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Effect of combinations organic and mineral fertilizers on the growth and productivity performance of two sesame (*Sesamum indicum* L.) varieties grown in Burkina Faso

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Abstract

In Burkina Faso, 85% of soils are leached tropical ferruginous soils with concretions, poor in organic matter, nitrogen, phosphorus and potassium. This soil poverty significantly reduces crop productivity. The aim of this study was to evaluate the effect of organic and mineral fertilizer combinations on the growth and productivity performance of sesame varieties (S-42 and Humera). The study was carried out in the field at Ipelcé, 45 km south of the capital Ouagadougou. The experimental set-up was a randomized complete blocks design with three replications. The variety factor (S-42 and Humera) and the soil fertilization factor (F0: 0 fertilizer, control); F1: cattle manure compost (7.5 t/ha); F2: mulched hen droppings (1.5 t/ha); F3: cattle manure compost (2.5 t/ha) + mulched hen droppings (1 t/ha); F4: cattle manure compost (5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F5: Mulched hen droppings (0.75 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F6: Cattle manure compost (1.25 t/ha) + mulched hen droppings (0.5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F7: NPK (100 kg/ha) + Urea (50 kg.ha^{-1}) were studied. The results showed that the F5 and F6 combinations significantly improved the growth and development of the two sesame varieties (S-42 and Humera), but even more so in Humera. The Humera variety had the highest above-ground dry biomass (61.54g) under F6 and the highest root dry biomass (14.90g) under F5. The S-42×F6 interaction produced the highest number of capsules (101.33 capsules/plant). The Humera×F6 combination produced more seeds (71.42 seeds/capsule). For 1000-seed weight, the Humera variety with fertilization F5 and F6 recorded the highest weight (3.22 g). For seed yield, the Humera×F5 combination (20.03 g/plant or 3324.59 kg/ha) recorded the highest values. Thus, the F5 and F6 combinations were the best fertilizers for the growth, development and production of both varieties (S-42 and Humera), but even more so for the Humera variety. The F5 and F6 combinations and the Humera variety are therefore recommended.

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Introduction

Burkina Faso's main source of food and income, agriculture employs over 80% of the population. This agriculture is mainly based on cereals, which annually occupy more than 88% of sown areas and constitute the staple diet of most of the population (Africa Fertilizer, 2018). These crop productions are almost exclusively extensive, and are mainly practiced on family farms, dominated by small farms of 3 to 6 ha maximum, poorly mechanized and modern farms under construction (Africa Fertilizer, 2018). A highly profitable cash crop, Sesame is Burkina Faso's third-largest agricultural export after cotton and cashew nuts, and a highly profitable cash crop (M.I.C.A., 2021). Farmers are increasingly turning to this crop due to favorable global market trends and its accessibilitý for the most disadvantaged, especially women (DGESS/MARAH, 2022). Unfortunately, average sesame yields on the farm remain low (generally less than 0.5 t/ha) and hardly reach 1.5 t.ha^{-1} among the best producers (Miningou *et al.*, 2018; DGESS/MARAH, 2022). Thiombiano*et al.*, 2012 showed that leached tropical ferruginous soils make up 85% of Burkina Faso's soils. They are mainly concretion soils, generally poor in organic matter, nitrogen, phosphorus and potassium, with numerous other constraints such as: the sometimes high gravelling rate (60 to 80%), low useful water reserves, a structure unfavorable to root penetration beyond the upper horizon, and surface crusting that favors rainwater runoff (Pallo *et al.*, 1989). As a result, the adoption of good agricultural practices, notably the use of improved seeds, chemical and organic fertilizers, has increased over the years (DGESS/MARAH, 2022). Authors such as Fairhurst (2015), Kitabala *et al.* (2016), Gomgnimbou *et al.* (2016) have shown that for the sustainable management and restoration of the productive capacity of agricultural land, amendment is indispensable. However, less work has been done in Burkina on the effects of organo-mineral fertilization on sesame, even though this plant is not very demanding in terms of fertilization (Boureima and Sani, 2021). Also, the high cost of fertilizers limits their use by poor producers. Thus, to reduce production costs, enable sustainable land management and minimize environmental impact, the use of organic inputs is essential. This is the background to the present study, the aim of which was to evaluate effect of combinations organic and mineral fertilizer on the growth and productivity performance of two sesame (*Sesamum indicum* L.) varieties. Specifically, the aim was: (i) to assess the effect of each fertilization formulation on the growth and development of each sesame variety; (ii) to assess the effect of each fertilization formulation on the seed yield of each variety.

Materials and methods

Experimental site of experiment

The experiment was carried out in central Burkina Faso at an experimental site with geographical coordinates 11°55' N 1°32' W and an altitude of 318 m. This site (Fig. 1) is located in Ipelcé, a rural commune 45 km south of the capital Ouagadougou in the Centre-Sud region, Bazèga province.

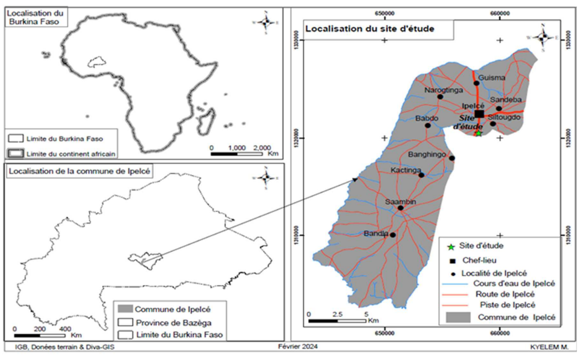

Fig. 1. Location of experimental site (Diarra, 2024)

Study soil characteristics

Physicochemical analysis (Table 1) shows that the study soil was slightly acidic, with average organic matter content and a high C/N ratio. Total nitrogen and total phosphorus levels were low, and total potassium content was average.

Rainfall at the experimental site

Fig. 2 shows the monthly rainfall and number of rainy days at the Ipelcé experimental station during the trial. August (376.68 mm) and September (363.17 mm) were the wettest months. Cumulative rainfall during the trial was 903.53 mm.

Table 1. Physicochemical characteristics of study soil

Granulometric composition							
Clay (%)			Silt (%)				Sand (%)
25,49			39,22				35,29
Mineral elements							
pH water	C_t (%)	MO (%)	N_t (%)	C/N	P_t (mg.kg⁻¹)	P_{ass} (mg.kg⁻¹)	K_t (mg.kg⁻¹)
6,06	1,17	2,02	0,06	19	100,60	3,70	957,70

Legend: MOt: total organicmatter; Ct: total carbon; Nt: total nitrogen; Pass: assimilable phosphorus; Pt: total phosphorus; Kt: total potassium; pH: Hydrogenpotential.

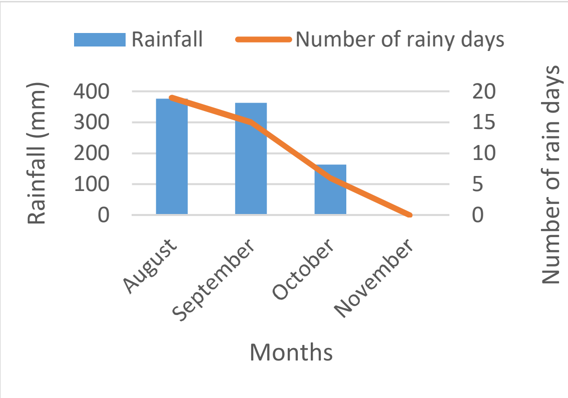

Fig. 2. Monthly rainfall and number of rainy days at Ipelcé station from August to November 2022

Plant material using

The plant material used consisted of two sesame varieties: S42 of Indian origin and Humera of Ethiopian origin. These two varieties were selected on the basis of their cycle, seed color, and resistance to lodging and high yield. The Table 2 presented the characteristics of varieties.

Table 2. Characteristics of the two varieties used

Parameters	Varieties	
	S-42	Humera
SLCHD	Very dense	Sparse
FC	White + slight purplish tint	White
SC	White	White
LN	Very few	Very few
LR	Good	Good
ED(DAS)	3	3
SF(DAS)	35	42
EF(DAS)	65	83
CM(DAS)	84	100
CL(DAS)	90	105
Potential yield (t/ha)	2t/ha	2.3t/ha

Source: ILY, 2011

Legend: SLCHD: stem, leaf and capsule hair density; FC: flower color; SC: seed color; LN: leaf necrosis; LR: lodging resistance; ED: emergence date; SF: start of flowering; EF: end of flowering; CM: capsules maturity; CL: cycle length; DAS: day after sowing.

Characteristics of organic fertilizers in terms of major chemical elements

The fertilizers used in this experiment consisted of two mineral fertilizers (NPK formulated 15N-15P-15K and urea containing 46% of Nitrogen). Organic fertilizers consisted of mulched broiler droppings and cattle manure-based compost. The Table 3 shows that both organic manures are rich in organic matter and mineral elements. The total nitrogen content of the hen droppings was five times higher than that of the compost. The C/N ratio of the manure was more than twice that of the compost. The total phosphorus and total potassium contents of the two manures were roughly equal.

Table 3. Chemical characteristics of the organic manures used in the study

Organic manures	MO_t(%)	C_t (%)	N_t (%)	P_t (mg.kg⁻¹)	K_t(mg.kg⁻¹)	C/N
Cattle manure compost	41,30	23,95	0,49	3016,56	8486,22	48,87
Mulched hen droppings	84,56	49,04	2,52	2858,03	11612,71	19,45

Legend: MOt: total organic matter; Ct: total carbon; Nt: total nitrogen; Pt:total phosphorus; Kt :total potassium.

Experimental set-up, sowing and plant maintenance

The experimental set-up used was a randomized complete block design (RCB) with 3 replicates. Each repetition or block consisted of 16 elementary plots of 1.8m² (1.8m × 1m) spaced 1m apart. Two factors were studied: variety with two modalities (S-42 and Humera) and fertilization with eight levels (F0, F1, F2, F3, F4, F5, F6 and F7). Each elementary plot consisted of four rows of seedlings spaced 0.60 m apart, and each row contained 6 seedlings spaced 20 cm so 24 seedlings per elementary plot and 48 plants with two plants per seedling. A distance of 2 m was maintained between the blocks. The trial contained a total of 48 elementary plots with a surface area of

336.6m² (19.8m × 17m). Sowing was carried out flat after tractors ploughing on August 16, 2022, after 36mm of rain the previous day. Seeds were sown at a rate of 5 to 6 grains per poquet and at a depth of around 2 cm. After three weeks, 2 plants were separated from each other in order to make better use of available resources. The first weeding was carried out 21 days after sowing, at the same time as weeding, followed by weeding two weeks later, at the start of flowering, to prevent lodging.

Treatments applied

The following treatments were applied to the plants

F0: Control treatment (no fertilizer)

F1; Cattle manure compost (7.5 t/ha)

F2 ; Mulched hen droppings (1.5 t/ha)

F3: Cattle manure compost (2.5 t/ha) + mulched hen droppings (1 t/ha)

F4 : Cattle manure compost (5 t/ha) + NPK (50 kg/ha + Urea (25 kg/ha)

F5 : Mulched hen droppings (0.75 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha)

F6: Cattle manure compost (1.25 t/ha) + Mulched hen droppings (0.5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha)

F7: NPK (100 kg/ha) + Urea (50 kg/ha)

Fertilization techniques

Mineral and organic fertilizers were applied according to the technique recommended in the manual “Manual of Certified Seed Production Techniques”. Fertilizers were evenly distributed along the sowing lines. All organic fertilizers (manure and compost) were applied before sowing. NPK and urea were applied at the vegetative stage (21 DAS) and at the beginning of flowering (35 DAS) respectively.

Evaluation of parameters

Plant height (HP) at maturity was measured using a graduated ruler, and plant collar diameter (CD) at maturity using an electronic caliper. Above-ground dry biomass (ADB), root dry biomass (RDB), total dry biomass (TDB) and 1000-seeds weight (TSW) were determined using a 0.001g precision electronic balance (Denver AC- 1200D). The number of branches (NB) at maturity, the number of capsules per plant (NCP) and the number of seeds per capsule (NSC) were determined by manual counting. Seed yield per plant (SYP or W) was calculated using Garfius (1964) formula:

$W = XYZ$

(X: number of capsules per plant; Y: average number of seeds per capsule; Z: average seed weight). The potential yield per hectare (PYH) was calculated as follows:

$PYH=W66000$

(66000 is the average plant density per hectare and W is the seed yield per plant). The harvest index per plant (HI) was obtained by dividing the total dry seed weight per plant by the total dry weight of the plant.

Data processing and statistical analysis

Data entry, calculation of averages and histograms were carried out using Excel 2016. Analysis of variance with two classification criteria (ANOVA 2) was used to assess the effect of fertilizer combinations and sesame varieties on all measured parameters. Means were compared using the Tukey’s test. Significance levels for fertilizer treatments, varieties and fertilizer treatment x variety interactions were determined at a probability threshold of 0.05.R software version 4.3.0. (http://CRAN.R-project.org/) in Rstudio (https://rstudio.com/) (Accessed on 29-02-2023) using the agricolae library (Steel *et al.*, 1997) was used to carry out all these analyses.

Results

Treatments Influence on growth parameters

For plant height, a significant interaction ($P < 0.0001$) was found between the two factors (variety × treatment interaction) (Table 4, Fig. 3). For the S-42 variety, the tallest plants at maturity were obtained under treatments F5 (125.56cm), F7 (123.24cm) and F6 (123.18cm).

The lowest plants were obtained under F0 (114.45cm) and F1 (112.77cm). In the Humera variety, the highest heights were obtained under treatments F5 (157.96cm) and F6 (153.36cm), and the lowest heights were obtained under F0 (127.80cm) and F1 (138.29cm).

Table 4. Results of analysis of variance between the Variety and fertilization option on growth parameters

Variety×Treat.	MPH (cm)	MCD(mm)	NPB
S-42×F0	112.42^{a}	10.99^{a}	2.75^{a}
S-42×F1	114.77^{cd}	12.51^{cd}	3.08^{ac}
S-42×F2	114.42^{bd}	12.73^{bd}	3.58^{ac}
S-42×F3	115.18^{d}	12.20^{d}	2.75^{a}
S-42×F4	122.98^{cd}	12.48^{cd}	3.25^{ac}
S-42×F5	125.56^{bc}	13.18^{bc}	3.42^{ac}
S-42×F6	123.18^{b}	13.34^{b}	3.75ac
S-42×F7	123.24^{bd}	12.66^{bd}	3.17^{ac}
Humera F0	127.80^{b}	13.29^{b}	4.0^{bc}
Humera×F1	138.29^{ef}	15.43^{ef}	5.08^{d}
Humera×F2	143.73^{egh}	14.81^{egh}	5.08^{d}
Humera×F3	148.04^{gh}	14.39^{gh}	5.08^{d}
Humera×F4	151.51^{fg}	15.13^{fg}	5.58^{d}
Humera×F5	157.96^{f}	15.86^{f}	5.01^{bd}
Humera×F6	153.36^{i}	17.16^{i}	5.00^{bd}
Humera×F7	151.43^{h}	14.28^{h}	5.08^{d}
F de Fisher	16.12	9.20	2.23
P à 5%	<0.0001***	< 0.0001***	< 0.0001*

Legend: P: probability; F: Fisher's variable; *** highly significant difference; * significant difference; MCD: mature collar diameter; MPH: mature plant height; NPB: number of primary branches per plant; Values followed by the same letter in the same column are not significantly different at the 5% threshold.

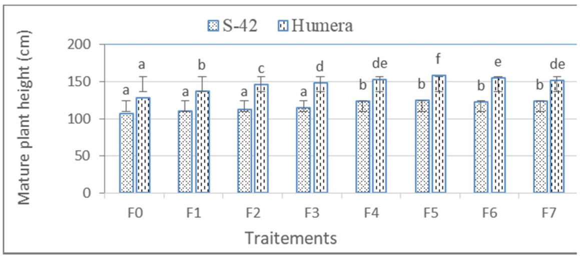

Fig. 3. Plant height at maturity according to treatments

Legend: F0: Control treatment (no fertilizer); F1; Cattle manure compost (7.5 t/ha); F2; Mulched hen droppings (1.5 t/ha); F3: Cattle manure compost (2.5 t/ha) + Mulched hen droppings (1 t/ha); F4; Cattle manure compost (5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F5: Straw hen droppings (0.75 t.ha^{-1}) + NPK (50 kg/ha) + Urea (25 kg/ha); F6: Cattle manure compost (1.25 t/ha) + Chicken manure (0.5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha) ; F7 : NPK (100 kg/ha) + Urea (50 kg/ha)

For collar diameter, the variety × treatment interaction (Table 4, Fig. 4) revealed a highly significant difference (P < 0.0001). The least vigorous plants were obtained under the F0 control treatment in both S-42 (10.99mm) and Humera (13.29mm), while the most vigorous plants were obtained under the F6 treatment in both S-42 (13.34mm) and Humera (17.16mmFor the number of branches, the variety × treatment interaction (Table 4, Fig. 5), a highly significant difference (P < 0.0001) was found between treatments and varieties. For the S-42 variety, the most branched plants were obtained under F6 (3.75 branches) and F2 (3.58 branches), while the least branched plants were obtained under F0 (2.75 branches). For the Humera variety, the plants treated with fertilizers produced more branches than the control plants.

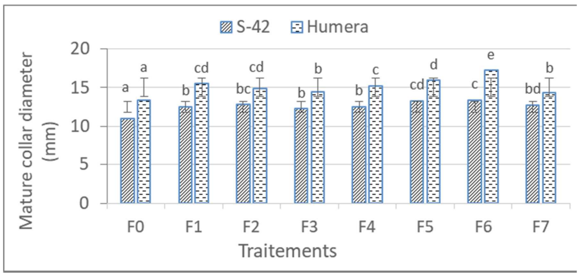

Fig. 4. Plant collar diameter as a function of treatments

Legend: F0: Control treatment (no fertilizer); F1; Cattle manure compost (7.5 t/ha); F2; Mulched hen droppings (1.5 t/ha); F3: Cattle manure compost (2.5 t/ha) + Mulched hen droppings (1 t/ha); F4; Cattle manure compost (5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F5: Straw hen droppings (0.75 t.ha^{-1}) + NPK (50 kg/ha) + Urea (25 kg/ha); F6: Cattle manure compost (1.25 t/ha) + Chicken manure (0.5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha) ; F7 : NPK (100 kg/ha) + Urea (50 kg/ha)

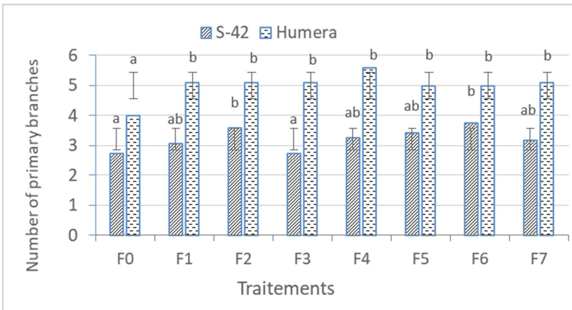

Fig. 5. Number of primary branches according to treatments

Legend: F0: Control treatment (no fertilizer); F1; Cattle manure compost (7.5 t/ha); F2; Mulched hen droppings (1.5 t/ha); F3: Cattle manure compost (2.5 t/ha) + Mulched hen droppings (1 t/ha); F4; Cattle manure compost (5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F5: Straw hen droppings (0.75 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F6: Cattle manure compost (1.25 t/ha) + Chicken manure (0.5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha) ; F7 : NPK (100 kg/ha) + Urea (50 kg/ha)

Influence of treatments on production parameters or yield components

ANOVA results revealed the highly significant interaction between the two factors (P < 0.0001) on above-ground, root and total dry biomass.The Humera×F6 combination recorded the highest value (61.54g) and the S-42×F0 combination recorded the lowest value (45.03g) for above-ground dry biomass (Table 5, Fig. 6). The same Humera×F6 combination recorded the highest root dry biomass (Table 5, Fig. 7) (14.90g), while the S-42×F0 combination recorded the lowest (8.39g).For total dry biomass (Table 5, Fig. 8), the same Humera×F6 combination recorded the highest total dry biomass (76.31g) and the S-42×F0 combination the lowest (45.03g). The variety x treatment interaction showed a highly significant difference (P < 0.0001) in the number of capsules per plant (Table 5, Fig. 9). The highest number of bolls per plant (101.33 capsules) was favoured by the S-42×F6 combination, however the Humera×F0 combination produced the lowest (55.17 capsules).

Table 5. Results of analysis of variance between the Variety and fertilization option on growth parameters on production parameters

Var×Treat.	ADB (g)	RDB (g)	TDB (g)	NCP	NSC	TSW (g)	SYP (g)	PYH (kg)	HI
S-42×F0	45.03[a]	8.39[a]	45.03[a]	70.67[a]	52.67[a]	2.38[ab]	8.84[a]	1467.99[a]	0.16[a]
S-42×F1	48.43[bc]	9.08[ac]	48.43[c]	97.83[c]	58.17[e]	2.59[d]	14.74[bc]	2446.73[bc]	0.26[cd]
S-42×F2	48.76[bc]	9.75[ce]	48.76[ce]	97.67[c]	59.08[ce]	2.59[d]	14.93[bc]	2477.88[bc]	0.25[bd]
S-42×F3	48.4[bc]	8.47[a]	48.4[c]	98.58[c]	57.92[e]	2.35[a]	13.41[g]	2225.38[g]	0.22[bc]
S-42×F4	47.43[b]	8.86[af]	47.43[c]	98.42[c]	60.42[de]	2.39[b]	14.21[cg]	2359.54[cg]	0.26[cd]
S-42×F5	50.37[bc]	9.72[ce]	50.37[be]	100.83[c]	62[bcdh]	2.52[h]	15.73[bf]	2611.59[bf]	0.27[d]
S-42×F6	49.97[ch]	10.0[e]	49.97[be]	101.33[c]	62.25[bdh]	2.44[i]	15.39[bcj]	2555.05[bcj]	0.25[bd]
S-42×F7	48.0[bh]	9.37[cef]	48[c]	97.42[c]	61.25[cd]	2.4[b]	14.31[cg]	2376.23[cg]	0.24[c]
Humera×F0	49.53[bc]	12.50[b]	62.03[b]	55.17[b]	61.83[bcd]	2.94[c]	10.03[a]	1665.70[a]	0.17[a]
Humera×F1	53.29[d]	13.19[bd]	66.48[d]	83.92[de]	69[f]	3.01[e]	17.42[de]	2892.30[de]	0.26[cd]
Humera×F2	54.80[de]	13.23[bd]	68.03[df]	78.33[d]	68.75[f]	3.14[f]	16.89[ef]	2803.51[ef]	0.26[cd]
Humera×F3	57.15[f]	13.72[d]	70.87[g]	80[df]	64.92[gh]	3.04[e]	15.80[bf]	2623.09[bf]	0.24[c]
Humera×F4	56.62[ef]	13.62[d]	70.24[fg]	85.75[ef]	65.58[g]	3.22[g]	18.12[eh]	3007.35[eh]	0.25[bd]
Humera×F5	59.88[g]	14.90[g]	74.78[h]	88.5[e]	70.33[f]	3.22[g]	20.03[i]	3324.59[i]	0.26[cd]
Humera×F6	61.54[g]	14.77[g]	76.31[h]	86.92[e]	71.42[f]	3.12[f]	19.36[hi]	3214.48[hi]	0.27[d]
Humera×F7	55.07[df]	13.65[d]	68.72[dg]	82.83[de]	64.75[bg]	3.02[e]	16.22[dfj]	2693.05[dfj]	0.25[bd]
F de Fisher	14.34	7.20	17.59	2.20	8 .58	139	9.89	9.89	3.03
P à 5%	< 0.0001***	< 0.0001***	< 0.0001***	< 0.0001*	< 0.0001***	< 0.0001***	< 0.0001***	< 0.0001***	< 0.0001***

Legend: P: probability; F: Fisher's variable; *** highly significant difference; NCP: number of capsules per plant; NSC: number of seeds per capsule; TSW: 1000 seeds weight; ADB: above-ground dry mass; RDB: root dry biomass; TDB: total dry biomass; SYP: seed yield per plant; PYH: potential yield per hectare; HI: harvest index; Values followed by the same letter in the same column are not significantly different at the 5% threshold.

Concerning the number of seeds per capsule (Table 5, Fig. 10), a highly significant difference (P < 0.0001) was revealed by the variety x treatment interaction. The highest number of seeds per capsule (71.42 seeds) was favored by the Humera×F6 combination. while the S-42×F0 combination produced the lowest (52.67 seeds). For 1000-seed weight (Table 5, Fig. 11), analysis of the variety x treatment interaction also showed a significant difference (P < 0.0001). The Humera×F5 and Humera×F6 combinations recorded the highest weight (3.22g) and the S-42×F3 combination the lowest (2.35g).

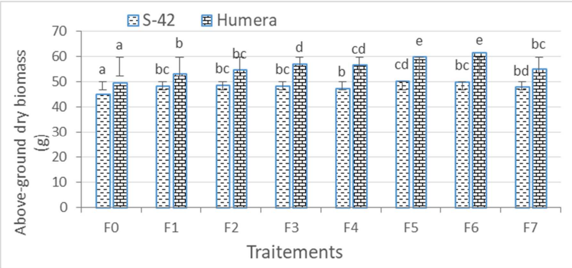

Fig. 6. Above-ground dry biomass by treatment

Legend: F0: Control treatment (no fertilizer); F1; Cattle manure compost (7.5 t/ha); F2; Mulched hen droppings (1.5 t/ha); F3: Cattle manure compost (2.5 t/ha) + Mulched hen droppings (1 t/ha); F4; Cattle manure compost (5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F5: Straw hen droppings (0.75 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F6: Cattle manure compost (1.25 t/ha) + Chicken manure (0.5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha) ; F7 : NPK (100 kg/ha) + Urea (50 kg/ha)

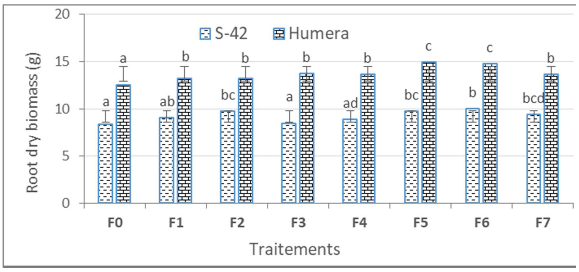

Fig. 7. Root dry biomass by treatment

Legend: F0: Control treatment (no fertilizer); F1; Cattle manure compost (7.5 t/ha); F2; Mulched hen droppings (1.5 t/ha); F3: Cattle manure compost (2.5 t/ha) + Mulched hen droppings (1 t/ha); F4; Cattle manure compost (5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F5: Straw hen droppings (0.75 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F6: Cattle manure compost (1.25 t/ha) + Chicken manure (0.5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha) ; F7 : NPK (100 kg/ha) + Urea (50 kg/ha)

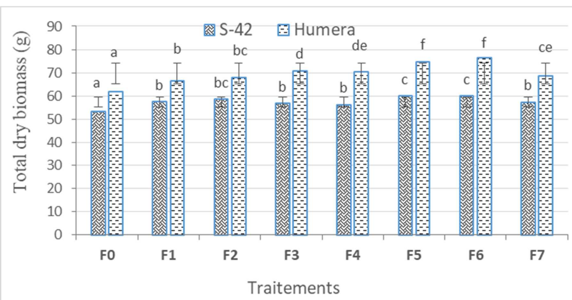

Fig. 8. Total dry biomass by treatment

Legend: F0: Control treatment (no fertilizer); F1; Cattle manure compost (7.5 t/ha); F2; Mulched hen droppings (1.5 t/ha); F3: Cattle manure compost (2.5 t/ha) + Mulched hen droppings (1 t/ha); F4; Cattle manure compost (5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F5: Straw hen droppings (0.75 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F6: Cattle manure compost (1.25 t/ha) + Chicken manure (0.5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha) ; F7 : NPK (100 kg/ha) + Urea (50 kg/ha)

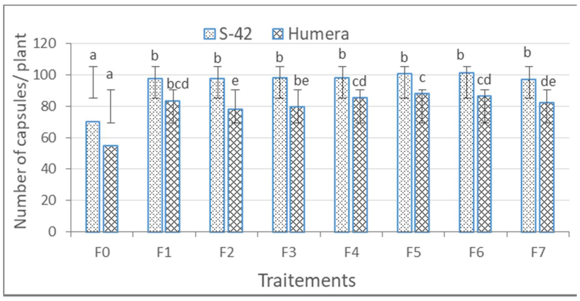

Fig. 9. Number of capsules per plant according to treatments

Legend: F0: Control treatment (no fertilizer); F1; Cattle manure compost (7.5 t/ha); F2; Mulched hen droppings (1.5 t/ha); F3: Cattle manure compost (2.5 t/ha) + Mulched hen droppings (1 t/ha); F4; Cattle manure compost (5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F5: Straw hen droppings (0.75 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F6: Cattle manure compost (1.25 t/ha) + Chicken manure (0.5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha) ; F7 : NPK (100 kg/ha) + Urea (50 kg/ha)

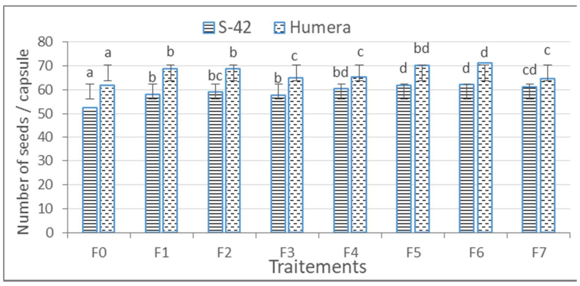

Fig. 10. Number of seeds per capsule according to treatments

Legend: F0: Control treatment (no fertilizer); F1; Cattle manure compost (7.5 t/ha); F2; Mulched hen droppings (1.5 t/ha); F3: Cattle manure compost (2.5

t/ha) + Mulched hen droppings (1 t/ha); F4; Cattle manure compost (5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F5: Straw hen droppings (0.75 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F6: Cattle manure compost (1.25 t/ha) + Chicken manure (0.5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha) ; F7 : NPK (100 kg/ha) + Urea (50 kg/ha)

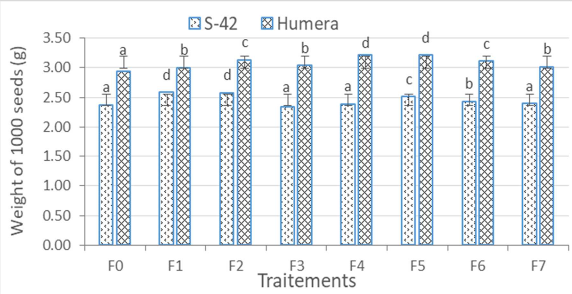

Fig. 11. Weight of 1000 seeds according to treatment

Legend: F0: Control treatment (no fertilizer); F1; Cattle manure compost (7.5 t/ha); F2; Mulched hen droppings (1.5 t/ha); F3: Cattle manure compost (2.5 t/ha) + Mulched hen droppings (1 t/ha); F4; Cattle manure compost (5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F5: Straw hen droppings (0.75 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F6: Cattle manure compost (1.25 t/ha) + Chicken manure (0.5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha) ; F7 : NPK (100 kg/ha) + Urea (50 kg/ha)

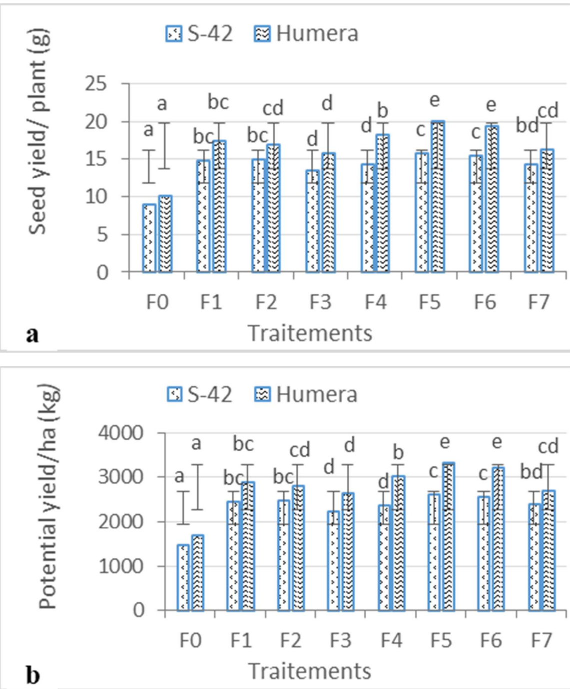

Fig. 12. Seed yield per plant (A) and potential yield per hectare (B)

Legend: F0: Control treatment (no fertilizer); F1; Cattle manure compost (7.5 t/ha); F2; Mulched hen droppings (1.5 t/ha); F3: Cattle manure compost (2.5 t/ha) + Mulched hen droppings (1 t/ha); F4; Cattle manure compost (5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F5: Straw hen droppings (0.75 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F6: Cattle manure compost (1.25 t/ha) + Chicken manure (0.5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha) ; F7 : NPK (100 kg/ha) + Urea (50 kg/ha)

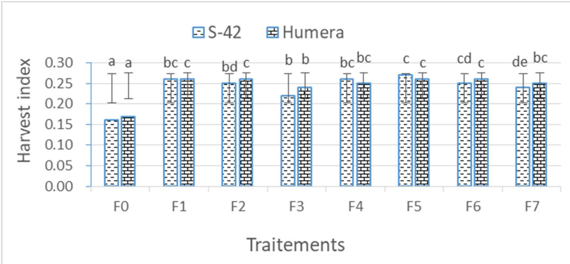

Fig. 13. Harvest index as a function of treatments

Legend: F0: Control treatment (no fertilizer); F1; Cattle manure compost (7.5 t/ha); F2; Mulched hen droppings (1.5 t/ha); F3: Cattle manure compost (2.5 t/ha) + Mulched hen droppings (1 t/ha); F4; Cattle manure compost (5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F5: Straw hen droppings (0.75 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha); F6: Cattle manure compost (1.25 t/ha) + Chicken manure (0.5 t/ha) + NPK (50 kg/ha) + Urea (25 kg/ha) ; F7 : NPK (100 kg/ha) + Urea (50 kg/ha)

For seed yield [Table 5, Fig. 12 (a & b)], analysis of the variety x treatment interaction also revealed a highly significant difference ($P < 0.0001$). The same combinations Humera×F5 (20.03 $g.plant^{-1}$ or 3324.59 $kg.ha^{-1}$) and Humera-F6 (19.36 $g.plant^{-1}$ or 3214.48 $kg.ha^{-1}$) recorded the highest values, and the S-42×F3 combination the lowest (8.84 $g.plant^{-1}$ or 1467.99 $kg.ha^{-1}$). As for the harvest index, the S-42×F4 combination recorded the highest value (0.27), while the S-42×F0 combination recorded the lowest (0.16) (Fig. 13).

Discussion

The experiment was carried out under temperature conditions ranging from 24 to 33°C, with relative humidity varying between 33 and 80%. Naturland (2000) and Carvalho *et al.* (2001) report that the minimum temperature for sesame germination is between 12.8°C and 13°C, while the maximum is between 45.5°C and 46°C. These conditions were favorable to the growth and development of these sesame varieties. According to the same authors, a temperature of 31.9°C to 35.1°C favors rapid germination and good sesame growth and development. Waterfall during the trial averaged 301.18 mm. This quantity of water is satisfactory for the growth and development needs of sesame. In fact, OMM (1991) reported that sesame needs a lot of water, especially between sowing and fruit set, and that rainfall of 250 to 600 mm is sufficient for the crop cycle. Physicochemical analysis of the study soil revealed its fertility limitations. Indeed, the study soil was slightly acidic, with an average organic matter content and a high C/N ratio. Total nitrogen and phosphorus levels were low, and total potassium content was average. From a soil and maintenance point of view, sesame has far fewer requirements than many other crops and can grow indifferently on a wide range of soils (Bapoyo, 1960). Nevertheless, the plant prefers permeable soils with low acidity and good aeration. A high proportion of clay is acceptable if the environment is not asphyxiating (Santens, 1980). Other authors such as Weiss (1971), OMM (1991), Schilling and Cattan (1991) show that although neutral pH soils are preferable, sesame also tolerates slightly acid or alkaline soils (pH 5.5 to 8). The organo-mineral fertilizers including hen droppings, i.e. F5: Hen droppings (0.75 $t.ha^{-1}$) + NPK (50 kg/ha) + Urea (25 kg/ha) and F6: Compost (1.25 t.ha-1) + Hen droppings (0.5 $t.ha^{-1}$) + NPK (50 kg/ha) + Urea (25 kg/ha), produced the tallest, most vigorous and branched plants. These results corroborate those of Wei *et al.* (2013), Jakusko *et al.* (2013) and Miningou *et al.* (2020), who also reported an increase in height and number of branches of sesame plants following the application of increasing doses of NPK fertilizers. This is explained by the greater availability of mineral elements essential for plant growth and development, notably phosphorus, nitrogen and potassium, provided by these fertilizers. Nitrogen increases the photosynthetic pigment content and the rate of photosynthesis, which in turn increases the quantity of metabolites synthesized and thus promotes greater growth. Miningou *et al.* (2020) report that the more the plant grows, the greater the branching and development potential of the main stem. For yield parameters (number of capsules, number of seeds, and seeds), the best values were observed under organo-mineral fertilizers F4 (Compost + NPK + Urea); F5 (Manure + NPK + Urea) and F6 (Compost + Manure + NPK + Urea) in both varieties. These results are in line with those of other authors such as CIRAD (2002), Okpara *et al.* (2007) and Muhammad *et al.* (2016), who showed that an increase in nitrogen level favors an increase in sesame production. This can be explained by the improved structural stability of the soil and its enhanced fertility, thanks to the supply of necessary mineral elements, notably phosphorus, which stimulates flowering, and fruiting, potassium, which improves plant fruiting (Miningou *et al.*, 2020) and, above all, nitrogen. Nitrogen is the main factor in plant growth (FAO, 1980), and is supplied both by nitrogen fertilizers (NPK and urea) and by organic fertilizers, of which one fraction is ammoniacal nitrogen, which is immediately available to plants, and the other fraction, the addition of urea to NPK fertilizer further increases the availability of nitrogen to the plant, and further increases capsule production. The F5 fertilizer (Manure + NPK + Urea) stood out with the highest seed yield. This could be explained by the more rapid mineralization of organic nitrogen in poultry droppings compared with cattle manure compost, making it rapidly available to plants. Analysis of variance showed a significant difference between varieties. In fact, soil amendment was more favorable for the Humera variety than for the S-42 variety. This could in part be linked to the intrinsic (genetic) characteristics of the Humera variety.

Conclusion

At the end of the study, it was found that the F5 and F6 organo-mineral fertilizers significantly increased the height, number of branches and crown diameter of the plants in both varieties (S-42 and Humera), but even more so in Humera. Humera had the highest above-ground dry biomass in the F6 treatment and the highest root dry biomass in the F5 treatment. The S-42×F6 combination produced the highest number of capsules per plant. The Humera×F6 combination produced the highest number of seeds per capsule. In terms of 1000-seed weight, the Humera×F5 and Humera×F6 combinations recorded the highest weight. For seed yield, the same Humera×F5 and Humera×F6 combinations recorded the highest values. Humera×F5 and Humetra×F6 interactions resulted in the highest seed yields. The F5 and F6 formulations were the best fertilizers for both varieties, but even more so for Humera. Thus, the Humera variety and the F5 and F6 fertilizer combinations recommended for best production.

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