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Assessing the effect of tillage and fertilization on the accumulation of minerals in pearl millet stover

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Abstract

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] constitutes the third most important cultivated cereal and source of nutrients in Burkina Faso. The study carried out in 2018 and 2019 at the Saria Environment and Agricultural Researches Station aimed to assess the effects of tillage and organo-mineral fertilization on the quantities of minerals accumulated in pearl millet stover that could be used in animal diets as nutritional supplements. The experimental design was a completely randomized block with a split-plot arrangement of treatments, three replications with four tillage methods assigned to main plots and eight organo-mineral fertilizations to subplots. Results showed that the quantities of minerals accumulated in pearl millet stover were affected by tillage methods and organo-mineral fertilizations as well as by their interactive effects. Compost associated with mineral fertilizers resulted in higher accumulations of minerals in pearl millet stover. In terms of tillage methods, the results indicated that ploughing and scarifying were more favorable for greater but not varying mineral accumulations compared to manual zaï and tie-ridging.

Keywords: Cereal; Compost; Manual zaï; Ploughing; Scarifying; Tied-ridging

1. Introduction

In Burkina Faso, the agricultural sector occupies 84% of the active population and contributes 35% to the gross domestic product (GDP) [1]. Agricultural production is the main source of income for rural populations and provides most of the nutritional needs of the population [1]. Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is one of the most important sources of nutrients in semi-arid and arid regions of Africa and India [2,3]. This cereal is also widely used in animal diets [4, 5, 6] from stover stocked after grain harvest. The country livestock production is affected by the lack of feed due to the degradation and scarcity of natural resources during dry season and the reduction of pastoral areas which do not assure substantial diet for animals, thus reducing their potential productivity [7]. Therefore, the production of fodder is one of the best alternatives for solving the big problem of diet requirements for cattle [7].

Most research activities had focused on the assessment of the pearl millet grain and stover yields with little attention paid to mineral accumulations in this stover which is used in animal nutrition [8, 9, 10]. Minerals are essential for animal body building and the daily nutrition intakes are used to compensate for the daily mineral losses [11]. Previous works had reported the recommended daily mineral nutrient requirements for animals [11, 5].

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The objective of this investigation is to assess the effects of tillage and organo-mineral fertilization on the quantities of minerals accumulated in pearl millet stover that could be used as nutritional supplements in animal diets in Burkina Faso and other countries in West Africa.

2. Material and methods

2.1. Study site

The experiment was conducted in 2018 and 2019 at the Saria Environment and Agricultural Researches Station in Burkina Faso (12° 16' N; 2° 09' W) located in the Sudano-sahelian agroecological zone (Figure 1). The area has a dry season from November to April and a rainy season from May to October.

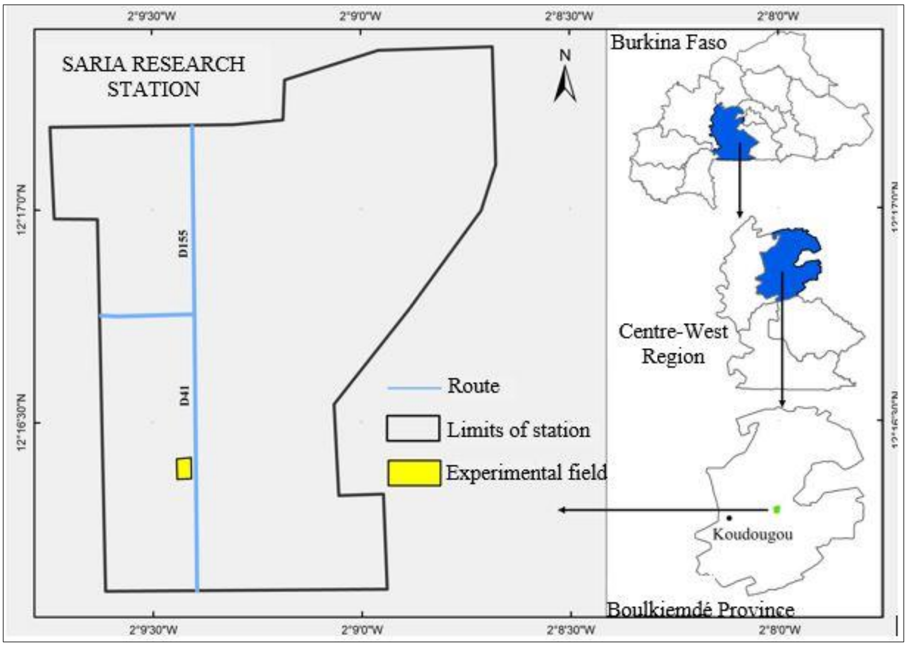

Figure 1 Map of Saria Research Station showing the location of the experimental field (Map drawn by Abdel Kader DRAME, 2021)

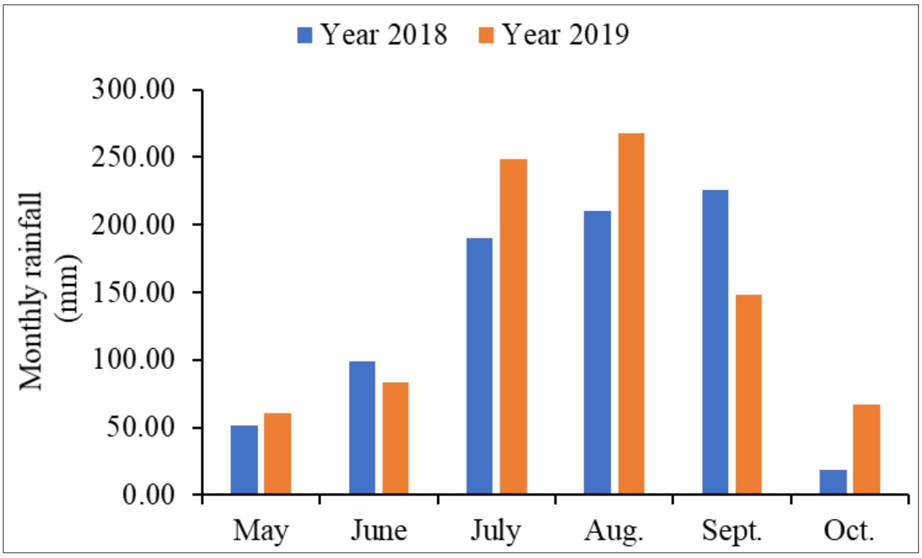

Figure 2 Monthly rainfall in 2018 and 2019 at Saria Environment and Agricultural Researches Station

The experiment was conducted under rainfed conditions and on a leached indurated tropical ferruginous-type soil with a shell at a depth of about 50 cm, with a sandy-loamy texture on the surface (9.4% clay, 31.4% silt and 59. 2% sand), low water holding capacity and a pH (water) of 5.4. In addition, the soil minerals are mainly composed of low N, P and K [12]. Monthly rainfall during the agricultural seasons varied from 19 to 225.6 mm in 2018 and from 60.3 to 267.3 mm in 2019 (Figure 2). Those of the last ten years (2010 to 2019) varied from 42.3 to 253.2 mm with higher precipitation occurring during the months of July to September. The average annual temperatures were 21.7°C at minimum and 36.4°C at maximum in 2018 and 21.2°C at minimum and 35.3°C at maximum in 2019 [12]. The previous crop in the field was cowpea grown for two years before the experiment was set up in 2018.

2.2. Plant material

The pearl millet variety used was IKMP5 with a maturity rating of 110 days, a good vigor at emergence, resistant to lodging, drought, insects, diseases (mildew, ergot and anthrax) and striga [13]. The grains of this variety are much used by local processors for the preparation of infant porridge, *tô*, *zom-koom* (soft drink) and *dolo* (traditional beer), while the stover is used as animal feed.

2.3. Fertilizers

The organic matter used was compost with a pH of 8.1 and containing 15.27% total carbon (Ctot), 1.40% total nitrogen (Ntot), 2.98% total phosphorus (Ptot), 0.64% total potassium (Ktot) and a C/N ratio of 10.95. The mineral fertilizers used are: NPK-S-CaO (15N-15P2O5-15KCl + 13SO3 + 8CaO), Urea-30N (30N + 3MgO + 8S + 0.3Zn + 0.2B) and Urea-46 N.

2.4. Experimental design

The experimental design was a completely randomized block with a split-plot arrangement of treatments with three (03) replications. Four (04) tillage methods (Figure 3) were assigned to the main plots and the sub-plots represented by eight (08) levels of mineral fertilization with or without compost (Table 1). Plots were ten (10) m long and four (04) m wide.

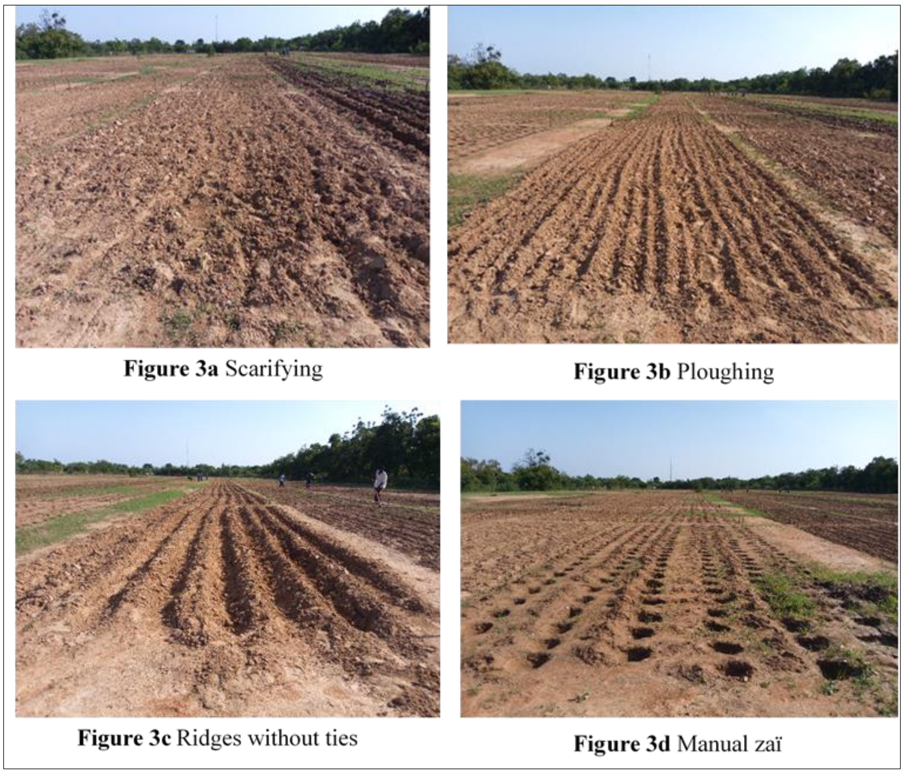

Figure 3a Scarifying

Figure 3b Ploughing

Figure 3c Ridges without ties

Figure 3d Manual zaï

Figure 3 Plots after tillage methods realized in 2018 and 2019 at Saria Environment and Agricultural Researches Station

Planting was done on July 5 in 2018 and July 23 in 2019 at the recommended spacing of 80 cm between rows and 80 cm within the row, with 1 or 2 plants per hill after thinning realized on July 26 in 2018 and August 20 in 2019, NPK was applied to the seed hills 15 days after planting and urea 45 days after planting. The microdose technique, which consists of applying the fertilizer 3-5 cm from the seedling hole, was used for the application of mineral fertilizers. The dose of compost broadcasted per year in plots without zaï pits before scarifying, ploughing and tied-ridging was 5.0 t ha^{-1}. In plots with manual zaï, the recommended dose of 300 g per pit of zaï was applied giving a total of 9.4 t ha^{-1}. For all tillage methods, compost was applied to the plots before planting. The doses of compost, NPK and urea applied are those recommended in Burkina Faso by the Institute for Tropical Agronomic Research and Food Crops (IRAT) and the Institute of Environment and Agricultural Researches (INERA) for decades, improved later by the International Fertilizer Development Center (IFDC) in 2018 [14]. The treatments were applied to the same plots each year. Weeding was done when needed.

Table 1 Levels of tillage method and mineral fertilization with or without compost

Tillage method (T)									
T1 = Scarifying (or shallow cultivation) using a Manga hoe, an animal drawn tool to loosen the first centimeters of the top soil.									
T2 = Manual Zaï (traditional) with holes made along the planting rows with 10 to 15 cm depth and 20 to 40 cm diameter for the hole.									
T3 = Ploughing using oxen drawn plough called CH9 that penetrates the soil beyond 15 cm soil depth.									
T4 = Tied-ridging. Ridges were made before planting along the planting rows using oxen drawn ridger; ties were made manually at 100 cm distance using manual hoes one month after planting.									
Fertilization (F)									
	N	**P_2O_5**	**K_2O**	**S**	**CaO**	**Mg**	**Zn**	**B**	**Compost**
	---------------------------------- **kg ha^{-1}** --------------------------------								
F1 = 100 kg ha^{-1} NPK-S-CaO + 50 kg ha^{-1} Urea (46 N)	38	15	15	13	8	0	0	0	0
F2 = 150 kg ha^{-1} NPK-S-CaO + 100 kg ha^{-1} Urea (46 N)	68.5	22.5	22.5	19.5	12	0	0	0	0
F3 = 150 kg ha^{-1} NPK-S-CaO + 100 kg ha^{-1} Urea 30	52.5	22.5	22.5	27.5	12	3	0.3	0.20	0
F4 = 100 kg ha^{-1} NPK-S-CaO + 50 kg ha^{-1} Urea 30	30	15	15	17	8	1.5	0.15	0.10	0
F5 = F2 + 5 t ha^{-1} compost	68.5	22.5	22.5	19.5	12	0	0	0	5 000
F6 = F1 + 5 t ha^{-1} compost	38	15	15	13	8	0	0	0	5 000
F7 = F3 + 5 t ha^{-1} compost	52.5	22.5	22.5	27.5	12	3	0.3	0.20	5 000
F8 = F4 + 5 t ha^{-1} compost	30	15	15	17	8	1.5	0.15	0.10	5 000

Note: N: nitrogen; P_2O_5: phosphorus; K_2O: potassium; S: sulphur; CaO: calcium; Mg: magnesium; Zn: zinc; B: boron

2.5. Stover samples analysis and data analysis

2.5.1. Stover samples analysis

Stover samples sent to the laboratory were collected in 2018 and 2019 from stover hand-harvested in the middle of each plot (28.16 m^2) and air-dried. Samples were fine ground to 0.5 mm diameter and mineralized according to the Kjeldahl method described by Isaac and Johnson [15]. A sample of 0.5 g of this ground stover was again subjected to mineralization with a mixture of sulfuric acid (H_2SO_4), selenium (Se) and salicylic acid ($C_7H_6O_3$) in the presence of peroxide (H_2O_2). Selenium is used as catalyst. The mineralization of the sample with the mixture of sulfuric acid - selenium - salicylic was done by progressive heating (100 to 340 °C) until complete mineralization. At the end of the mineralization, the samples were placed in a hood for slight cooling. Then, distilled water was added to 2/3 of the tubes for a second cooling to room temperature. The mineralizate is mixed with active carbon and then filtered. Total N and total P are determined in an AutoAnalyzer. Total K was determined using a Flame Photometer. Total Ca, total Mg, total Zn and total Fe were determined using an Atomic Absorption Spectrophotometer (AAS). The samples were diluted in 2000 ppm Lanthanum nitrate for AAS reading of Ca and Mg. The total quantity of each mineral accumulated in the stover was obtained by multiplying the stover nutrient content by the pearl millet stover yield reported by Palé *et al.* [16].

2.5.2. Data analysis

Total minerals accumulated in the stover yields were analyzed using standard analysis of variance and pair-wised comparisons by the General Linear Model Procedure on the software SAS version 9.2/STAT® [17]. Pearson correlations between stover yield and quantities of minerals accumulated were conducted. Results were considered significant at the $P \leq 0.05$ level.

3. Results

The analysis of variances (ANOVA) indicated that the quantities of minerals accumulated in pearl millet stover were mainly affected by the year (Y) x Tillage (T) interaction effects (Table 2) and T x Fertilizer (F) interaction effects (Table 3) and the main effect of F (Table 4).

3.1. Year x Tillage effects on macro-minerals accumulated in pearl millet stover

3.1.1. N variations

The use of scarifying, manual zaï and ploughing resulted in no differences across years for the quantities of N accumulated in pearl millet stover, while the use of tied-ridging revealed greater accumulations in the lower rainfall year of 2018 than in the higher rainfall year of 2019 (Table 2). Averaged across tillage methods, N quantities accumulated in pearl millet stover were greater in 2018 with a difference of 3 kg compared to 2019. Averaged across years, results indicated greater N quantities accumulated in the scarified plots with differences ranging from 3 to 5 kg depending on the tillage method used.

Table 2 Year (Y) and Tillage method (T) interaction effect on the mineral accumulation in the pearl millet stover, Saria, Burkina Faso. [ANOVA probabilities (P): $N_{Y*T} = 0.04$, $N_Y = 0.53$, $N_T = 0.66$; $K_{Y*T} < 0.01$, $K_Y = 0.83$, $K_T = 0.58$; $Ca_{Y*T} < 0.01$, $Ca_Y = 0.65$, $Ca_T = 0.37$; $Mg_{Y*T} < 0.01$, $Mg_Y = 0.90$, $Mg_T = 0.74$; Probability for Main effect of year on Zn = 0.05]

Tillage method	2018	2019	Mean	2018	2019	Mean
	N			K		
	---------- kg ha^{-1} ----------					
Scarifying	22^{aA}	18^{aA}	20^{a}	25^{aA}	22^{aA}	23^{a}
Manual zaï	15^{bA}	14^{abA}	15^{b}	22^{bA}	24^{aA}	23^{a}
Ploughing	17^{bA}	18^{aA}	17^{ab}	18^{bB}	29^{aA}	24^{a}
Tied- ridging	19^{aA}	11^{bB}	15^{b}	18^{bA}	15^{bA}	17^{b}
Mean	18^{A}	15^{B}		21^{A}	22^{A}	
	Ca			Mg		
Scarifying	3.96^{aA}	5.01^{bA}	4.48^{b}	4.63^{bA}	4.63^{bA}	4.63^{b}
Manual zaï	3.10^{aB}	4.76^{bA}	3.93^{b}	3.97^{bA}	4.40^{bA}	4.18^{b}
Ploughing	4.24^{aB}	7.31^{aA}	5.77^{a}	4.91^{abB}	6.81^{aA}	5.86^{a}
Tied- ridging	3.56^{aA}	3.8^{bA}	3.68^{b}	5.23^{aA}	3.87^{baB}	4.55^{b}
Mean	3.71^{B}	5.22^{A}		4.68^{A}	4.93^{A}	

Note: Values followed by the same capital letter in the same row or small letter in the same column are not significantly different at $p \leq 0.05$.

3.1.2. K variations

With the exception of ploughing, which recorded a difference of 11 kg in 2019 compared to 2018, the quantities of K accumulated in the stover produced in the three other tillage methods did not vary across the 2 years (Table 2). Averaged K quantities across tillage methods indicated no differences among years. Except for the use of tied-ridging that resulted in lower accumulated K in the pearl millet stover when accumulations were averaged across years, no differences were observed among the other tillage methods during the two years of the study.

3.1.3. Ca variations

Results showed no differences in the quantities of Ca accumulated in the stover for all tillage methods in 2018 (Table 2). In the higher rainfall year of 2019, ploughing increased Ca quantities by 3.51 kg compared to tied-ridging, by 2.55 kg compared to zaï and 2.3 kg compared to scarifying. The averages of Ca quantities accumulated in the pearl millet stover indicated no differences between the scarifying and tied-ridging methods but greater in ploughed plots, while the averages across tillage methods indicated higher accumulations in year of higher rainfall compared to lower rainfall year.

3.1.4. Mg variations

The quantities of Mg accumulated in the pearl millet stover produced in tied-ridging plots in 2018 and in ploughed plots in 2019 were the greatest (Table 2). In both years, the lowest accumulated quantities occurred in plots where scarifying or zaï methods were used. The averaged Mg accumulated in the pearl millet stover across tillage methods indicated no differences among years. However, averaged across years, results showed an additional accumulation from the use of tied-ridging which ranged from 1.23 to 1.68 kg compared to the other tillage methods.

3.2. Tillage x Fertilization effects and variations of macro-mineral P accumulated in pearl millet stover

Results showed that except for the F7 and F8 fertilizations that generated greater P accumulations in the pearl millet stover when these different fertilizations were applied in the zaï plots, no differences in the quantities of P accumulated were observed among the other fertilization levels across all tillage methods (Table 3). The application of F5 fertilization in the ploughed plots and F6 in the tied-ridging resulted in greater accumulations. In the scarified plots, no difference was observed among levels of fertilization. Variations in the quantities of P accumulated were observed from one level of fertilization to another for all tillage methods. However, in average, the use of zaï generated greater accumulations and that of scarifying lower accumulations. Averaged across tillage methods, results showed greater P accumulations in plots that received the fertilization levels F5, F6 and F7. Compared to the control F1, the increases in P accumulated in the stover due to these three fertilization levels ranged from 0.93 to 1.39 kg. Results also showed no differences in Zn accumulated in the stover across the two years of the study. Additional quantities of minerals accumulated in the stover due to the combination of compost and mineral fertilizers were observed ranging from 21 to 25% depending on the mineral fertilization level. This showed the benefit effect of compost.

Table 3 Tillage method (T) and Fertilization (F) interaction effect on the P accumulation in the pearl millet stover, Saria, Burkina Faso. [ANOVA probabilities: $P_{T*F} = 0.03$, $P_T = 0.94$, $P_F < 0.01$]

Fertilization	Tillage method					Contrast		
	Scarifying	Manual zaï	Ploughing	Tied-ridging	Mean	Type	P	AA- CP (%)
	---------------------------------- kg ha^{-1} -----------------------							
F1 = 100 kg ha^{-1} NPK-S-CaO + 50 kg ha^{-1} Urea (46 N)	1.64^{aA}	0.66^{cA}	1.49^{abA}	0.65^{bA}	1.11^{b}	MF vs MF+CP	< 0.01	
F2 = 150 kg ha^{-1} NPK-S-CaO + 100 kg ha^{-1} Urea (46 N)	1.05^{aA}	2.04^{bcA}	1.37^{bA}	1.29^{bA}	1.43^{b}	F1 vs F6	< 0.01	46
F3 = 150 kg ha^{-1} NPK-S-CaO + 100 kg ha^{-1} Urea 30	1.53^{aA}	1.27^{cA}	1.60^{abA}	1.63^{abA}	1.51^{b}	F2 vs F5	0.02	30
F4 = 100 kg ha^{-1} NPK-S-CaO + 50 kg ha^{-1} Urea 30	1.42^{aA}	1.06^{cA}	1.62^{abA}	1.13^{bA}	1.31^{b}	F3 vs F7	< 0.01	40
F5 = F2 + 5 t ha^{-1} compost	1.52^{aA}	2.46^{bA}	2.54^{aA}	1.67^{abA}	2.05^{a}	F4 vs F8	< 0.01	36
F6 = F1 + 5 t ha^{-1} compost	1.76^{aA}	2.00^{bcA}	1.77^{abA}	2.64^{aA}	2.04^{a}			
F7 = F3 + 5 t ha^{-1} compost	1.65^{aB}	3.92^{aA}	2.15^{abB}	2.29^{abB}	2.50^{a}			
F8 = F4 + 5 t ha^{-1} compost	1.83^{aAB}	2.72^{bA}	1.44^{bB}	2.16^{abAB}	2.04^{ab}			
Mean	1.55^{B}	2.02^{A}	1.75^{AB}	1.68^{AB}				

Note: Values followed by the same capital letter in the same row or small letter in the same column are not significantly different at $p \leq 0.05$; MF: Mineral Fertilizer; MF+C: Mineral Fertilizer + Compost; AA-CP: Additional accumulation due to compost; P: probability

3.3. Effects of fertilization and variations in macro-elements accumulated in pearl millet stover

The variations in the mineral accumulations clearly showed (1) a superiority of the K accumulated in the pearl millet stover in plots that received the fertilization levels F5 and F6 compared to the control F1, (2) a superiority of the Ca accumulated for all fertilization levels except for F1 (control) and F4 and (3) a superiority of the Mg accumulated when F6 and F7 were used in pearl millet production, compared to F1 control (Table 4). The differences in the quantities accumulated were 11 kg in F5 and 9 kg in F6 plots, from 1.45 to 2.15 kg for Ca depending on the fertilization levels, 2.49 kg in F6 plots and 2.52 kg in F7 plots for Mg. Additional quantities of minerals accumulated in the stover due to the combination of compost and mineral fertilizers were observed only in the plots that received the F6 fertilization, with an increase of 45% in the accumulated quantities.

Table 4 Main effect of fertilization (F) on the accumulations of K (kg ha^{-1}), Ca (kg ha^{-1}) and Mg (kg ha^{-1}) in the pearl millet stover, Saria, Burkina Faso. [ANOVA probabilities: K = 0.03; Ca = 0.04; Mg < 0.01]

	K				Ca				Mg			
	Contrast				Contrast				Contrast			
Fertilization	Mean	Type	P	AA-CP (%)	Mean	Type	P	AA-CP (%)	Mean	Type	P	AA-CP (%)
F1 = 100 kg ha^{-1} NPK-S-CaO + 50 kg ha^{-1} Urea (46 N)	15^{b}	MF vs MF+CP	0.05		2.97^{b}	MF vs MF+CP	0.05		3.03^{b}	MF vs MF+CP	< 0.01	
F2 = 150 kg ha^{-1} NPK-S-CaO + 100 kg ha^{-1} Urea (46 N)	23^{ab}	F1 vs F6	0.01	38	5.00^{a}	F1 vs F6	< 0.01	38	4.76^{ab}	F1 vs F6	< 0.01	45
F3 = 150 kg ha^{-1} NPK-S-CaO + 100 kg ha^{-1} Urea 30	22^{ab}	F2 vs F5	0.45	12	4.42^{a}	F2 vs F5	0.43	2	4.58^{ab}	F2 vs F5	0.35	11
F4 = 100 kg ha^{-1} NPK-S-CaO + 50 kg ha^{-1} Urea 30	18^{b}	F3 vs F7	0.72	5	3.99^{ab}	F3 vs F7	0.86	2	4.23^{b}	F3 vs F7	0.14	17
F5 = F2 + 5 t ha^{-1} compost	26^{a}	F4 vs F8	0.09	24	5.12^{a}	F4 vs F8	0.13	19	5.36^{ab}	F4 vs F8	0.06	22
F6 = F1 + 5 t ha^{-1} compost	24^{a}				4.81^{a}				5.55^{a}			
F7 = F3 + 5 t ha^{-1} compost	23^{ab}				4.52^{a}				5.52^{a}			
F8 = F4 + 5 t ha^{-1} compost	23^{ab}				4.91^{a}				5.42^{ab}			

Note: Values followed by the same letter in the same column are not significantly different at p ≤ 0.05; MF: Mineral Fertilizer; MF+C: Mineral Fertilizer + Compost; AA-CP: Additional accumulation due to compost; P: probability

3.4. Correlations

Pearson correlations showed that the stover yield reported by Palé *et al.* [16] was positively associated with quantities accumulated in the stover for all minerals (P ≤ 0.01).

3.5. Averages for minerals accumulated in pearl millet stover

The results showed that the quantities of minerals accumulated in the pearl millet stover produced in the present study were lower than those reported by previous investigators (Table 5). The pearl millet stover yields reported by these researchers appeared to be much greater (163 to 301%) than the yield obtained in the present study. The quantities of accumulated minerals which are related to yields were higher by 128 to 497% for N, 314 to 1417% for P, 196 to 796% for K, 723% for Ca, 811% for Mg, 190 to 860% for Zn.

Table 5 Pearl millet yields and minerals accumulated in stover for different locations

Author	Yield	N	P	K	Ca	Mg	Zn	Fe
	--kg ha^{-1}--							
Present study	2 822	16.72	1.75	21.43	4.46	4.85	0.10	0.72
Kadivala *et al.* (2018)	4 595	-	-	-	-	-	0.08	0.47
Choudhary *et al*. (2019)	-	51.1	15.0	106.2	-	-	-	-
Giana *et al.* (2017)	4 851	21.46	5.50	-	-	-	-	-
Kumar and Singh (2019)	8 132	47.33	7.90	149.78	-	-	0.86	-
Singh (2019)	8 491	40.76	7.66	160.74	-	-	-	-
Chauhan *et al.* (2017)	8 322	43.85	10.80	170.63	-	-	-	-
Nwajei *et al.* (2018)	8 478	306.85	24.79	357.63	32.24	39.32	0.19	-
Nuraddeen *et al.* (2020)	6 561	49.65	18.08	42.01	-	-	-	-

4. Discussion

The quantities of minerals accumulated in the pearl millet stover reported by previous researchers clearly indicate that the accumulated quantities are closely related to the stover yields that depend on soil fertility management practices [18, 19, 20, 21, 22], soil water and nutrient management [4], environment and soil nutrient management [22] and the cropping system combined with soil fertility management [23]. Only the quantity of Zn compared to that reported by Kadivala *et al.* [20] and Fe showed superiority. The late planting dates in this study might have affected the pearl millet biomass production, thus leading to low quantities of minerals accumulated. Nevertheless, the reported quantities for nitrogen and potassium reported by Nawajei *et al.* [24] seem "eccentric".

The results showed the great importance of the addition of quantitative and qualitative compost to quality mineral fertilizer on the pearl millet stover yields [16, 25] and the quantities of accumulated minerals. Many authors [22, 26, 27, 28, 29, 30, 31] reported that improving soil fertility by adding sufficient amounts of quality mineral and organic fertilizers such as compost substantially improved the uptake of nutrients such as N, P and K. Hussain *et al.* [32] also indicated that the growth stage of the plant and the environmental conditions of production are factors that greatly influence the uptake of nutrients from the soil. Bationo *et al.* [32] indicated that the plant species and the interrelation between the plant and soil nutrients influence the uptake and accumulation of minerals in the plant.

Results showed greater quantities of minerals accumulated in the stover from ploughed, tied-ridging plots and zaï plots. Divya *et al.* [33] reported that water stress was one of the main factors limiting pearl millet yields. The use of ploughing, tied-ridging and zaï methods that limit water stress had increased stover yields [16] and consequently the quantities of accumulated minerals in this pearl millet stover.

On the other hand, though the quantities of minerals accumulated depend on the yields, it should be noted that the values of N and K reported by Nawajei *et al*. [24] seemed "eccentric" and require additional investigations to characterize the pearl millet environment (especially soil) for its production and therefore a better understanding of these N and P values. The results also showed that little emphasis is placed by researchers on the accumulation of minerals such as calcium, magnesium, zinc and iron.

5. Conclusion

Effects of tillage and organo-mineral fertilization on the accumulations of minerals in the pearl millet stover were assessed. The addition of compost to the different mineral fertilizer levels has revealed the great benefit of the combinations, thus making it possible to obtain additional quantities of accumulated minerals in the stover that ranged from 30 to 46% depending on the mineral fertilizer level applied.

Results clearly demonstrated that ploughing and scarifying were more favorable for greater and not varying accumulations across years compared to manual zaï and tied-ridging. The quantities of minerals accumulated in pearl millet stover were affected by tillage and fertilization as well as by their interactive effect.

The quantities of minerals accumulated in the pearl millet stover, which is closely related to yields, appeared to be lower in the present investigation, compared to those reported in previous studies. These results indicated that better water management and nutritional conditions be used in pearl millet production to expect an increase in its biomass and greater quantities of minerals accumulated in the stover which can be used to supplement cattle diets.

Compliance with ethical standards

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Disclosure of conflict of interest

- All authors have reviewed the manuscript and approved its submission to the World Journal of Advanced Research and Reviews (WJARR).
- The manuscript is not submitted elsewhere.

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