



Screening of three sesame (*Sesamum indicum* L.) cultivars for defoliation effects on growth and yield in Côte d'Ivoire

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Abstract

Defoliation causes significant production losses in sesame. However, the varied reactions in relation to the phenological stages are not known. Therefore, the present study aimed to determine the most sensitive phenological stages. Thus, three varieties were subjected to 50 % defoliation at three phenological stages in a complete randomized block trial with three repetitions of 12 treatments. The analyses of variance carried out on the data recorded at the end of the cycle showed that the values of six of the seven parameters studied were different according to the variety of sesame and the phenological stage of the defoliation application. Thus, overall, the plants defoliated at the vegetative stage presented the lowest value for the number of bolls per plant (84), the mass of dry grains per plant (4.48 g) and the yield (597.082 to 1066.677 kg / ha). Also, plants defoliated at the beginning of flowering presented the lowest average value for three vegetative parameters: plant height (126.90 cm), stem diameter (10.04 mm), length of the shortest branch (0.47 cm). Consequently, plants defoliated at the start of flowering have the greatest average mass of dry grains, except in the cultivar *Benais Gbè* from Ladoué. Similarly, plants defoliated at the start of fruit set presented the highest average value for four of the six parameters. These latter results indicate that 50 % defoliation at the vegetative and early flowering stage decrease production and growth, respectively. They are useful for more efficient integrated management of farms.

Keywords: 50 % defoliation effects, Côte d'Ivoire, growth parameters, sesame (*Sesamum indicum* L.), yield parameters

Introduction

Sesame (*Sesamum indicum* L) is cultivated for its grains which are widely used because of their great richness in lipids, essential fatty acids, protein, vitamins (B, E), mineral elements (Ca, Fe, Mg, P, Zn) and oxalic acid (IPS, 2010; Amoukou *et al.*, 2013; Sene *et al.*, 2018a; Zanguï, 2020) ^[1, 2, 3, 4]. They are also used in oil production (Abou-Gharbia *et al.*, 2000) ^[5], in the pharmaceutical and cosmetic industries. Plant extracts are used in the integrated fight against biotic stresses (Syed *et al.*, 2015) ^[6].

So, the food, nutritional and socio-economic interests of these grains (IPS, 2010; Saha *et al.*, 2014; Sene *et al.*, 2018a, b) ^[1, 7, 3, 8] encourage large production. (Gamene, 2016) ^[9].

However, the yield per hectare, being very low (Rongead, 2013; Gamene, 2016) ^[10, 9], leads to the exploitation of very large areas of land. This low yield is due to several factors including the cropping system, agricultural inputs and abiotic and biotic stresses. Among bio-aggressors, insect pests or phytophagous (Some, 2000; Siéné *et al.*, 2021) ^[11, 12] are the most dangerous because they cause more than 70 % loss of production (Macoumba, 2002; Egonyu *et al.*, 2005) ^[13, 14]. Several control approaches are initiated by farmers. The most widespread and effective is chemical control. However, its misuse degrades the health of users, disturbs and/or kills pollinating insects and pollutes the environment (Tasei, 1996; Charlier and Plomteux, 2002; Jas, 2010; Gouda *et al.*, 2018) ^[15, 16, 17, 18].

Thus, in the context of agro-ecology and sustainable agriculture, to reduce these disadvantages as much as possible, is it wise to apply chemicals only at the phenological stage when they are most effective and efficient, i.e. say the stage where the defoliating effects decrease production the most. These phenological stages are, however, not known.

Thus, the present study aimed to determine the phenological stages most sensitive to defoliating agents through defoliation trials in three varieties of sesame.

The initiative for this research is based on the existence of at least one phenological stage at which defoliation reduces production the most.

Materials and Methods

Plant material

The plant material analyzed in this work was constituted of 720 four-months-old plants of three sesame varieties: these are variety *Benais Gbè* (V1) from Fouinan, variety *Yeya* (V) from Dioman and variety *Benais Gbè* (V3) from Ladoué. These varieties are less resistant to drought and less attacked by insects. They have good taste.

Collecte zone and experimental site

The seeds were collected in the villages (Dioman, Fouinan, Ladoué) of the administrative Department of Touba (8,17 ° N, 7,41° W) in Bafing region Western Côte d'Ivoire. The experiments were conducted at the experimental site of the Université Jean Lorougnon Guédé in Daloa (6,54° N, 6,26° W) (Côte d'Ivoire).

Carrying of the experiments

Plot setting and management

The cultural background of the plot was tomato and a combination of soybean, okra and maize. The plot was cleared with a machete and biomass burned when became dry. The soil has been finely worked with a hoe.

The experimental design adopted in this study is a randomized complete block with three replications. Blocks were distant of 0.5 m. Every block was splitted into 12 elementary plots separated by 0.3 m, with four for every one of the three varieties. Every elementary plot included four rows spaced 0.3 m apart and every row five sowing points also spaced 0.3 m apart.

Sowings were done at the rate of about 15 seeds per hole in december included in dry season spanning period in Côte d'Ivoire. From sowing to the end of the vegetative stage, watering was ensured before 8 a.m. every two days period. From flowering to capsule maturation, watering was daily. Five days after a rain, watering was resumed.

A thinning was carried out, leaving four seedlings per hole, as soon as the first pair of leaves appeared. Another thinning was carried out on the 16th day after germination, leaving the seedling with the highest number of true leaves.

Regular and continuous manual weeding was carried out. Two pesticide treatments with DECIS forte were carried out at a dose of 100 g/L on the 14th and 47th day after germination (DAG) at the vegetative stage. At the fruiting stage a fungicide, BANCO PLUS (550 g/L) was applied.

Application of defoliation

The defoliation consisted in manually cutting 50 % of the leaves (one leaf out of two per node) of every plant at three phenological stages: at the vegetative stage (30 days after germination: 30 DAG, at the start of the flowering and fruit set. Each of the four elementary plots assigned to each of the three varieties per block corresponds to one of the four defined levels of defoliation. These levels were:

- Do: non-defoliated plants (controls);
- D1: defoliation at the vegetative stage (30 days after germination: 30 DAG);
- D2: defoliation at the start of flowering; and,
- D3: defoliation at the start of fruit set (beginning of capsules formation).

Data recording

The data were recorded, at the individual plant basis and at the end of the cycle, for plant height (PH), main stem diameter (SDia), number of branches (NBr) on the main stem and twigs, length of the longest branch (LLBr), length of the shortest branch (LSBr), number of capsules per plant (NCap) and dry seeds mass per plant (SMass).

Data processing

Two factors of variability are studied: the variety and the stage of development and growth of the plant at which the defoliation was applied or stage of defoliation.

The numerical data obtained were subjected to analyses of variance (ANOVA) with these two variability factors to assess, at the risk $\alpha = 0.05$, $\alpha = 0.01$, $\alpha = 0.001$ the statistical significance of the differences in the means for the varieties, the defoliation stages and their interactions. The Fisher's LSD test was performed to determine the different homogeneous groups of means per parameter in relation to the levels of every one of the factors, when the ANOVA showed a significant difference. All these analyses were performed with Statistica software version 7.1.

Results and Discussion

Effects of the variety on the parameters

The three varieties (V1 : *Benais Gbè*, V2 : *Yeya*, V3 : *Benais Gbè*) were different significantly ($p < 0.01$) for plant height (PH), highly significantly ($p < 0.01$) for stem diameter (SDia), length of the shortest branch (LSBr), dry seeds mass per plant (SMass), very highly significantly ($p < 0.001$) for the number of branches (NBr) (Table 1).

Table 1: Comparison of the mean values of the parameters in the three sesame varieties studied

Parameter	Varieties			P
	V1	V2	V3	
PH (cm)	141.57 ^{a*}	133.49 ^b	137.45 ^{ab}	0.038043
SDia (mm)	12.58 ^a	12.99 ^a	11.72 ^b	0.005115
NBr	18.18 ^b	22.23 ^a	18.78 ^b	0.000041
LLBr (cm)	78.50 ^a	75.30 ^a	77.38 ^a	0.670554
LSBr (cm)	0.98 ^a	0.92 ^a	0.57 ^b	0.001323

NCap	107.69 ^a	99.57 ^a	94.93 ^a	0.393703
S _{Mass} (g)	6.69 ^a	7.21 ^a	5.20 ^b	0.003936

PH : plant height, SDia : stem diameter, NBr : number of branches, LLBr : length of the longest branch, LSBr : length of the shortest branch. NCap : number of capsules, S_{Mass} : dry seeds mass, V1 : variety with white seeds from Fouinan (*Benais Gbè*), V2 : variety with red seeds from Dioman (*Yeya*), V3 : variety with white seeds from Ladoué (*Benais Gbè*), P : probability associated to Fisher F test. *Values with same letter(s) on a line do not differ significantly at 5, 1 or 0.1 % level by LSD test.

Thus, the variety V1, *Benais Gbè* collected in Fouinan, presented the greatest average plant height (141.57 cm), the variety Yeya (V2) with red seeds collected in Dioman presented the largest average diameter (12.99 mm), the largest number of branches (22) and the largest average grain mass per plant (7.22 g) (Table 2), while the variety *Benais Gbè* (V3) from Ladoué has the smallest average diameter (11.72 mm), the shortest length (0.57 cm) of the least developed branch, the lowest average grain mass per plant (5.20 g).

Similar significant variations have also been observed by Ogbonna and Ukaan (2012) ^[19], Pandey *et al.* (2015) ^[20], Kumar *et al.* (2016) ^[21], Udo *et al.* (2017) ^[22], Zangui (2020) ^[4], Siéné *et al.* (2021) ^[12] in growth and yield attributes (plant height, stem diameter, ramifications number, pod number per plant, 1000-seeds weight, seeds weight per plant, seed yield) of sesame lines or accessions. This type of results was noted in other crops. Significant differences were reported for plant height, number of branches per plant, number of fruits per plant, number of fruits per cluster, single fruit weight by Saiful *et al.* (2016) ^[23] in tomato, for boll number per plant, boll weight, seed cotton yield by Gormus *et al.* (2017) ^[24] in cotton, grain yield and its components in soybean by Durli *et al.* (2020) ^[25].

According to Fraryand Douánlar (2003) ^[26], Cai *et al.* (2016) ^[27], Yang *et al.* (2021) ^[28], some plant morphology and yield-related traits such plant height, stem caliber, branch and capsules numbers, branch height are genetically controlled, whereas others such yield depend on environmental resources. These environmental resources can regulate genetic control (Yang *et al.*, 2021) ^[28]. Thus, results comparison should be allowed when experimental conditions are similar. Results of this work were obtained in dry season on non-fertilized soil should not be logically compared to others obtained on fertilized ones (Siéné *et al.*, 2021) ^[12] and in rainy season (Amoukou *et al.* 2013) ^[2], although some similarities could be observed with other results (Macoumba, 2002 ; Amoukou *et al.*, 2013 ; Siéné *et al.*, 2021) ^[13, 2, 12].

Effects of growth stage for defoliation application on the parameters

The phenological stage at which defoliation was applied resulted in differences (Table 2) that were significant ($p < 0.05$) for dry seed mass per plant (S_{Mass}), highly significant ($p < 0.01$) for stem diameter the stem (SDia) and the length of the shortest branch (LSBr), very highly significant ($p < 0.001$) for the number of branches (NBr).

Concerning the diameter of the stem (SDia), the average values obtained in non-defoliated plants (controls) (D0), defoliated plants at the vegetative stage (30 days after germination: DAG) and at the start of flowering (D2) were statistically identical and lower than those of plants defoliated at fruit set (start of capsules formation) (D3).

Regarding the number of branches (NBr), the analysis showed that plants defoliated at the start of fruit set (D3) were the most branching (22.66), while plants defoliated at the vegetative stage (30 DAG) (D1) branched the least (17). The length of the shortest branch (LSBr) was greater in non-defoliated plants (controls) (D0) and decreased with growth and development (from D1 to D3). Concerning the mass of dry grains per plant (S_{Mass}), plants defoliated at the vegetative stage, 30 DAG, (D1) presented the lowest average value (5.39 g) and those defoliated at the beginning of flowering (D2), the highest value (7.24 g).

Table 2: Comparison of the mean values of the parameters across the phenological stages of defoliation application

Parameter	Defoliation				P
	D0	D1	D2	D3	
PH (cm)	137.63 ^{a*}	136.17 ^a	137.10 ^a	138.96 ^a	0.942991
SDia (mm)	12.25 ^b	11.78 ^b	12.16 ^b	13.54 ^a	0.001402
NBr	18.93 ^{bc}	17.02 ^c	20.43 ^{ab}	22.66 ^a	0.000012
LLBr (cm)	75.30 ^a	76.09 ^a	78.35 ^a	78.40 ^a	0.841524
LSBr (cm)	1.13 ^a	0.80 ^b	0.69 ^b	0.65 ^b	0.001109
NCap	101.28 ^a	87.77 ^a	106.74 ^a	107.36 ^a	0.216671
S _{Mass} (g)	6.43 ^{ab}	5.39 ^b	7.24 ^a	6.53 ^{ab}	0.036462

PH : plant height, SDia : stem diameter, NBr : number of branches, LLBr : length of the longest branch, LSBr : length of the shortest branch. NCap : number of capsules, S_{Mass} : dry seeds mass, D0 : non-defoliated plants (controls), D1 : plants defoliated in vegetative stage (30 days after germination), D2 : plants defoliated at the start of flowering, D3 : plants defoliated at the start of fruit set (beginning of capsules formation), P : probability associated to Fisher F test. *Values with same letter(s) on a line do not differ significantly at 5, 1 or 0.1 % level by LSD test.

For stem diameter and number of branches, compared to non-defoliated plants, the values decreased by defoliation at the vegetative stage (D1: 30 DAG), then increased until defoliation at the start of fruit set (D3) (Table 2) to be greater than those of the controls. At the levels of the less developed branch and the mass of dry grains, the values did not vary either in this direction or in the opposite.

Results from the present study are not in agreement with those of Islam (2010) [29] who observed in sesame, on the one hand, the highest number of capsules per plant (54) and seed mass per plant (9.6 g) in non-defoliated (control) plants and, on the other hand, 47 to 79 % seed yield per plant regular reduction with progressive growth stage of defoliation.

Also, contrasted results, compared with the present findings, were obtained in other crops. In cotton, similar values variation tendency in this work was described by Gormus *et al.* (2017) [24] for seed cotton yield in relation to defoliation timings treatments. Also, on the contrary, Khan and Y Lome (2005) [30] observed, for the same level of defoliation (50 %), that mustard (*Brassica juncea* L.) plants defoliated at pre-flowering (40 days after sowing) exhibited a higher rate of photosynthesis, growth and yield compare to defoliation in post-flowering stage and non-defoliation.

Defoliation at the start of flowering increased the mass of dry grains per plant. It certainly stimulated flowering with the corollary of increasing the number of capsules by increasing the number of flowers and reducing the fall of these or the increase in the mass of each grain.

Moreover, the effects of defoliation, inhibition or activation of growth and development and increase in plant production, also depend on the planting density. Indeed, even near total defoliation can increase production. This happened in sweetcorn where Bhandari *et al.* (2022) [31] obtained significantly higher values of number of kernels, number of rows, 1000 grains weight in plants 50 % tassed and carrying only three leaves below the ear

Effects of the interaction of the variety and the stage of defoliation application on the parameters

The analysis of variance revealed that the combined action of the variety and the phenological stage of defoliation application generated significant variations ($p < 0.05$) in plant height (PH), branch number (NBr), number of capsules per plant (NCap) (Table 4), highly significant ($p < 0.01$) at stem diameter (SDia), length of the shortest branch (LSBr), seeds mass per plant (SMass) (Table 3), by extrapolating the estimated seed yield (Figure 1).

For each of these six parameters, the sesame variety (V1, V2, V3) and the phenological stage of defoliation application (D0, D1, D2, D3) at the levels of which the minimum and maximum values were, respectively, obtained are mentioned in table 3 and figure 1. It is found that the smallest plants (123.90 cm) and those with the lowest diameter (10.4 mm) were observed in V3 defoliated at the start of flowering (D2), while tallest plants (143.76 to 145.82 cm) in V3 control, V1 defoliated at the start of flowering (D2) and fruit set (D3) and highest diameter (14.26 mm) in V1 plants defoliated at D3. The least branching plants (with about 16 branches) were V1 non-defoliated and defoliated at D1 and V3 defoliated at D1. The most branching (26) ones were V2 defoliated at D3.

Table 3: Effects of the interaction of variety and phenological stage of defoliation application on the parameters analyzed.

Variety	Defoliation	Parameters						
		PH (cm)	SDia (mm)	NBr	LLBr (cm)	LSBr (cm)	NCap	SMass (g)
V1	D0	136.67 ^{ab*}	11.10 ^{de}	15.70 ^d	71.43 ^a	1.58 ^a	91.38 ^{bc*}	5.57 ^{bcd}
V1	D1	140.58 ^a	11.76 ^{bcde}	15.91 ^d	76.78 ^a	0.68 ^d	89.08 ^{bc}	4.48 ^d
V1	D2	145.02 ^a	12.96 ^{abc}	19.48 ^{cd}	82.8 ^a	0.80 ^{bcd}	119.64 ^{ab}	8.65 ^a
V1	D3	145.82 ^a	14.26 ^a	21.10 ^{bc}	84.68 ^a	0.71 ^{cd}	126.51 ^a	7.62 ^{abc}
V2	D0	132.16 ^{ab}	13.40 ^{ab}	20.95 ^{bc}	72.81 ^a	1.23 ^{ab}	108.97 ^{abc}	8.14 ^a
V2	D1	133.27 ^{ab}	12.18 ^{bcd}	18.78 ^{cd}	79.16 ^a	0.99 ^{bc}	83.95 ^c	6.40 ^{abcd}
V2	D2	137.27 ^{ab}	13.03 ^{ab}	23.43 ^{ab}	76.41 ^a	0.75 ^{cd}	107.19 ^{abc}	7.83 ^{ab}
V2	D3	131.06 ^{ab}	13.42 ^{ab}	25.98 ^a	73.61 ^a	0.72 ^{cd}	99.24 ^{abc}	6.53 ^{abcd}
V3	D0	143.75 ^a	12.27 ^{bcd}	20.13 ^{bc}	81.22 ^a	0.57 ^d	103.51 ^{abc}	5.57 ^{bcd}
V3	D1	137.79 ^{ab}	11.39 ^{cde}	16.13 ^d	78.28 ^a	0.71 ^{cd}	90.74 ^{bc}	6.40 ^d
V3	D2	126.90 ^b	10.08 ^e	17.83 ^{cd}	74.86 ^a	0.47 ^d	89.94 ^{bc}	4.73 ^d
V3	D3	139.62 ^{ab}	12.91 ^{abc}	21.00 ^{bc}	76.41 ^a	0.50 ^d	94.73 ^{abc}	5.34 ^{cd}
	<i>P</i>	0.040132	0.002737	0.026515	0.347917	0.005828	0.029932	0.008244

PH : plant height, SDia : stem diameter, NBr : number of branches, LLBr : length of the longest branch, LSBr : length of the shortest branch, NCap : number of capsules per plant, SMass : dry seeds mass per plant, V1 : variety with white seeds from Fouinan (*Benais Gbè*), V2 : variety with red seeds from Dioman (*Yeya*), V3 : variety with white seeds from Ladoué (*Benais Gbè*), D0 : non-defoliated plants (controls), D1 : plants defoliated in vegetative stage (30 days after germination), D2 : plants defoliated at the start of flowering, D3 : plants defoliated at the start of fruit set (beginning of capsules formation), P : probability associated to Fisher F test. *Values with same letter(s) on a line do not differ significantly at 5, 1 or 0.1 % level by LSD test.

The lowest capsules number per plant (83.95) was recorded in V2 plants defoliated at D1, while the highest (126.51) in V1 x D3 defoliated plants. The lowest seeds mass per plant (4.47 to 5 g) were produced by V1 x D1 defoliated and V3 defoliated at D1 and D2, while the highest (8.14 to 8.65 g) produced by V2 non-defoliated and V1 x D2 defoliated plants. These observations are valid for the estimated seed yield: the lowest seed yield, 597.082 to 611.007 Kg/ha, were obtained in V1 defoliated at D1 and in V3 defoliated at D2, the highest, 1406.306 Kg/ha, in V1 defoliated at D2 (Figure 1).

Significant interaction effects of other kinds involving defoliation have been recorded in other studies. These are, for example, the interaction of the degree of defoliation by tomato variety on the plant height, number of branches per plant, number of fruits per plant, number of fruits per cluster, fruit weight, fruit yield per plant (Saiful *et al.*, 2016)^[23], degree of defoliation by growth stage on production components in cowpea (Smiderle *et al.*, 2017)^[32], variety by growth stages on cotton yield attributing characters (Gormus *et al.*, 2017)^[24], growth stage by degree of defoliation (Durlı *et al.*, 2020)^[25] on soybean grain yield and its components in vegetative stage.

It is not noted a continuous of increase or decrease in the values of a given parameter parallel to the growth of the plants, in the varieties studied. Increases and decreases over controls were observed. Gormus *et al.* (2017)^[24] observed the same in cotton for boll number per plant and seed yield, on the other hand, a unidirectional increase, for boll weight.

Yield increasing may be attributed, on the one hand, to improved capsules number per plant and seeds weight per capsule and, on the other hand, reduction in late defoliant application to environmental conditions (Gormus *et al.*, 2017)^[24] and to reduction of photosynthetic activity limiting quantity of the produced products and eventually reducing weight of grains.

It appeared in this study that plants defoliated at the beginning of flowering (D2) had the lowest average value for three (plant height, stem diameter, length of the shortest branch) of the four vegetative parameters.

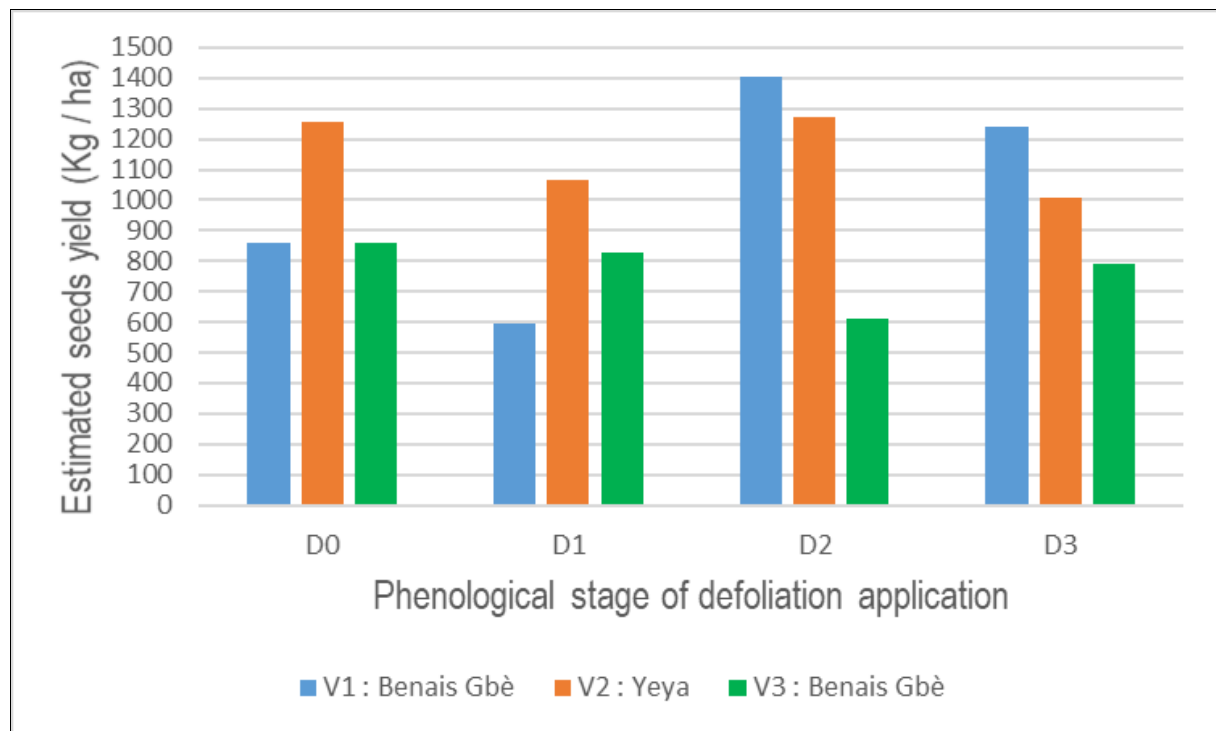


Fig 1: Estimated seed yield of the three sesame varieties studied defoliated at different growth stages

Legend :

- Do: non-defoliated plants (controls);
- D1: plants defoliated at the vegetative stage (30 days after germination);
- D2: plants defoliated at the start of flowering; and,
- D3: plants defoliated at the start of fruit set (beginning of capsules formation).

It also appeared globally that the defoliated plants at the vegetative stage (30 DAG) (D1) presented the lowest average value of the production parameters, 83.9500 capsules per plant, 4.48 g of seeds per plant and 597.082 Kg seeds/ha. Consequently, plants defoliated at the beginning of fruit set (capsule formation) (D3) presented the highest average value for four of the six parameters (Plant height: PH, stem diameter: SDia, number of granches: NBr, number of capsules: NCap). These last results suggest two facts: one is that defoliation at the beginning of fruit set (at the beginning of boll formation) (D3) does not seem to decrease production much less growth and development. Another is that, better, this defoliation seems to stimulate growth and development and production. Durlı *et al.* (2020)^[25] made similar findings in soybean.

Differences due to the growth stages at which defoliation was applied were also observed in sesame by Tewolde *et al.* (1994)^[33]. These authors showed clear and pronounced differences from 66 to 100 % defoliation. At 66 % defoliation before heavy fruiting (54 days after planting or earlier), plants are producing 85 to 103 % of the level of non-defoliated plants. Such variations were obtained in the present study. However, at 50 % defoliation at the start of fruit set, reductions in production were not systematic in the three varieties studied. While Tewolde *et al.* (1994)^[33] reported reductions of 20 to 30 % when defoliation occurs after heavy fruiting. It seems important to test several genotypes, accessions or varieties. These authors confirmed the increasing reduction in production as the plant grows (from the vegetative stage to boll filling) for 100 % defoliation where it is more severe (from 7 to 84 %).

High degrees of defoliation also caused significant differences in Sunflower in plant height, seed weight, seed yield (Vazin *et al.*, 2011)^[34]. Severe leaf removal (80 %) reduced the seed yield and seed weight to 11 % and 10.5 % respectively (Vazin *et al.* (2011)^[34]. This is in agreement with Saiful *et al.* (2016)^[23] who have observed in tomato that defoliation up to 38 % increased plant height, number of branches, number of fruits per plant, individual fruit weight, fruit yield per plant, whereas defoliation over reduced them.

These contrasts are reported by Smiderle *et al.* (2017)^[32] who observed, in cowpea, that defoliation up to 67 % at vegetative, flowering and pod production stages did not influence the number of seeds per pod, but reduced the mass of one thousand seeds. They also reported that defoliation of 67 %, at the flowering stage, reduced the number of pods per plant, the number of seeds per plant, mass of seeds and pods per plant, as well as yield estimate. Also, defoliations of 67 % reduced number of seeds per pod at pod production stages. Gormus *et al.* (2017)^[24] revealed that cotton cultivars and growth stages impacted the defoliation efficacy. Thus, significant reductions in seed cotton yield and boll number per plant occurred with defoliant applications both prior to and after 60 % open boll.

It is noted, in this work, that, contrary to the other parameters, for the mass of dry grains, it is the plants defoliated at the beginning of flowering (D2) and not defoliated (controls) (D0) which presented the average value the highest in two (respectively, V1: 8.65 g and V2: 8.14 g) of the three varieties studied. So, to have a very good regularity of the effects, it would be interesting to extend the study to many more varieties and repeat it over several years. In addition, the estimated grain yield varied according to the varieties and the stages of defoliation. Thus, the lowest individual values were obtained 597.082 kg/ha in V1 plants defoliated at D1 and 611.007 kg/ha in V3 plants at D2, while the highest 1406.306 kg/ha in V1 plants defoliated at D2. Overall, yield was much lower in plants defoliated at the vegetative stage and higher in plants defoliated at the start of flowering. In non-defoliated plants, it was 858,336 to 1,255,602 kg/ha.

The yields obtained in the present work are lower than the 1523 and 1832 kg ha⁻¹ of Tewolde *et al.* (1994)^[33], 1812.8 to 3987.4 kg.ha⁻¹ from Siéné *et al.* (2021)^[12], included between those 800 and 1400 kg.ha⁻¹ of Housseini (2013)^[35], 224 to 1648.33 kg/ha from Zangui (2020)^[4], higher than 640.3 to 863.9 kg/ha from Ogbonna and Ukaan (2012)^[19], 159.10 to 600 Kg/ha from Amoukou *et al.* (2013)^[2], 708.33 kg/ha from Kumar *et al.* (2016)^[21]. In these studies, yields were obtained under fertilization and sometimes during the rainy season. However, this work was carried out in the dry season and without fertilization. In similar conditions, the present values could be higher.

All the results of this study revealed the significant variations in certain vegetative and production parameters due to the varieties, the phenological stages at which the defoliations are applied and their interactions. They highlighted the phenological stages most sensitive to defoliation at 50 %. For better discrimination of effects, levels of 75 to 100 % defoliation should be tested.

Conclusion

The three varieties of sesame studied showed different mean values for plant height, stem diameter, number of branches of the main stem and branches, length of least developed branch, dry grain mass and different values for seed yield.

Also the phenological stage at which the 50 % defoliation was applied generated significant differences for the dry seeds mass, highly significant for the stem diameter and length of the shortest branch, very highly significant for the number of branches and the seed yield. Plants defoliated at the vegetative stage (30 days after germination) and at the start of flowering showed the lowest mean diameter and branched the least. On the other hand, plants defoliated at the vegetative stage produced the lowest average dry grain mass per plant and presented the lowest yield, whereas those defoliated at the beginning of flowering, the greatest average dry grain mass and the highest yield.

Furthermore, the values of six of the seven parameters studied which are plant height, stem diameter, number of branches, the length of the shortest branch, number of capsules, dry seeds mass per plant and seed yield were different according to the variety of sesame and the phenological stage of defoliation application. Thus, overall the plants defoliated at the vegetative stage presented the lowest average value for the production parameters, the plants defoliated at the start of flowering presented the lowest average value for three of the four vegetative parameters. Consequently, plants defoliated at the beginning of fruit set (boll formation) presented the highest average value for four of the six parameters including yield. Then, these results indicate that 50 % defoliation before the onset of fruit set decreases growth and development and production. They are useful for more efficient integrated farm management.

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