b}	62.11±9.29^{a}	0.72±0.188^{b}	0.21±0.015^{d}
F6	38±65±4,727^{ab}	5.38±0.706^{b}	4.54±0.493^{ab}	7.64±0.691^{b}	3.34±0.469^{b}	48±1,657^{bc}	0.84±0.12^{ab}	0.31±0.025^{a}
F7	44.54±9.703^{a}	5.79±1.008^{b}	4.8±0.694^{a}	8.37±0.555^{ab}	3.24±0.531^{b}	50.89±4.48^{b}	1.05±0.163^{a}	0.27±0.029^{abc}

The means with the same letter in a column were not significantly different at 5% threshold. F: Fertilizer, PH: plant height; SD: Stem Diameter; PL: petiole length; LL: leaf length; LW: leaf width; LNP: leaf number per plant; FBW: fresh biomass weight; DBW: dry biomass weight; Fert: Fertilizer, cm: centimeter, mm: millimeter, kg: kilograms

Table 5: Effect of fertilizers on yield and its components in untapped soil

Fertilizer	PH (cm)	SD (cm)	PL (cm)	LL (cm)	LW (cm)	LNP	FBW (kg)	DBW (kg)
F0	45±29.6.696^{b}	5.5±0.532^{b}	3.61±0.37^{b}	8.22±0.416^{b}	3.45±0.651^{b}	52.67±1,921^{b}	0.85±0.205^{b}	0.24±0.089^{b}
F1	54.01±11.168^{ab}	6.45±1.207^{ab}	4.13±0.595^{ab}	8.48±0.805^{ab}	3.98±1.303^{ab}	61.44±7.164^{ab}	0.98±0.076^{ab}	0.37±0.099^{ab}
F2	72.45±10.965^{a}	8.33±1.022^{a}	5.49±0.543^{a}	9.26±1.047^{a}	4.29±1.304^{a}	71.67±9.435^{a}	1.87±0.761^{a}	0.62±0.208^{a}
F3	65.56±9.549^{a}	8.15±1.036^{a}	5.4±0.733^{a}	9.65±1.817^{a}	4.41±1.194^{a}	70.33±10.183^{a}	1.78±1.172^{a}	0.58±0.276^{a}
F4	56.57±12.611^{ab}	7.04±0.745^{ab}	5.21±0.363^{ab}	9.49±1.22^{ab}	3.88±0.747^{ab}	67.33±6.15^{ab}	1.38±0.271^{ab}	0.54±0.144^{ab}
F5	57±89.9,572^{ab}	7.06±0.356^{ab}	4.94±0.157^{ab}	9.98±0.291^{ab}	4.41±1,163^{ab}	69±83.7,817^{ab}	1.91±0.465^{ab}	0.44±0.031^{ab}
F6	60.24±14.485^{ab}	7.87±1.031^{ab}	5.25±0.68^{ab}	10.43±0.793^{ab}	4.51±1.277^{ab}	80.72±4,548^{ab}	1.72±0.203^{ab}	0.65±0.037^{ab}
F7	58 ± 78 ± 8,266^{ab}	7.26±0.814^{ab}	5.74±1.385^{ab}	10.61±0.628^{ab}	5.59±2.286^{ab}	72±61±8,965^{ab}	0.98±0.171^{ab}	0.46±0.064^{ab}

The means with the same letter in a column were not significantly different at the 5% threshold. F: Fertilizer, PH: plant height; SD: Stem Diameter; PL: petiole length; LL: leaf length; LW: leaf width; LNP: leaf number per plant; FBW: fresh biomass weight; DBW: dry biomass weight; Fert: Fertilizer, cm: centimeter, mm: millimeter, kg: kilograms

Discussion

The results obtained at the level of the different varieties showed a morphological diversity within the characters studied under the results of Kiébré et al. 2016 which proved that the agro-morphological evaluation of the 41 accessions of Burkina Faso revealed the existence of several discriminant characters thus reflecting a very great morphological diversity within the material studied. Our results are also in agreement with those of Mbaye et al. (2001) which showed that the leaves of *Corchorus* L. have many common characteristics. However, a closer observation reveals differential characteristics that allow a better identification of these species.

At the end of the analysis of the performance of the varieties, it is to be noted that, following the analysis of the Weight of the Dry Biomass and the Weight of the Fresh Biomass, a particularity which shows that the improved variety is more efficient than the two local varieties.

The results obtained during the study showed that the effects of fertilizers on growth and yield varied with the dose regardless of the type of soil. The doses of organic fertilizers associated with both cultivated and uncultivated soil significantly influenced the growth parameters. A high degree of variability was observed between varieties for all traits measured at both the assessment medium and combined assessment levels. These could be explained by the availability and rapid release of nutrients as well as the rapid degradation of the fertilizers contained in the two fertilizers used and their easy uptake by the plant. Ouedraogo et al. (2022) in a study reported that fallow plays a very important role in restoring soil fertility and that organic manure and mineral fertilizers are commonly used by farmers during cultivation techniques to assist plants in production. According to the latter authors. Abbas and Abdelguerfi (2005) have shown that fallow plays a more effective role in managing climate risk, maintaining agricultural fertility, combating drought and erosion, preserving the environment, managing space, and maintaining the cultural and social wealth of many areas. Romain in 2010 showed that non-tillage is a means of combating runoff, soil losses, and off-site impacts (muddy floods in particular). In this context, understanding the factors that control runoff formation is crucial to ensuring that the use of non-tillage produces the desired effects. Similar observations are made with the cultivated soil where the coefficient of variation ranges from 7.91% to 22.24%. The largest variations on this soil are obtained with LW, FBW, and DBW for a CV greater than 20%. These variations could also be explained by the availability and rapid release of nutrients contained in the two fertilizers used and their easy uptake by the plant and confirmed by Kotaix et al. (2019), which reported that organic matter plays a determining role in soil fertility and is essential to retain nutrients and moisture in the soil. It stabilizes its structure, and nourishes and shelters soil organisms. The same observations were noted by Gomgnimbou et al. (2019), according to which the use of organic manure maintains or improves soil fertility with very good crop yields and does so in a sustainable manner.

The combination of the data from the two media makes it possible to note a wide variation in the yield characters. Similarly, a comparison of the mean values of the different characters from one medium to another associated with the combined data reveals that the lowest mean values were recorded with the harvested soil. However, the dynamics of organic matter contribute to the availability of mineral elements in soils and consequently to the improvement of crop productivity and quality. It is from this perspective that integrated soil fertility management was introduced according to Aboubakar et al. 2020.

Results of the effect of organic fertilizer doses showed that fertilizers significantly improved the performance of the varieties for each of the traits considered. Indeed, according to Ognalaga et al. (2017), manure leads to a significant increase in the height of the plants, which is a sign of greater vegetative development. These results are consistent with those of Tchaniley et al. (2020), who reported that nitrogen is a critical growth factor in plants, especially in leaves and stems. As for the interaction between variety and soil type, a significant difference was observed for traits except for stem diameter (SD), leaf length (LL), and petiole length (PL). The assessment of the interaction between treatment and soil types also indicates a significant interaction through fertilizer expression due to soil type for all measured traits. Evaluating the significant interaction between varieties, fertilizers, and soil type, we can say that organic manure plays an important role in improving crop productivity as reported by Gomgnimbou et al. (2019).

The application of different doses of cow dung (2 kg/m^2, 2.5 kg/m^2; 3 kg/m^2) contributed to a slight improvement in the growth of *Corchorus olitorius* plants. This could be justified by the fact that the nutrients contained in cow dung and urine are immediately available for the plants. Kpéra et al. (2017) reported that fertilizer application generally improves plant growth.

The same observation is made with the application of different doses of poultry manure (0.5 kg/m^2; 0.75 kg/m^2; 1 kg/m^2) except that manure applied to the soil already in the course of operation and contributed more to the growth of the traits evaluated with essentially positive values. This result, in line with the conclusions of Gomgnimbou (2019), indicates that the input of poultry droppings is recommended for crops with an immediate need for fertilizers, as it increases the richness of the major elements, the cation exchange capacity (CEC) and thus improves the structural and textural level of the soil. For Ravonjiarison et al., (2018) the input of organic and/or mineral fertilizers and the practice of conservation agriculture remain the main knowledge reported by farmers surveyed in a study on the maintenance of soil fertility. These manures are locally perceived to promote fruiting and plant growth.

Unused land is set aside and yields better as a result of the application of different fertilizer doses. These results are similar to those obtained in Cameroon by Alissou (2011), which showed that organic fertilization (chicken droppings) yields as much and has a much better benefit-cost ratio than mineral fertilizer NPK (19-4-16). Our results are also similar to those obtained by Itelima et al. (2018) and Alissou (2011) in an evaluation study of the effects of liquid organic fertilizer D.I.GROW and mineral fertilizer NPK 17-17-17 + Urea on maize yield and profitability in Ngandajika, Democratic Republic of the Congo.

The results obtained during the study showed that on almost all treatments and varieties, we noticed higher productivity on the unexploited part than the exploited part. This is due to the effectiveness of fertilizers and in addition, the unexploited part contains much more nutrients, according to Tchaniley (2020). Practices become more diverse as land pressure increases and fallow disappears. The work of Kouelo et al. in 2012 confirms that tillage can lead to better water infiltration into the soil. In Burkina Faso, studies by Coulibaly et al. (2018) on soil fertility management indicate that poultry can contribute nearly 30% to the production of organic substrates on farms. It can also allow farms that strongly integrate poultry farming to fertilize nearly 5% of their field, compared to 0.52% for farmers who more closely integrate livestock into agriculture. On the other hand, these farms, which are dominated by livestock rearing, have a greater capacity to fertilize their fields (more than 70% of the cultivated area) with all the organic substrates they produce. The coverage of the organic substrate requirements of other farms varies between 12 and 17% depending on the size of the livestock (Coulibaly et al. 2018). Adekambi et al. (2021) proposed to adopt at least one of four integrated soil fertility management practices: crop rotation and rotation, organic matter use, crop residues, and soil regeneration with legumes.

Conclusion

The results of this study showed that the different parameters evaluated varied considerably depending on the varieties, fertilizers, and the study site. The input of the different doses of organic fertilizers induces a performance on the yield and its components at the level of all varieties. However, better performances were obtained with both local toothed and mono varieties compared to the improved variety in the study. Soil amendment with varying doses of organic fertilizers combined with varieties on cultivated or uncultivated soil thus promotes nutrient availability to plants and improves yields. Thus, organic fertilizer is a significant fertilizer capable of improving soil fertility and giving useful performance to the plant. We note a higher yield on the unexploited part than the exploited part justified by the effect of fallow through the mineralization of dead organic matter and the action efficiency of the fertilizer types. In addition, the fallow area contains many more nutrients than the harvested area. In addition, analyses indicate that nutrients from poultry droppings are more readily available than those from cow dung and contribute more to a good yield.

Authorship

Faton Manhognon Oscar Euloge, Bonou-Gbo Zaki, Montcho Hambada koffi David, Ogoubiyi Chakour-Ola Tounde, Djedatin Gustave, and Gnancadja-Andre Léopold Simplice contributed to the study conceptualization and designed the experiments. Faton Manhognon Oscar Euloge, Bonou-Gbo Zaki, and Ogoubiyi Chakour-Ola Tounde contributed to the statistical analysis. Faton Manhognon Oscar Euloge wrote the manuscript. Akotegnon Azonwakin Rodrigue, Cynthia Atindehou, Lucie Fanou, Gandonou Gbossegnon Bernard Christophe, Gnancadja-Andre Léopold Simplice, and Edorh Patrick Aléodjrodo supervised the entire study. Bonou-Gbo Zaki, Montcho Hambada Koffi David, Gnancadja-Andre Léopold Simplice, and Gandonou Gbossegnon Bernard Christophe reviewed and edited the manuscript. All authors contributed to the manuscript.

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