EVALUATION OF THE PHYSIOLOGICAL AND AGRONOMIC PERFORMANCE OF NEW SESAME VARIETIES (*SESAMUM INDICUM* L.) INTRODUCED IN BURKINA FASO

Abstract

In Burkina Faso, where agriculture employs more than 80% of the working population and contributes more than 40% of GDP, stepping up research in this field is becoming a must for sustainable food and economic resilience. Thus, this study was carried out on sesame (*Sesamum indicum* L.) to highlight the morpho-physiological and agronomic performance of new sesame varieties. The experiment was carried out at the Gampèlaagropedagogical station, east of Ouagadougou. A randomized complete block design with 3 replications was used. The study revealed that seed emergence took place on 3 DAS, the start of flowering varied with variety, and the cycle length was 90 days for all varieties. Varieties SN103 (24.5 mm) and SN303 (23 mm) were the most vigorous. S42 produced more capsules (245.53 capsules/plant), while LC162 (155.33 capsules/plant) and SN303 (154.47 capsules/plant) produced fewer. SN103 (84.80 seeds/capsule) and SN203 (82.66 seeds/capsule) contained more seeds. Seeds of all varieties are statistically the same weight (approx. 3.4 g/1000 seeds).Thus, in descending order of seed yield, we have: S42 (57.43 g/plant) HB168 (50.05 g/plant), SN103 (49.81 g/plant), SN203 (47.49 g/plant), SN303 (40.97 g/plant) then LC162(37.89 g/plant). The most productive variety of foreign origin is therefore HB168. It needs to be subjected to water deficit conditions in order to assess its adaptability.

Keywords: Burkina Faso, sesame, variety, yield.

1. Introduction

Burkina Faso is a West African country whose socio-economic development is largely based on the primary sector, and specifically on agriculture. For several years now, the emphasis has been on developing cash crops, including sesame (*Sesamum indicum* L.). It is an annual oleaginous plant whose seeds contain high levels of dry matter, protein, carbohydrates, potassium, phosphorus, calcium, iron, vitamin C and certain phytochemical compounds such as polyphenols, tannins and flavonoids [1, 2]. Sesame is mainly grown for its high-quality oil, which is mainly used in salads or cold dishes in certain countries such as China and Korea, but also in soups or certain hot dishes. It is also used in the manufacture of various products including soaps, insecticides, pharmaceuticals, paints, etc. Sesame seeds are used to make sauces, fritters, drinks, bread and croquettes. Finally, sesame cake, the main extraction residue, is a concentrate of high nutritional and energy value for livestock and poultry feed [3]**.** The second most important agricultural export after cotton, Burkina Faso's sesame production, estimated at 106,674 tonnes in 2021, has fallen by 51.22% and 30.48% respectively compared with the 2020 season and the five-year average [4]**.** Burkina Faso's interest in sesame cultivation can be explained by favorable trends on world markets, but also by the fact that sesame remains one of the crops accessible to all, especially women. However, production is not evenly distributed throughout Burkina Faso, with some regions producing more than others [4]**.** Also, sesame yield per hectare remains low, around 1,000 kg/ha in stations and 450 kg/ha in farming areas [5].This low production is linked to various constraints, including increasingly severe climatic hazards, with pockets of drought and a spatio-temporal distribution of rainfall out of phase with the agricultural calendar. This study was therefore initiated. Its general objective was to highlight the morpho-physiological and agronomic performance of new sesame varieties introduced to Burkina Faso. Specifically, the aim was: (i) to evaluate the growth and development parameters of these varieties; (ii) to evaluate the agronomic parameters of these varieties in a real environment.

2. Materials and methods

2.1. Plant material

The plant material was obtained from the Institut de l'Environnement et de RecherchesAgricoles (INERA), Kamboinsé, Burkina Faso. It consisted of seeds of six (6) branched-stem sesame varieties, including three (SN103, SN203 and SN303) introduced from Niger, two (LC162 and HB168) from Senegal and variety S42 from Burkina Faso. The latter was used as a control variety, as it is the one most widely grown by Burkinabè for its seed quality and higher yield. These foreign varieties were chosen to identify the most productive under real conditions in Burkina Faso. The characteristics of the different varieties are presented in Table 1.

Table 1: Some characteristics of the six sesame varieties

Varieties	SN103	SN203	SN303	S42	LC162	HB168
Provenance	Niger	Niger	Niger	Burkina Faso	Sénégal	Sénégal
SC	White				Creamy white	
LC	Green	Dark green		Green	Dark green	
FC	White + slight purplish tint					

HSLC	Very hairy					
ET (DAS)	3					
BF (DAS)	36	38	37	35	37	36
DF50% (DAS	41	42	41	37	42	38
EF (DAS)	65	67	67	65	67	66
CT (DAS)	90					

Legend: SC: seed color; LC: leaf color; FC: flower color; HSLC: hairiness on stem, leaves and capsules; ET: emergence time; BF: beginning of flowering; DF50%: date of 50% flowering; EF: end of flowering; CL: cycle time; DAS: day after sowing.

2.2. Experimental site

The experiment was conducted at the Gampèlaagro-pedagogical research station (figure 1) located at longitude 12°22' W and latitude 12°25' N, some 20 km east of Ouagadougou (capital of Burkina Faso). The area's climate is Sudano-Sahelian.

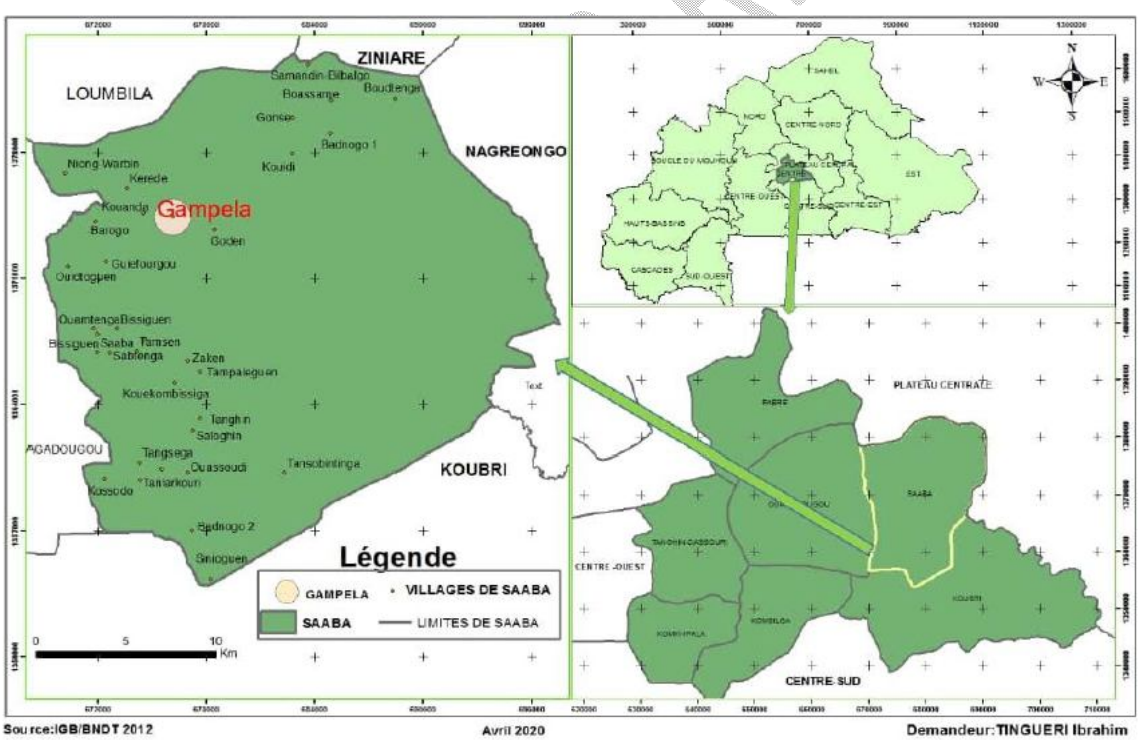

Figure 1: Location of experimental site; source: [6]

3.1 Mineral and particle size composition of the study soil and rainfall at the study site

A sample of the upper soil horizon (0 - 20 cm) was taken from the field and analyzed at the "Laboratoire du Bureau National des Sols" (BUNASOLS). The results of the granulometric and mineral analyses (Table 2) indicated that the soil at the experimental site is sandy-loamy, acidic (pH=4.92), relatively low in organic matter (0.819%) and mineral elements, especially nitrogen (0.04%), phosphorus (7.41ppm) and potassium (31.97ppm). The cumulative rainfall recorded from the start to the end of the experiment was 637 mm.

Table 2: Analytical characteristics of the soil sample

Granulometric composition									
Clay %			Silt %				Sand %		
17.67			21.57				60.78		
Mineral elements									
pH KCl	C %	OM %	N %	C/N	P ppm	K ppm	Fe ppm	Ca ppm	Mg ppm
4.92	0.475	0.819	0.040	12	7.41	31.97	82	613	114

2.3.Experimental set-up, sowing and crop maintenance

The experimental set-up used for the study was a randomized complete block design with three replications. Only one factor was studied, namely variety. The replicates were separated from each other by a 1m interval. Each repetition consisted of six (6) elementary plots of 4.8 m^2 (1.2 m x 4 m) spaced 0.6 m apart. Plots were randomly assigned to varieties. The elementary plots each comprised three rows of 20 plants spaced 60 cm apart, and the distance between bunches was 20 cm. The total area of the experimental field was 142.8 m^2 (10.2 m x 14 m). Seeding was carried out manually on July 30, 2021. Seeds were mixed with sand (40g of sand for 10g of sesame) to reduce the number of seeds per poquet. Seeds were sown to a depth of around 2 cm, and the soil was lightly compacted to ensure good moisture contact with the seed. An initial weeding and removalwas carried out on 17 days before applying NPK fertilizer (formulation 14N-23P-14K) at a rate of 100 kg/ha, or 1.428 kg/m^2, on 18 days. A second weeding accompanied by a light ridging and an application of Urea at a dose of 50 kg/ha or 0.714 kg/m^2 were carried out on 32 days. These doses of NPK and urea were applied in accordance with the “Manuel de technique de Production de SemencesCertifiées au Burkina Faso”[3].

2.4. Evaluation of parameters

Varieties were assessed on the basis of phenological, morphological and agronomic parameters. Phenological observations covered emergence time, start of flowering, date of 50% flowering, end of flowering and cycle time. Morphological measurements included collar diameter (CD) using an electronic caliper, plant height (PH) with a graduated ruler, number of branches (NB) per plant by manual counting, stem dry weight (SDW), root dry weight (RDW) and total dry biomass (TDB) using a 0.001g precision electronic balance

(Denver AC- 1200D). The number of capsules per plant (NCP) and the number of seeds per capsule (NSC) were determined by manual counting. The 1000-seed weight (TSW) was determined using the same scale mentioned above. Seed yield per plant (SYP) was calculated using the Garfius[7] formula: W = XYZ (X: number of capsules per plant; Y: average number of seeds per capsule; Z: average seed weight). Potential yield per hectare (PYH) was calculated according to the following formula: W x 66000 (66000 being the average density of plants per hectare). The harvest index per plant (HIP) was calculated according to the formula: ratio of the total weight of dry seeds from a plant to the total dry weight of the plant.

2.5. Data analysis

The data collected were entered using Excel 2016 spreadsheet software, which was also used to generate the graphs. Analysis of variance (ANOVA) was performed using R software to assess performance and differences between varieties across the different variables. Means were compared using the SNK test at the 5% probability threshold.

3. Results

3.1 Phenological observations

Table 3 below shows the analyses of variance for the phenological characteristics of the six sesame varieties. Observations made on the different evolutionary phases of the six varieties showed that there was no significant difference (P = 0.458) between the varieties for emergence, which was observed from day 3 after sowing (DAS), when 100% emergence was noted. A significant difference (P = 0.0155) was observed between varieties for the start of flowering, which occurred at 35 DAS for variety S42; 36 DAS for varieties SN103, HB168; 37 DAS for varieties SN303 and LC162 and 38 DAS for variety SN203. As for the 50% flowering date, there was a significant difference (P = 0.00238) between varieties. This date was 37 DAS for variety S42; 38 DAS for variety HB168; 41 DAS for varieties SN103, SN303 and 42 DAS for varieties SN203 and LC162. There was no significant difference (p = 0.458) between varieties for cycle time, which was 90 DAS for all varieties.

Table 3: Analysis of variance for phenological traits of six sesame varieties

Varieties	Parameters				
	ET(DAS)	BF(DAS)	DF50%(DAS)	EF(DAS)	CT(DAS)
HB168	3^{a}	35.67^{ab}	38.33^{b}	66.33^{ab}	90^{a}
LC162	3^{a}	37.33^{ab}	41.67^{a}	67.33^{a}	90^{a}
S42	3^{a}	35.00^{b}	37.33^{b}	65.33^{b}	90^{a}
SN103	3^{a}	35.67^{ab}	41.33^{a}	65.33^{b}	90^{a}
SN203	3^{a}	37.67^{a}	42.00^{a}	67.00^{a}	90^{a}

SN303	3^{a}	37.67^{a}	41.33^{a}	66.67^{ab}	90^{a}
F of Fisher	1	4.482	7.283	4.8	1
P at 5%	0.458^{ns}	0.0155*	0.00238**	0.04471*	0.458^{ns}

Legend: ** highly significant difference; * significant difference; ns: non-significant difference at 5% threshold; F: Fisher's variable; P: associated probability. A single letter for a parameter: non-significant difference; two letters for a parameter: significant difference; ET: emergence time; BF: beginning of flowering, DF50%: date of 50% flowering; EF; end of flowering; CT: cycle time.

3.2. Morphological parameters

The analysis of variance for morphological characteristics yielded the following results:

For the plant height trait (Table 4, Figure 2), no significant differences (P = 0.0572) were revealed between varieties. In fact, all varieties had the same growth kinetics and final heights were statistically similar. For plant collar diameter (Table 4, Figure 3), a highly significant difference (P = 0.0000769) was revealed between varieties. Neck diameters showed the same evolutionary kinetics, but at maturity, SN103 plants were the most vigorous (24.50 mm) and S42 plants the least vigorous (19.20 mm). In terms of plant branching (Table 4, Figure 4), there were no significant differences between varieties in either the number of primary branches (P = 0.29) or the number of secondary branches (P = 0.398). In fact, the overall average for primary branching was 6.13/plant and for secondary branching 6.95/plant. For stem dry weight (Table 4, Figure 5), no significant difference was revealed between varieties (P = 0.692). In fact, the average stem dry weight was around 105 g/plant for all varieties. As for root dry weight (Table 4, Figure 6), there was a highly significant difference between varieties (P = 0.0031). Varieties HB168 (27.57 g/plant), SN103 (27.26 /plantg) and SN203 (25.96 g) showed the highest values. For total plant dry biomass (Table 4, Figure 7), no significant differences were revealed between varieties (P = 0.967). In fact, all varieties presented an average dry biomass of around 128g/plant.

Table 4: Analysis of variance for morphological characteristics of six sesame varieties

Varieties	Parameters						
	PHM(cm)	CDM(mm)	NPB	NSB	SDW(g)	RDW(g)	TDB(g)
HB168	172.60^{a}	21.77^{bc}	6.90^{a}	7.66^{a}	100.59^{a}	27.57^{a}	126.16^{a}
LC162	170.16^{a}	20.05^{cd}	6.26^{a}	6.47^{a}	105.4^{a}	20.74^{b}	126.15^{a}
S42	150.27^{ab}	19.20^{d}	5.40^{a}	5.40^{a}	107.79^{a}	19.91^{b}	127.70^{a}
SN103	170.80^{a}	24.50^{a}	6.50^{a}	6.50^{a}	103.84^{a}	27.26^{a}	131.10^{a}
SN203	168.67^{a}	21.40^{bcd}	5.63^{a}	5.63^{a}	102.94^{a}	25.96^{a}	128.90^{a}
SN303	169.27^{a}	23.00^{ab}	6.10^{a}	6.10^{a}	109.46^{a}	20.43^{b}	129.89^{a}
F de Fisher	2.963	15.25	1.405	1.127	0.613	6.834	0.175
P à 5%	0.0572^{ns}	0.0000769***	0.29^{ns}	0.398^{ns}	0.692^{ns}	0.0031**	0.967^{ns}

Legend: ***very highly significant difference; **highly significant difference; ns: non-significant difference at 5% level; F: Fisher variable; P: associated probability. A single letter for a parameter: non-significant difference; two letters for a parameter: significant difference; more than two letters for a parameter: highly significant difference; PHM: plant height at maturity; CDM: collar diameter at maturity; NPB: number of primary branches; NSB: number of secondary branches; SDW: stem dry weight; RDW: root dry weight; TDB: total dry biomass.

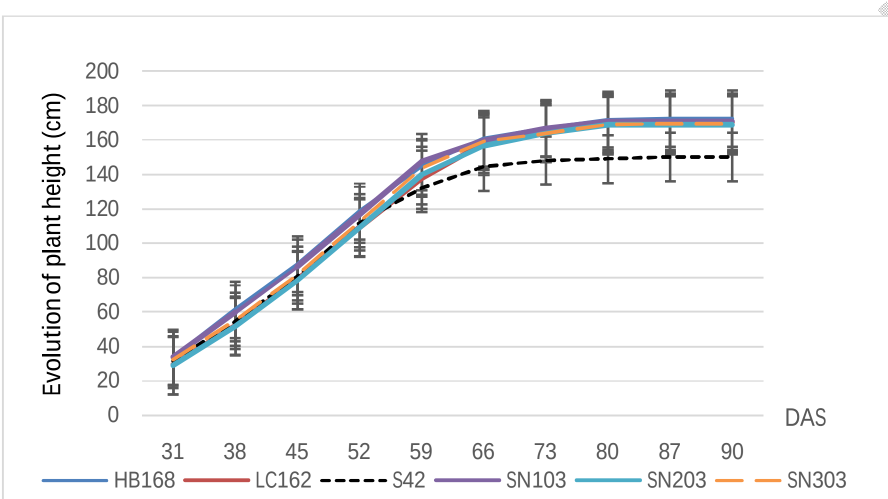

Figure 2: Evolution of plant height

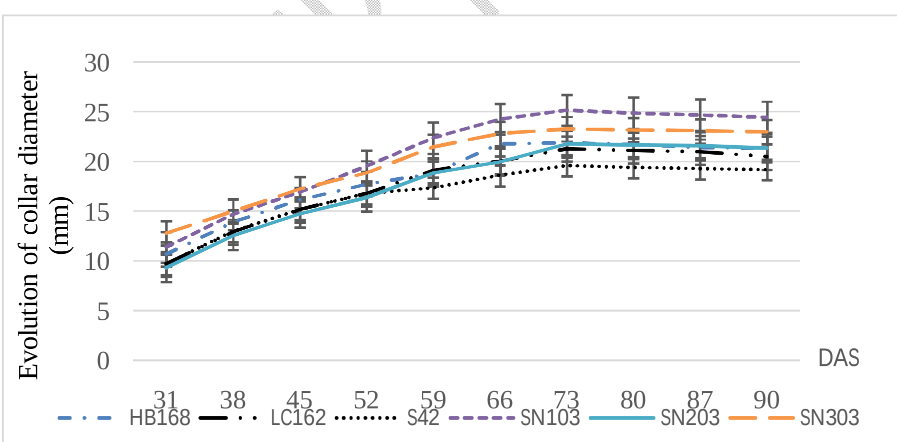

Figure 3: Evolution of plant collar diameter

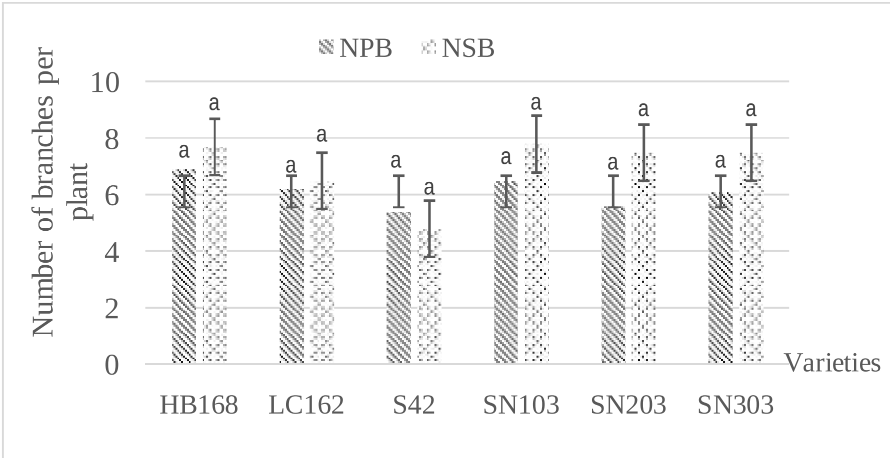

Figure 4: Number of primary and secondary branches per plant

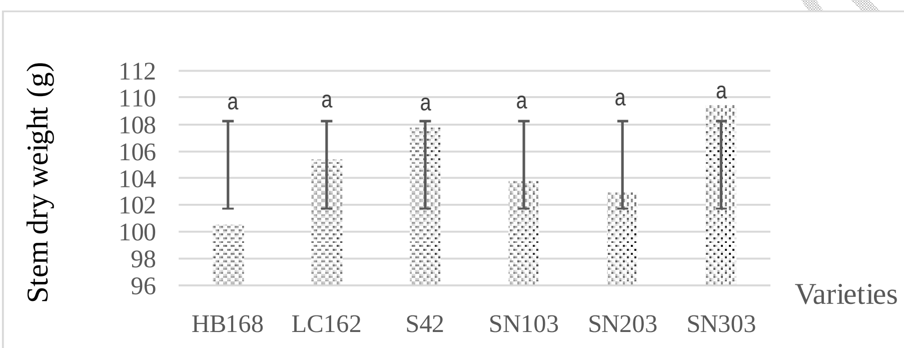

Figure 5: Plant stem dry weight

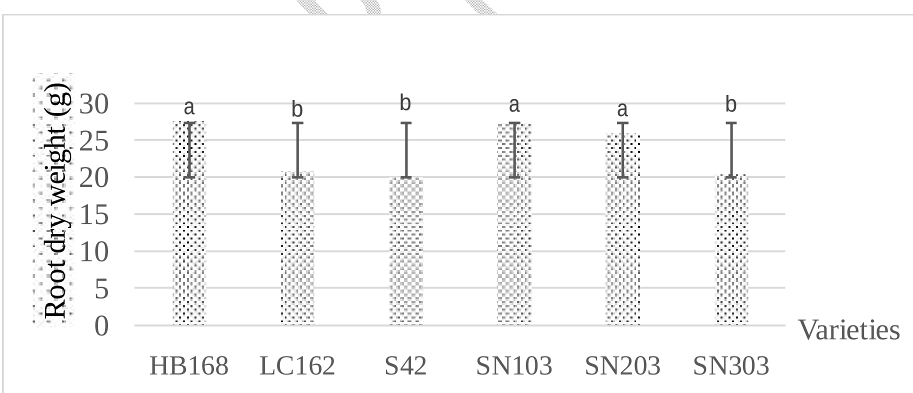

Figure 6: Root dry weight of plants

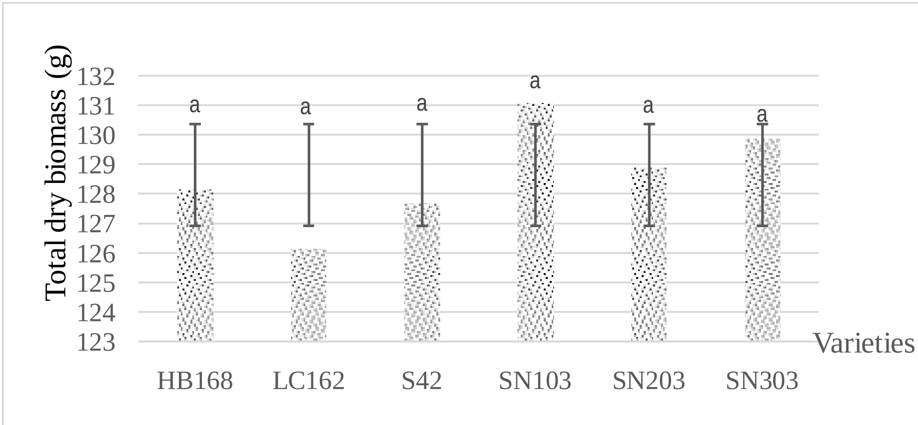

Figure 7: Total plant dry biomass

3.3. Agronomic parameters

The analysis of variance for the agronomic parameters of the six varieties is as follows: For the number of capsules per plant (Table 5, Figure 8), a highly significant difference (P = 0.000602) was revealed between varieties. Variety S42 produced the highest number of capsules (245.53 capsules/plant), while varieties SN303 (154.47 capsules/plant) and LC162 (155.33 capsules/plant) produced the lowest. For the number of seeds per capsule (Table 5, Figure 9), a highly significant difference (P = 0.00631) was found between varieties. SN103 (84.8 seeds/capsule) and SN203 (82.66 seeds/capsule) produced the most seeds per capsule, while HB168 (67.20 seeds/capsule) produced the fewest. No significant differences (P = 0.226) were found between varieties for 1000-seed weight (Table 5, Figure 10). For seed yield per plant (Table 5, Figure 11), a highly significant difference (P = 0.00714) was revealed between varieties. Variety S42 (57.43 g/plant) showed the highest seed yield per plant, while varieties LC162 (37.89 g/plant) and SN303 (40.97 g/plant) showed the lowest. For potential yield per hectare (Table 5, Figure 12), a significant difference (P = 0.0156) was revealed between varieties. Variety S42 (3.79 t/ha) had the highest potential seed yield per hectare, while varieties LC162 (2.5 t/ha) and SN303 (2.71t/ha) had the lowest. For harvest index (Table 5, Figure 13), a highly significant difference (P = 0.00333) was revealed between varieties. Variety S42 (0.45) had the highest harvest index, while varieties LC162 (0.3) and SN303 (0.32) had the lowest.

Table 5: Analysis of variance for agronomic characteristics of six sesame varieties

Varieties	Parameters					
	NCP	NSC	TSW(g)	SYP(g/plant)	SYH(kg/ha)	HIP
HB168	207.67^{ab}	67.20^{b}	3.59^{a}	50.05^{ab}	3.30^{ab}	0.39^{ab}

LC162	155.33[b]	74.93[ab]	3.26[a]	37.89[b]	2.5[b]	0.3[b]
S42	245.53[a]	75.00[ab]	3.13[a]	57.43[a]	3.79[a]	0.45[a]
SN103	169.53[ab]	84.80[a]	3.48[a]	49.81[ab]	3.29[ab]	0.38[ab]
SN203	167.67[ab]	82.66[a]	3.44[a]	47.49[ab]	2.8[ab]	0.37[ab]
SN303	154.47[b]	76.80[ab]	3.47[a]	40.97[b]	2.71[b]	0.32[b]
F of Fisher	9.945	5.72	1.631	5.541	4.47	6.717
P at 5%	0.000602***	0.00631**	0.226 ns	0.00714**	0.0156*	0.00333**

Legend: ***very highly significant difference; **highly significant difference; *significant difference; ns: non-significant difference at 5% level; F: Fisher variable; P: associated probability. A single letter for a parameter: non-significant difference; two letters for a parameter: significant difference; more than two letters for a parameter: highly significant difference; NCP: number of capsules per plant; NSC: number of seeds per capsule; TSW: thousand-seed weight; SYP: seed yield per plant; SYH: potential seed yield per hectare; HIP: harvest index per plant.

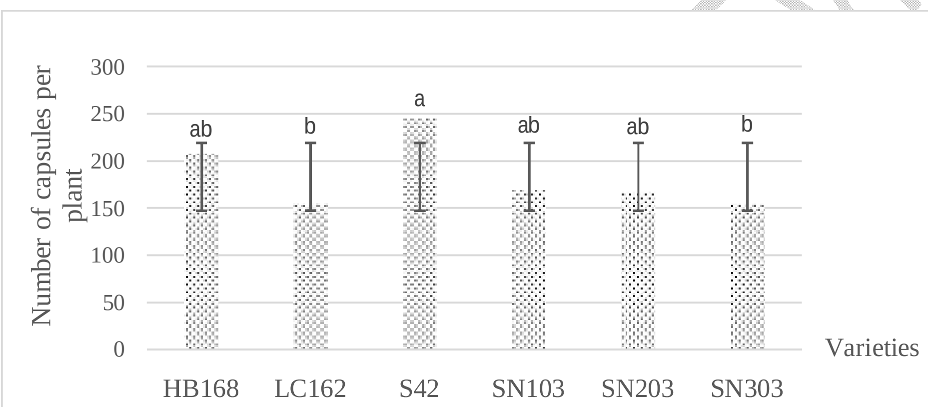

Figure 8: Number of capsules per plant

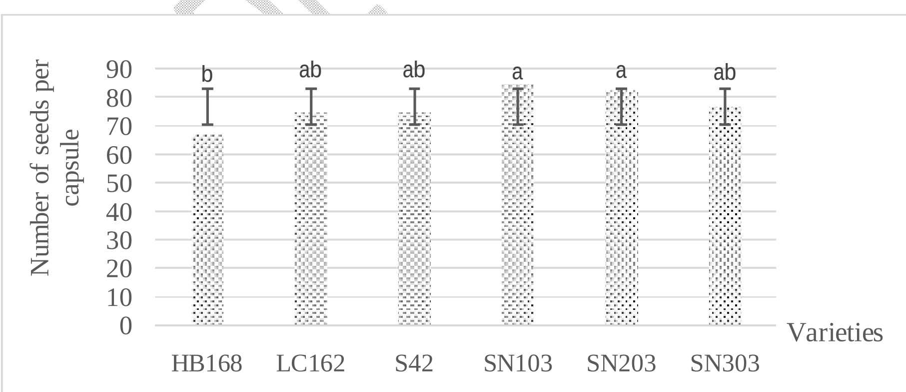

Figure 9: Number of seeds per capsule

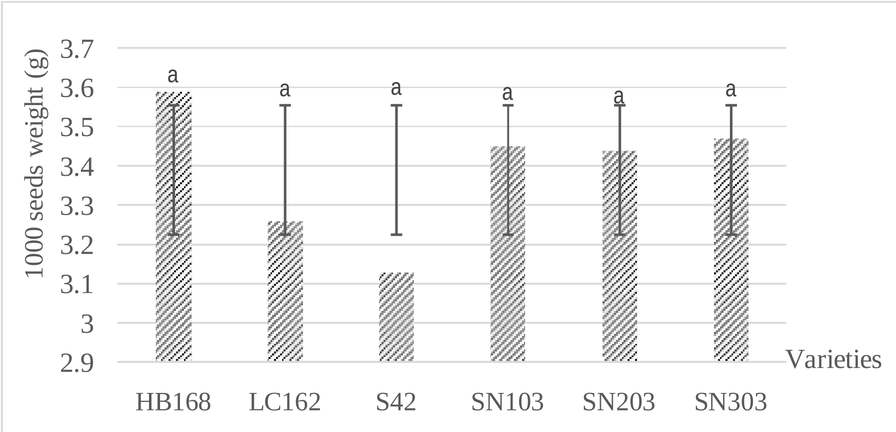

Figure 10: 1000-seed weight by variety

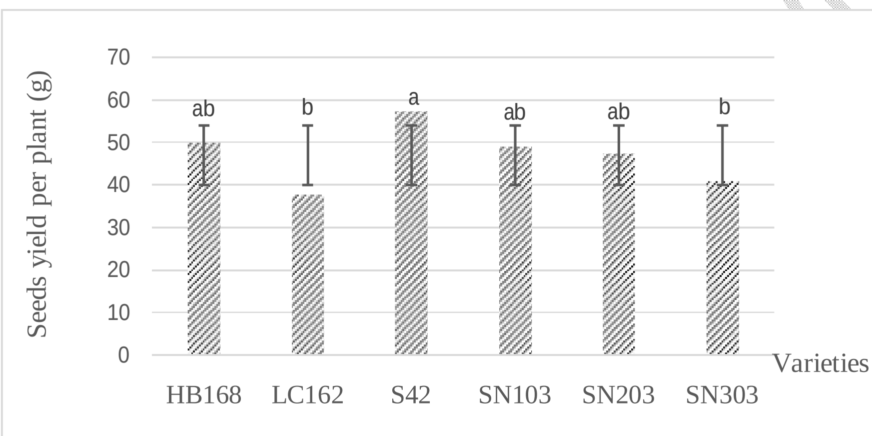

Figure 11: Seed yield per plant

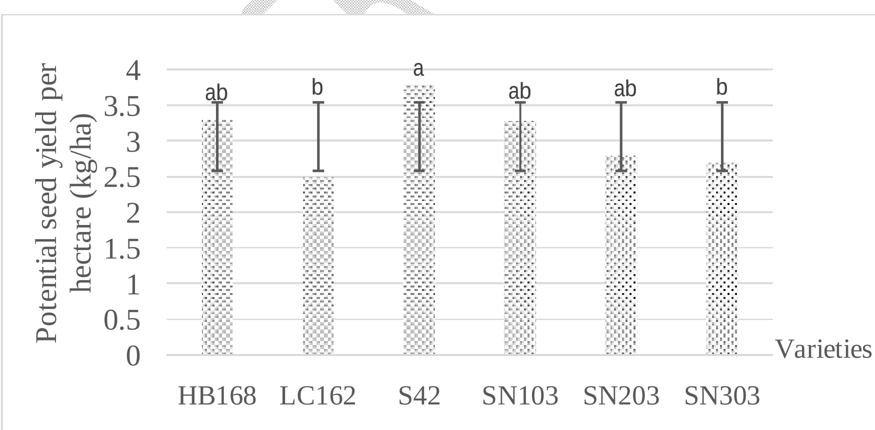

Figure 12: Potential seed yield per hectare

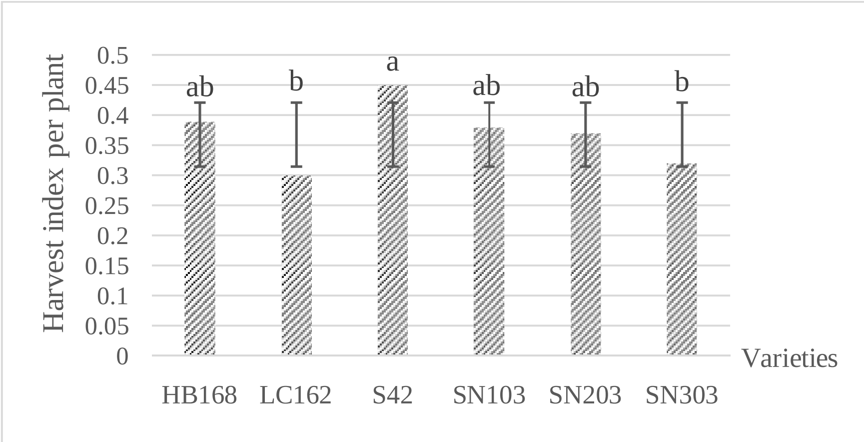

Figure 13: Harvest index per plant

3.4. Some illustrative images

Figure 14a shows a partial view of the field. Figures 14b and 14c show flowers and young bolls, respectively, of variety S42. Figure 14d shows the white seeds of varieties S42, SN103, SN203 and SN303 and Figure 14e shows the creamy-white seeds of varieties LC162 and HB168

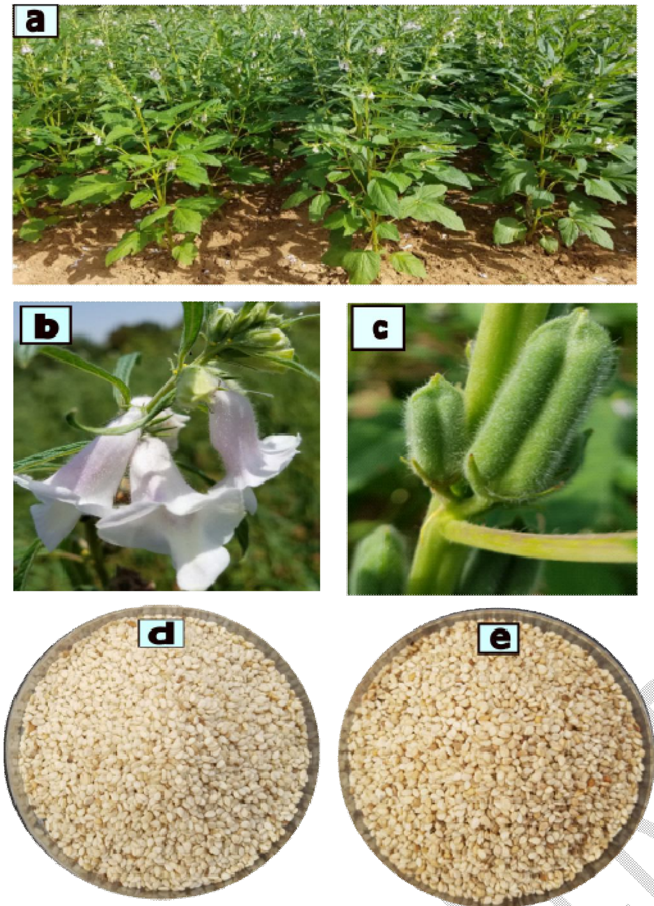

Figure 14: Illustrative photos (Badiel, 2022)

3.5. Discussion

Emergence was observed on day 3 after sowing (DAS) in all varieties. This means that humidity and temperature conditions were optimal, asIly[8] reported that emergence time in sesame can vary from 3 to 10 DAS depending on soil temperature and humidity. Indeed, the minimum temperature value for sesame germination is between 12.8°C and 13°C, while the maximum is between 45.5°C and 46°C [9, 10]. Flowering started at 35 days on the S-42 variety; 36 days on the SN103 and HB168 varieties; 37 days on the SN303 and LC162 varieties and 38 days on the SN203 variety, but there was no significant difference between the varieties in terms of cycle length, which was 90 days for all of them. Similar dates have been reported by other authors on sesame. These include: Seyniet *al*. [11], Ily[7] and Badiel [12] who reported a start of flowering at 34th DAS in the varieties S42 and 32-15, at 42nd DAS in Wollega and at 45th DAS in Humera with a cycle time of 90 DAS in the varieties S42 and 32-15 then 105 DAS in the varieties Wollega and Humera. These different flowering dates and cycle lengths show that the varieties S42, HB168, LC162, SN103, SN203 and SN303 can be considered as early-maturing due to their shorter cycle lengths than Wollega and Humera.

The study revealed that flowering occurred almost a third of the way through the development cycle in all varieties. This could be used to shift sowing dates to avoid water deficit at flowering and late rains at boll maturity [13]. The value of the collar diameter is a reminder of the plant's vigor. Neck diameters followed the same evolutionary kinetics, but at maturity, SN103 plants were the most vigorous (24.50 mm) and S42 plants the least vigorous (19.20 mm). In terms of root dry weight, HB162 (27.57 g), SN103 (27.26 g) and SN203 (25.96 g) had the highest values. As for height, number of branches and total dry biomass, no differences were revealed between varieties. This shows that vegetative development was similar in varieties HB168, LC162, S42, SN103, SN203 and SN303. This is linked to the genetic factor; as environmental conditions were the same for all varieties. Indeed, the environmental factor was also decisive on the development of these sesame varieties as, Compaoré [14], Ily[7] and Seyni et *al*. [9] have shown that the height, vigor and leaf area of sesame plants increase with the availability of water and nutrients in the soil. Similarly, Badiel [12] showed that water-deficient sesame plants were less developed than those with normal nutrition. This is due to the reduction in growth caused by the drop in photosynthesis intensity linked to the lack of water [15, 16].

Calculating the seed yield per plant produced different results for different varieties. Thus, the highest yield (57.43 g/plant) was recorded for variety S42, and the lowest (37.89 g/plant) for variety LC162. This difference in yield could be explained essentially by genetic character, as all these varieties were grown under the same climatic and environmental conditions. The number of capsules/plant and the number of seeds/capsules were decisive in the yield of these sesame varieties, as seed weight revealed no difference. In fact, the varieties that produced the most capsules and seeds per capsule had the highest seed yields (Table 5). Root dry weight was a discriminating factor between these sesame varieties (Table 4), in terms of its influence on seed yield. The SN203, SN103 and HB168 varieties with the highest root dry weights did not have the best seed yields. These results are similar to those reported byBadiel [12] on other sesame varieties. This author reported better seed yields in varieties S42, Wollega and Humera compared with that of variety 32-15, which had a higher root dry weight. Thus, greater root development in sesame would be at the root of a reduction in seed yield, as a large proportion of the photo assimilates destined for seed production would be used for root development. This hypothesis is supported by Diallo [17], who states that excessive root volume can reduce the translocation of nutrients from the roots to the aerial part, particularly to the plant's reproductive organs, and thus adversely affect yield. Similarly, Seyni et *al*. [9], who worked on sesame varieties 32-15 and Primoca, found a higher total root biomass in the Primoca variety, while the latter had a lower yield than the 32-15 variety. In fact, several authors such as Forestier [18], Diallo [17], Compaoré [14] and Seyni et *al*. [9] agree that the disproportionate development of the root system is a means of adapting to water deficits, by focusing on the search for water. We can therefore deduce from this study that varieties HB168, SN103 and SN203, which have a more developed root system, are better adapted to water deficit conditions than varieties S42, LC162 and SN303.

Conclusion

At the end of this study of sesame varieties, we found that seed emergence took place on the 3rd day of the season, the start of flowering varied from one variety to another, but the cycle duration was 90 days for all of them. All varieties had a similar level of vegetative development, but SN103 and SN303 were the most vigorous. Variety S42 produced more capsules, while LC162 and SN303 produced fewer. SN103 and SN203 capsules contained more seeds, while HB168 capsules contained fewer. The seeds of all these varieties had statistically the same weight. The ranking of these varieties in descending order on the basis of their seed yields is as follows: S42 HB168, SN103, SN203, SN303 then LC162. The best variety of foreign origin was HB168. It would be interesting to subject this variety to temporary and continuous water deficits in order to assess its adaptability.

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