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Organic, Mineral and Organo-mineral Fertilization and Agronomic Performance of Chilli Pepper (*Capsicum chinense* Jacq.) in the Semi-arid Burkina Faso

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Abstract

The chilli pepper (*Capsicum chinense* Jacq.) is a highly prized and widely consumed vegetable throughout the world. In Burkina Faso, its production remains marginal, despite its numerous agronomic and economic potential. The aim of the study was to assess the effect of organic, mineral and organo-mineral fertilization on the agronomic performance of chilli pepper. A trial was conducted in a completely randomized block design with four treatments (Compost = 16 t/ha Compost; Compost+NPK = 8 t/ha +100 kg/ha; NPK = 200 kg/ha; and Absolute control) and four replications. Morphological, physiological, phytosanitary and harvesting parameters were assessed. The results showed that the treatments did not induce any significant difference in the physiological parameters. The NPK significantly reduced the number of harvested plants by 87 % compared with the Absolute control ($p \leq 0.01$). NPK treatment significantly ($p < 0.05$) improved plant collar diameter by 41 %; number of fruits harvested by 73 %; number of yellow fruits harvested by 74 %; number of fruits harvested per number of plants harvested by 57 %; fruit length by 25 %; and fruit yield by 70 % of chilli pepper compared with the Absolute control. The Compost treatment significantly increased the number of perforated fruits by 79 % compared with the control. Thus, compared with other treatments, mineral fertilization (200 kg/ha of NPK) was more effective of the best agronomic performance of chilli pepper.

Keywords: Compost; NPK; Organo-mineral fertilization; Chilli pepper; Agronomic performance; Burkina Faso

Introduction

Vegetable gardening, defined as highly specialized agriculture, plays an important role in human nutrition and is one of the most productive agricultural systems in Africa [1]. Today, it helps reduce unemployment in rural areas during the dry season. Indeed, market gardening helps combat poverty [2]. Vegetable crops also play a key role in most nutrition and poverty reduction programs, and contribute significantly to family income [3,4]. This agricultural activity of vegetable and fruit production ensures the production of a highly diversified range of speculations [3,5,6].

Of all the vegetable speculations produced in Burkina Faso, chili pepper, the most widely consumed spice in the world, is also grown mainly in the Cascades, Centre-Sud, Plateau Central and North [7]. Chilli pepper is grown all over the world especially in tropical and subtropical regions [8].

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It offers numerous ecological, nutritional, pharmaceutical and economic benefits. It is regarded as one of the leading commercial spices. Thanks to its bioactive components, chilli pepper has a number of pharmacological properties that are highly beneficial to health [9]. *C. chinense* extracts have antifungal and antiviral properties [10]. Red chilli pepper contains vitamins C, B1, B2, calcium (Ca), phosphorus (P) and alkaline compounds such as capsaicin, which are quite high compared with other vegetables [11]. Vitamin C levels are higher in fresh green chilli pepper than in citrus fruits [8]. In ecological terms, chilli pepper is used as a pesticide to counter the use of synthetic pesticides. Asare et al. [12] highlighted the ability of Capsicum sp. to minimize the severity of whitefly virosis and. Also, Fening et al. [13] showed that *Capsicum chinense* extract has a typical effect on cabbage and bean pests compared with emamectin and a binary pesticide. In economic terms, chilli pepper cultivation generates enormous income for thousands of families. However, for good growth, chilli pepper requires well-drained soil rich in organic matter [14]. Indeed, phosphorus-rich organic fertilizer is an indispensable element needed by the chilli pepper plant to increase its capacity to produce fruit [15]. It is also demanding in terms of potassium and nitrogen, which are supplied at different rates depending on the plant's growth [16,17]. Indeed, application of 180-40 kg N-K_2O ha^{-1} are recommended for better growth and yield of chillies [18]. The varieties cultivated and marketed are *Capsicum annum*, *Capsicum frutescens* and *Capsicum chinense*. To meet the world's ever-increasing demand, fertilization appears to be one of the answers to increasing production. Indeed, yields can be increased through the use of various organic and/or inorganic fertilizers that provide the necessary nutrients required by plants for their growth [19]. Fertilizers (organic or inorganic) are necessary to supplement one or more nutrients essential for plant growth and development. In Burkina Faso, research results on the fertilization of chillies remain little or under-documented. It was with this in mind that the present study was conducted. The objective of the study is to contribute to the improvement of pepper production under organic, mineral and organo-mineral fertilization.

Materials and Methods

Study site

The study was conducted in Tenkodogo (Boulgou province, Centre-Est region, Burkina Faso). The geographical coordinates of the study site are 11°49'2.71812" N and 0°22'42.80412" W. The trial was conducted from July to October 2023. Temperatures generally range from 18°C to 39°C. The hot season runs from February to May, with an average maximum temperature of over 37°C. The hottest month is April. The coldest month is January, with an average minimum temperature of 19°C and a maximum of 33°C. The wettest month is August. Annual rainfall ranges from 750 to 1,000 mm (for more information, see: https://fr.weatherspark.com).

The number of rainy days was 1 in April and 13 in August, considering only rainy months. The main plant species encountered are: *Vitellaria paradoxa* C.F. Gaertn., *Borassus aethiopium* Mart., *Lannea microcarpa* Engl. et K. Krause, *Andasonia digitata* L., *Tamarindius indica* L., and *Andropogon gayanus* Kunth [20].

The commune has a flat topography, and most of the area (central and western) is covered by ferruginous and leached soils, poor in calcium, potassium and phosphorus, with low water retention capacity. Soils are generally heterogeneous in structure and texture, ranging from sandy to gravelly.) According to the World Reference Base for Soil Resources [21], the soil groups encountered include: *Leptic Leptosols*, *Epipetric Plinthosols*, *Endopetroplinthic Lixisols*, *Haplic* or *Vertic Cambisols*, *Umbric Gleysols*, *Hypereous* or *Mazic Vertisols.*

Fertilizers and plant material

The NPK mineral used fertilizer was formula 14-23-14. Compost was a mixture of cow dung, pig dung and plant debris stored in a basin for a few months. The organic and chemical characteristics of the compost are given in Table (1).

Table 1: Organic and chemical characteristics of compost.

Parameters	Units	Values
Total Organic matter	%	48.14
Total Carbone (C)	%	27.92
Total Nitrogen (N)	%	1.81
C/N		15
N-NH_4^+	mg/kg	171.91
N-NO_3^-	mg/kg	58.75
Mineral Nitrogen (N-NH_4^++ N-NO_3^-)	mg/kg	230.67
Total Phosphorus	%	2.84
Available Phosphorus	g/kg	20.22
Total Potassium	%	2.28
Available Potassium	g/kg	21.12

N-NH_4^+ = ammoniacal nitrogen; N-NO_3^- = nitrate nitrogen

The *Capsicum chinence* species (Jaune de Burkina Faso), a chili pepper with more or less conical fruits, was used as plant material. It is a local variety prized by Burkina Faso populations. The nursery phase lasted two months. The variety has a transplanting-maturity cycle of 120 days, with a potential yield of 12.4 t/ha.

Experimental design and treatments

The experimental design consisted of four completely randomized Fischer blocks, with 4 treatments per block repeated 4 times. The treatments were:

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- Compost: 16 t/ha of compost;
- Compost+NPK: 8 t/ha of comost+100 kg/ha of NPK;
- NPK: 200 kg/ha of NPK;
- Absolute control: controls without any fertilizers.

In total, the system consisted of 16 elementary plots. The dimensions of each elementary plot were 4 m long and 1.5 m wide. The distance between blocks and plots was 0.5 m. Each elementary plot was delimited by ridges. The total surface area was 171 m^2.

Crop management

On July 05, 2023, the area was delimited by manual weeding and ploughing. Compost was applied by spreading, followed by burial and watering. The chilli seedlings were transplanted one per planting on July 11, 2023, i.e., four days after the compost was applied, with a spacing of 40 cm on the row and between rows. There was a total of ten plants per line, i.e. forty plants per elementary plot. A total of 640 plants were transplanted. NPK was applied two weeks after transplanting by spreading followed by burial.

Several manual weeding operations were carried out, depending on the level of weed cover, to minimize weed competition with the chilli plants. Hoeing was also carried out every two weeks. Insecticide treatments to reduce pathogen damage were used only once, and usually when all plots were attacked. These included bioprotect and acarus at 25 ml per 16 l, both of which are registered.

Bioprotect is a 100 % natural, eco-friendly biostimulant whose active ingredient is a blend of neem and azadiracntin essential oils. These essential oils are insect repellents. Bioprotect was sprayed once. Thirty-five days later, an acarus-based spray was applied. With acaricide as its active ingredient, acarus is a chemical compound specifically designed to eliminate acarids.

Agronomic data collection

Data were collected on morphological, physiological and phytosanitary parameters, as well as on chilli pepper harvesting. A summary of the various parameters is given in Table 2.

Table 2: Summary of agronomic chilli pepper parameters evaluated.

Agronomic Parameters	Meanings and definitions	Measurement instruments
Morphological parameters		
PH (cm)	Plant height (five plants concerned): The height of each plant is measured from ground level to the highest leaf on the plant.	Graduated ruler
PD (mm)	Plant collar diameter: measured at the base of the main stem of each of the five plants concerned.	Caliper with 0.001 precision
NB	Number of branches (five plants): count the of branches of each of the five plants.	-
NL	Number of leaves: count the leaves of each of the five plants.	-
NFL	Number of flowers: count the flowers of each of the five plants.	-
NP	Number of plants for growing stage	
Physiological parameters		
RR (%)	Recovery rate of plants assessed 15 days after transplanting out of the number of seedlings transplanted per plot.	-
NDFL (days)	Number of days from transplanting to appearance of first flower per elementary plot.	-
NDPL 50 (days)	Number of days from transplanting to flowering of 50% of plants per elementary plot.	-
NDFR (days)	Number of days from transplanting to appearance of first fruit per elementary plot.	-
NDFR 50 (days)	Number of days from transplanting to fruiting of 50% of plants per elementary plot.	-
Phytopathological parameters		
NPL	Number of perforated plant leaves: counted by elementary plot.	-
NDP	Number of diseased plants: counted by elementary plot.	-
NRFR	Number of rotten fruits harvested: counted per elementary plot.	-
NPFR	Number of perforated fruits harvested: counted by elementary plot.	-
Harvesting parameters		
NFR	Number of fruits at harvested: counted by elementary plot.	-
NHP	Number of harvesting plants: counted by elementary plot.	-
NGFR	Number of green fruits harvested: counted by elementary plot.	-
NYFR	Number of yellow fruits harvested: counted by elementary plot.	-
LFR (mm)	Length of 10 fruits: the length of 10 randomly selected fruits measured among the fruits harvested in the elementary plot.	Caliper with 0.001 precision
WFR (mm)	Width of 10 fruits: the width of 10 randomly selected fruits measured among the fruits harvested in the elementary plot.	Caliper with 0.001 precision
FRY (kg/ha)	Fruit yields at harvest.	

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Statistical analysis

The EXCEL 2021 software was used to enter and process the data, and to produce the graphs. The Shapiro-Wilk test was used to test the normality of the data. An analysis of variance (ANOVA) and a Tukey HSD test of separation of means at the 5% significance level were performed on chilli pepper agronomic parameters at harvest according to treatments. XLSTAT 4.1 (ADDINSOFT, 2023) was used for this analysis.

Results

Effect of treatments on chilli pepper morphological performance

Table 3 shows the effect of treatments on plant height (PH), plant collar diameter (PD), number of branches (NB), number of leaves (NL), number of flowers (NFL) and number of fruits (NFR) of chili pepper. Analysis of variance (ANOVA) at 5 % significance level showed that there was no significant difference between the mean values of morphological parameters according to the different treatments, except for plant diameter.

PH varied from 23.73 ± 4.00 cm under the Compost+NPK treatment to 33.39 ± 4.00 cm under the NPK treatment. Increases of 21 % and 16 % were recorded under the NPK and Compost treatments respectively, compared with the Absolute control.

PD ranged from 8.90 ± 1.72 mm under the Compost+NPK treatment to 15.46 ± 1.72 mm under the NPK treatment. A significant ($P < 0.05$) 41 % increase in DP was obtained under NPK treatment compared with the Absolute control. A non-significant reduction of 22% was recorded under compost application compared with the Absolute control.

NB varied from 5.07 ± 1.02 under Compost+NPK treatment to 8.80 ± 1.02 under NPK treatment. Increases of 34 % and 25 % were recorded under the NPK and Compost treatments respectively, compared with the Absolute control.

NL fluctuated from 271.60 ± 83.76 under T0 to 500.60 ± 83.76 under NPK. Increases of 10 %, 46 % and 33 % were recorded under the Compost+NPK, NPK and Compost treatments respectively, compared with the Absolute control.

NFL ranged from 6.20 ± 3.84 under the Compost+NPK treatment to 19.73 ± 3.84 under the NPK treatment. Increases of 21 % and 60 % were obtained under the compost and NPK treatments respectively, compared with the Absolute control.

NFR ranged from 4.47 ± 3.98 under T0 to 11.33 ± 3.98 under Compost+NPK. Increases of 50 %, 58 % and 61 % were recorded under the NPK, Compost and Compost+NPK treatments respectively, compared with the Absolute control.

Table 3: Effects of treatments on chilli pepper morphological performance.

Treatments	PH (cm)	PD (mm)	NB	NL	NFL	NFR
Absolute control	26.27±4.00a	9.08±1.72ab	5.80±1.02a	271.60±83.76a	7.87±3.84a	4.47±3.98a
NPK	33.39±4.00a	15.46±1.72b	8.80±1.02a	500.60±83.76a	19.73±3.84a	8.93±3.98a
Compost	31.08±4.14a	11.13±1.78ab	7.71±1.06a	404.64±86.70a	8.29±3.98a	10.71±4.12a
Compost+NPK	23.73±4.00a	8.90±1.72a	5.07±1.02a	301.67±83.76a	6.20±3.84a	11.33±3.98a
P Significance	0.318 NS	0.033 S	0.050 NS	0.213 NS	0.062 NS	0.617 NS

Absolute control: controls without any fertilizers; NPK: 200 kg/ha; Compost: 16 t/ha; Compost+NPK: 8 t/ha +100 kg/ha; HP: Plant height; DP: Plant collar diameter; NB: Nnumber of branches; NL: Number of leaves; NFL: Number of flowers; NFR: Number of fruits; P = probability according to ANOVA at 5 % significance level. Means ± standard errors of the same column with the same letter do not differ significantly according to the Tukey HSD test at the 5% significance level. $P < 0.05$: significant (S). $P \geq 0.05$: not significant (NS).

Table 4: Effects of treatments on chilli pepper physiological parameters.

Treatments	RR (%)	NDFL (days)	NDFL (50 days)	NDFR (days)	NDFR (50 days)
Absolute control	100±0.38	50.00±1.23	63.00±2.08	61.00±1.33	78.67±6.50
NPK	100±0.38	48.00±1.23	60.33±2.08	58.00±1.33	71.00±6.50
Compost	99±0.47	51.00±1.51	60.50±2.55	61.50±1.62	69.00±7.96
Compost+NPK	100±0.38	52.00±1.23	62.00±2.08	61.33±1.33	78.33±6.50
P	0.217	0.223	0.793	0.303	0.69
Significance	NS	NS	NS	NS	NS

Absolute control: controls without any fertilizers; NPK: 200 kg/ha; Compost: 16 t/ha; Compost+NPK: 8 t/ha +100 kg/ha ; RR: Recovery rate of plants assessed 15 days after transplanting; NDFL: Number of days from transplanting to appearance of first flower; NDFL50: Number of days from transplanting to flowering of 50% of plants; NDFR: Number of days from transplanting to appearance of first fruit; NDFR50: Number of days from transplanting to fruiting of 50 % of plant; P = probability according to ANOVA at 5% significance level. $P \geq 0.05$: not significant (NS).

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Effects of treatments on chilli pepper physiological parameters

Table 4 shows the effects of treatments on the number of plants started at 14 days after transplanting (RR); number of days from transplanting to appearance of first flower (NDFL); number of days from transplanting to flowering of 50 % of plants (NDFL50); Number of days from transplanting to appearance of first fruit (NDFR); number of days from transplanting to fruiting of 50 % of plants (NDFR50). Analysis of variance (ANOVA) at 5 % significance level showed that there was no significant difference between the means values of the physiological parameters according to the different treatments.

RR ranged from 99 ± 0.47 % under the compost treatment to 100 ± 0.38 % under the Absolute control, Compost and Compost+NPK treatments. Increases of 0.01% were recorded under the compost treatments respectively, compared with the Absolute control.

NDFL ranged from 48.00 ± 1.23 days under the NPK treatment to 52.00 ± 1.23 days under the Compost+NPK treatment. A 2-day reduction in NDFL was recorded under the NPK treatment compared with the Absolute control.

NDFL50 varied from 60.33 ± 2.08 days under NPK treatment to 63.00 ± 2.08 days under the Absolute control. Increases of 2, 3 and 3 days in NDFL50 were recorded under the Compost+NPK, Compost and NPK treatments respectively, compared with Absolute control.

NDFR varied from 58.00 ± 1.33 days under the NPK treatment to 61.50 ± 1.62 days under the Compost treatment. A 3-day reduction in NDFR was obtained under the NPK treatment compared with Absolute control.

NDFR50 fluctuated between 69.00 ± 7.96 days under the compost treatment and 78.67 ± 6.50 days under the Absolute control. Reductions of 7 and 9 days in NDFR50 were recorded under the NPK and Compost treatments respectively, compared with the Absolute control.

Effects of treatments on chilli pepper phytopathological parameters

The effects of treatments on chilli pepper phytopathological parameters such as number of perforated leaves over number of leaves (NPL/NL); number of diseased plants over number of plants at growing stage (NDP/NP); number of rotten fruits (NRFR); number of perforated fruits (NPFR); are recorded in Table 5. With the exception of NPFR, no significant difference was observed between the means of the phytopathological parameters of chilli according to treatment (P > 0.05).

NPL/NL fluctuated between 0.42 ± 0.51 under the compost treatment to 1.21 ± 0.42 under the Compost+NPK treatment. Increases of 37 % and 36 % in NPL/NL were recorded under NPK and compost treatments respectively, compared with the Absolute control. A 55 % reduction was obtained under the Compost+NPK treatment compared with the Absolute control.

NDP/NP ranged from 4.22 ± 0.34 under the Compost+NPK treatment to 5.11 ± 0.42 under the compost treatment. Increases of 2 % and 17 % in NDP/NP were recorded under the NPK and Compost+NPK treatments respectively, compared with the Absolute control. A reduction of 0.6 % was obtained under the compost treatment compared with the Absolute control.

NRFR ranged from 4.29 ± 1.67 under T0 to 8.40 ± 1.62 under NPK. Reductions of around 90%, 69% and 96% in NRFR were obtained under the Compost, Compost+NPK and NPK treatments respectively, compared with the Absolute control.

NPFR ranged from 0.50 ± 0.48 under the T0 treatment to 2.40 ± 0.46 under the Compost treatment. A significant increase (P < 0.05) of 79 % in NPFR was obtained under the Compost treatment compared with the Absolute control. Non-significant increases of 74 % and 72 % in NPFR were recorded under the NPK and Compost+NPK treatments respectively, compared with the Absolute control.

Table 5: Effects of treatments on phytopathological parameters of chilli pepper.

Treatments	NPL/ NL	NDP/ NP	NRFR	NPFR
Absolute control	0.78±0.42a	5.08±0.34a	4.29±1.67a	0.50±0.48a
NPK	0.49±0.42a	4.99±0.34a	8.40±1.62a	1.93±0.46ab
Compost	0.42±0.51a	5.11±0.42a	8.13±1.62a	2.40±0.46b
Compost+NPK	1.21±0.42a	4.22±0.34a	7.27±1.62a	1.80±0.46ab
P Significance	0.605 NS	0.305 NS	0.287 NS	0.044 S

Absolute control: controls without any fertilizers; NPK: 200 kg/ha; Compost: 16 t/ha; Compost+NPK: 8 t/ha +100 kg/ha; NPL: Number of perforated leaves; NL: Number of leaves; NDP: Number of diseased plants; NP: Number of plants for growing stage; NRFR: Number of rotten fruits; NPFR: Number of perforated fruits; P = probability according to ANOVA at 5% significance level. Means ± standard errors of the same column with the same letter do not differ significantly according to the Tukey HSD test at the 5% significance level. P < 0.05: significant (S); P ≥ 0.05: not significant (NS).

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Effects of treatments on chilli pepper yield at harvest

Treatment effects on chilli pepper yield at harvest, such as number of harvested plants (NHP); number of fruits at harvested (NFR); number of green fruits harvested (NGFR); number of yellow fruits harvested (NYFR); number of fruits harvested over number of plants harvested (NFR/NHP); length of fruits (LFR); width of fruits (WFR); and fruits yields (FRY) are reported in Table 6. ANOVA shows significant differences between mean values of chilli pepper yield parameters across treatments, except for NGFR and WFR.

NHP fluctuated between 14.93 ± 2.41 under the Absolute control and 27.93 ± 2.50 under the NPK treatment. Reductions of 49 % and 31 % in NHP were recorded under the Compost and Compost+NPK treatments respectively, compared with the Absolute control. A significant 87 % ($p \leq 0.01$) reduction in NPRE was recorded under NPK treatment compared with the Absolute control.

NFR ranged from 73.87 ± 46.83 under the absolute control to 276.50 ± 48.48 under NPK treatment. Non-significant increases of 68 % and 54 % in NFR were obtained under the Compost and Compost+NPK treatments respectively, compared with the absolute control. A significant increase of 73 % ($P < 0.05$) in NFR was obtained under the NPK treatment compared with the Absolute control.

NGFR ranged from 7.53 ± 3.50 under the Absolute control to 20.33 ± 3.50 under Compost treatment. Non-significant increases of 56 %, 63 % and 46 % in NGFR were recorded under NPK, Compost and Compost+NPK treatments respectively, compared with Absolute control.

NYFR ranged from 66.33 ± 44.10 under the Absolute control to 259.36 ± 45.65 under NPK. A significant 74 % ($p < 0.05$) increase in NYFR was obtained under NPK treatment compared with T0. Non-significant increases of 65 % and 55 % in NYFR were recorded under the Compost and Compost+NPK treatments respectively, compared with the Absolute control.

NFR/NHP fluctuated between 3.91 ± 1.16 under the Absolute control and 9.03 ± 1.20 under the NPK treatment. A significant increase of 57% ($p<0.05$) in NFR/NHP was recorded under NPK treatment compared with the Absolute control. Non-significant increases of 53 % and 39 % in NFR/NHP were obtained under the compost and Compost+NPK treatments respectively, compared with the Absolute control.

LFR ranged from 30.78 ± 1.95 mm in the Absolute control to 38.51 ± 2.20 mm in the NPK treatment. Non-significant reductions of 19 % and 20 % of LFR were obtained under the Compost and Compost+NPK treatments respectively, compared with the Absolute control. A significant 25 % ($p < 0.05$) reduction in LFR was recorded under the NPK treatment compared with the Absolute control.

WFR ranged from 15.39±0.85 mm under the Absolute control to 17.51 ± 0.88 mm under NPK. Non-significant reductions of 14 %, 11 % and 10 % in WFR were recorded under the respective NPK, Compost and Compost+NPK treatments compared with the Absolute control.

FRY ranged from 286.11 ± 176 kg/ha under the Absolute control to 958.33 ± 182.18 kg/ha under the NPK treatment. A significant increase of 70 % ($p < 0.05$) in FRY was obtained under NPK treatment compared with the Absolute control. Non-significant increases of 69 % and 57 % were recorded under the Compost and Compost+NPK treatments respectively, compared with the Absolute control.

Discussion

This work investigated the effects of Compost, NPK and the Compost+NPK combination on morphological, physiological, phytosanitary parameters, yield attribute and yield of chilli pepper in semi-arid zone of Burkina Faso. The results of the analyses revealed a significant difference between treatments on the growth in diameter of chilli pepper plants. Indeed, the largest diameters were observed under the NPK

Table 6: Effects of treatments on chilli pepper yield at harvest.

Treatments	NHP	NFR	NGFR	NYFR	NFR/ NHP	LFR (mm)	WFR (mm)	FRY (kg/ha)
Absolute control	14.93±2.41a	73.87±46.83a	7.53±3.50a	66.33±44.10a	3.91±1.16a	30.78±1.95a	15.39±0.85a	286.11±176.00a
NPK	27.93±2.50b	276.50±48.48b	17.14±3.63a	259.36±45.65b	9.03±1.20b	38.51±2.20b	17.51±0.88a	958.33±182.18b
Compost	22.27±2.41ab	231.67±46.83ab	20.33±3.50a	191.33±44.10ab	8.36±1.16ab	36.68±1.95ab	17.06±0.85a	926.33±176.00ab
Compost+NPK	19.60±2.41ab	161.93±46.83ab	13.87±3.50a	147.93±44.10ab	6.36±1.16ab	36.88±1.95ab	16.87±0.85a	659.00±176.00ab
P Significance	0.005 TS	0.022 S	0.076 NS	0.028 S	0.014 S	0.041 S	0.345 NS	0.035 S

Absolute control: controls without any fertilizers; NPK: 200 kg/ha; Compost: 16 t/ha; Compost+NPK: 8 t/ha +100 kg/ha; NHP: Number of harvested plants; NFR: Number of fruits at harvested; NGFR: Number of green fruits at harvested; NYFR: Number of yellow fruits at harvested; LFR: length of fruit; WFR: width of fruit; FRY: Fruit yields. P = probability according to ANOVA at 5% significance level. Means ± standard errors of the same column with the same letter do not differ significantly according to the Tukey HSD test. $P < 0.05$: significant (S); $P \leq 0.01$: very significant (TS); $P \geq 0.05$: not significant.

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treatment. Our results are in line with those of Ganeshnauth et al. [22] who showed that NPK (14-23-14) has a significant effect on chilli pepper stem diameter. Also, the application of the treatments revealed no significant difference on the physiological parameters of the chilli pepper which translates that the chilli pepper remains physiologically insensitive to these treatments.

The Compost fertilization alone significantly increased the number of perforated fruits compared with the Absolute control. This is due to the fact that pests such as insects would have caused large numbers of the chilli pepper fruits to be perforated. Insects such as aphids and caterpillars perforate chilli fruits to feed [23]. A high level of available potassium (21.12 g kg^{-1} or 337.92 kg ha^{-1}) in the compost could also explain the appearance of perforated fruits. An imbalance between calcium and potassium in the compost would have led to an excessive accumulation of potassium in chilli pepper fruit tissues. Cell walls then become weak and more susceptible to fungal and bacterial infection [24].

Results showed that NPK treatment significantly improved the number of plants harvested, the number of fruits harvested, the number of yellow fruits harvested, average fruit length and fruit yield. In fact, the nitrogen, phosphorus and potassium contained in the mineral fertilizer (NPK 14-23-14) are available and easily assimilated by the plants partly explains these results. Ganeshnauth et al. [22] also showed the significant effect of chemical fertilizer (NPK 14-23-14) on diameter and yield of chilli pepper fruits. They highlight the important roles of the main elements (Nitrogen, Phosphorus, and Potassium). Nitrogen is an essential component of nucleic acids, enzymes, proteins and chlorophyll in plants [25,26]. It is therefore essential for crop growth and development. Nitrogen is therefore one of the nutrients that plants need to achieve high yields. Work carried out on tomatoes in Burkina Faso by Bories and Marguerie [27] reveals that nitrogen promotes strong early growth, guarantees sustained growth during vegetative growth, maintains plant growth and optimizes fruit formation. Also, phosphorus catalyzes carbohydrate synthesis and phosphorylation. It is not only a factor in resistance to cold and pests, but also in early flowering and fruiting [28]. Otherwise, potassium promotes the synthesis and accumulation of carbohydrates, and limits transpiration by increasing tissue rigidity [29]. Potassium also plays a role in starch formation, activates enzymes, promotes physiological and metabolic processes in cells and increases resistance to drought and disease [30,31]. Potassium therefore contributes to disease resistance, water regulation and fruit quality. Furthermore, it also emerges from the results of Adhikari et al. [32], that chemical fertilizers promoted a good yield similar to other treatments but were slow in flowering and fruiting. Our results corroborate those of the latter authors, as NPK significantly increased chilli fruit yield, but did not have a significant effect on the number of flowers and on the evolution of chilli fruiting.

The results also showed that the Compost treatment had no significant effect on the morphological and physiological parameters of the pepper, and on yield at harvest. This is due to the low mineralization of Compost. Indeed, only 15 % of nitrogen is transformed during the first year, suggesting that compost mineralization takes a long time [33]. Also, the Compost+NPK association did not improve the morphological and physiological parameters of the pepper, and yield at harvest. These results showed that the interaction effect between the organic amendment illustrated here by Compost and the mineral fertilizer (NPK) is not expressive in the first year of application. This lack of interaction effect could be linked to the quality of the organic fertilizer applied, as indicated by [34]. Contrary to this study, Hassan et al. [35] showed that a high level of poultry manure in combination with lower level of NPK (33% NPK + 67% PM) had the best performance in terms of growth and fruit yield of bell pepper

Conclusion

This study aimed to highlight the effect of organic, mineral and organo-mineral fertilization on the agronomic parameters of chilli pepper (*Capsicum chinense*). It was found that the different fertilizers had different effects on the parameters studied. The 200 kg/ha NPK treatment was effective in improving morphological and harvesting parameters. The NPK treatment produced a higher yield than the other treatments. It was the most effective fertilizer in terms of improving pepper yields. Also, none of the treatments had any significant effect on chilli pepper physiological parameters. In the future, it would be interesting to carry out a physico-chemical characterization of the soils prior to harvesting to determine the levels of essential elements (nitrogen, phosphorus and potassium), in order to determine the most appropriate inputs; and to assess the residual fertility of the soils according to the treatments, in order to determine the most suitable soil-improving treatment.

Declaration of Interest Statement

The authors declare no competing interest.

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