Australian Journal of Crop Science
AJCS
AJCS 17(5):353-360 (2023) ISSN:1835-2707
doi: 10.21475/ajcs.23.17.04.p3693

Performances of black seed sesame (*Sesamum indicum* L.) under low fertility saline soils

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Abstract

The world need for healthy cooking oil has readjusted research into other non-conventional oil crops like sesame. The importance of sesame is not only because of its healthy oil crop but also because of its short life cycle making it an attractive cash crop. The crop has been reported to be moderately sensitive to saline-soil and drought. Previous reports on the salinity tolerance were conducted on artificial saline soils with considering fertility thus it is important to evaluate the crops performance on naturally low fertility saline soils. Therefore, the objective of this study was to investigate the effect of saline-soil on growth, development and yield and yield related traits of black seed sesame. The pot experiment was conducted at Buri Ram province Thailand, in a 2 × 6 factorial in RCBD with three replications, where factor A was the soil salinity levels and factor B was the sesame cultivars. Sesame seeds were planted in a seedbed and later were transplanted into the 72 experimental pots each filled with 9 kg soil. Observed results showed that salinity levels had effect on sesame i.e. plant height, number of branches at 30 DAT, SCMR, total chlorophyll content, number of capsules, total dry weight and capsules dry weight. An interaction between salinity level and cultivar was also investigated i.e. number of branches and capsules, total and capsules dry weight and harvest index (HI). Salinity levels had influence on sesame both on growth and yield parameters; cv. Kanchanaburi and KKU2 showed higher number of capsules when compared with other cultivars grown under saline soil, whereas cv. Kanchanburi, UB3 and Buriram gave higher capsules dry weight under saline-soil.

Keywords: Salt tolerant, saline soil, black seed sesame, agronomic traits.
Abbreviations: RCBD_randomized complete block design; DAP_days after planting; DAT_days after transplanting; OM_organic matter; EC_electrical conductivity; SCMR_spad chlorophyll meter reading; TCC_total chlorophyll content; CF_chlorophyll fluorescence; HI_harvest index.

Introduction

Sesame (*Sesamum indicum* L.) is a member of the family Pedaliaceae. It is a short-day plant mostly grown in the tropical and subtropical areas of the world, it is considered a drought tolerant crop, thus making it ideal to be grown in areas that receives less rainfall (Amanullah et al., 2014). Sesame is ranked ninth among the cultivated oilseed crops in the world and world production is estimated at 6.80 million tons from 13.96 million ha of harvested area (FAOSTAT, 2020). It is one of the most ancient oilseed crops cultivated for its edible oil and also used as food for its very nutritious seeds that has also shown to confer health benefits (Wacal et al., 2021). The oil extracted from its seeds can be used in the manufacturing of pies, margarine, perfumes, lubricants, medicines and soap (Mamo et al., 2019). The seeds contain a very high oil content in the range of 32.8-62.7%. (Wei et al., 2015, Couch et al., 2017). Sesame is cultivated in arid and semi-dry regions of the world (Islam et al., 2016), Africa and Asia accounts for a larger share in cultivated area and production (FAOSTAT, 2020). Even though the crop has shown considerate drought tolerance, its biggest challenge is salinity as it has shown to limit sesame growth (Islam et al. 2016). One of the biggest challenges in arid and semi arid areas is the saline soils which is accelerated by deficit of precipitation and high temperature coupled with a high evaporation demand inadequate soil moisture (Aghajari et al., 2014; Joshi and Panchal, 2014; Azevedo et al., 2006). Plants capacity to tolerate saline soils varies widely between species and within species and level of tolerance also varies between phenological stages of a crop (Aghajari et al., 2014; Zhu et al., 2014). Sesame's response to salinity has been reported before and mostly varying in reference to the tolerance of the crop to salinity, Abbasdokht et al. (2012) and Bahrami (2012) reported sesame as moderately tolerant to saline stress while Land Development Department (2016) of Thailand reported that sesame is slightly tolerant to salt. Many studies have reported that plants at germination and initial growth stages tolerate higher salinity levels, but variability has been observed among sesame genotypes

(Abbasdokht et al., 2012; Bazrafshan and Ehsanzadeh, 2014). Salinity has been observed to significantly reduced sesame growth, yield, yield related traits and oil content, but in contrary it increased protein content of sesame cultivars (Yahya, 1998). Ramirez et al. (2005) and Gaballah et al. (2007) evaluated sesame genotypes for their salt tolerance and observed an increase in growth and yield parameters under low salinity level, but when the level of salinity increased the growth and yield parameters recorded a significant; variation in the level of tolerance varied among the genotypes evaluated.

In Thailand, sesame is cultivated as secondary crop, usually planted after harvesting main crops (rice, sugarcane or cassava) because of its short life cycle. This is an important crop for Thailand as some of the agricultural land is classified as saline and low fertility thus not suitable for the main crops that are saline sensitive like rice and cassava. However, knowledge of sesame cultivation under saline-soil especially in black seed sesame is unclear. Therefore, this study was conducted to evaluate growth, yield and yield related traits of black seed sesame grown under saline-soil with low fertility soil.

Results

Effect of saline soil on agronomic traits of sesame

Plant height: At 15 DAT, no significant difference was found on plant height between saline and non-saline soil, but at 30 and 45 DAT plant height of sesame showed significant difference for crops grown in saline and non-saline soil, as plants grown in saline soil had shorter plant height than non-saline soil (Fig. 1 A). A significant difference on plant height was also observed between the cultivars, cv. Kanchanaburi and UB3 had highest plant height at 15, 30 and 45 DAT whereas cv. KKU2 showed higher plant height both 30 and 45 DAT (Table 1). There was no interaction between soil and sesame cultivar on plant height at 30 and 45 DAT but a significant interactive was observed at 15 DAT ($P \leq 0.01$). The result on plant height on individual genotypes shows that Kanchanaburi grown under non-saline soil showed higher plant height (31.8 cm) than other combinations but was not significantly different to cv. Buriram, UB3, CM07 grown under saline soil (29.8, 28.2 and 28.0 cm, respectively) (Table 2).

Number of branches per plant: A significant difference was observed between plants grown under saline and non-saline soil at 30 DAT but none was found at 45 DAT. At 30 DAT, sesame grown under non-saline soil showed higher average number of branches (2.1) than grown in saline soil (1.7) (Fig. 1B), and cultivar recorded a higher average number of branches except for KU18 and Buriram both at 30 and 45 DAT (Table 1). The interactive effect of soils and sesame cultivar was significant at 30 DAT, with CM07, KKU2, UB3 and Kanchanaburi grown under non-saline soil recorded a higher average number of branches, whereas at 45 DAT, CM07 grown under non-saline soil and UB3 grown under saline soil recorded a higher average number of branches (3.5 and 3.0 branches, respectively) (Table 2).

Spad chlorophyll meter reading (SCMR): At 30 DAT, SCMR value was not significantly different but at 45 DAT a significant difference was observed. At 45 DAT, SCMR of sesame grown under saline soil was lower than for plants grown under non-saline soil (38.6 and 44.0 unit, respectively) (Fig.1 C). However, SCMR values were not influenced by sesame cultivars ($P>0.05$) (Table 1) and no interaction observed between salinity levels and sesame cultivar on SCMR value ($P>0.05$) (Table 2).

Total chlorophyll content: Soils differences had no effect on total chlorophyll content both at 30 and 45 DAT (Fig. 1D). However, total chlorophyll content showed significant differences among cultivars at 45 DAT ($P \leq 0.05$), cv. KKU2 had highest total chlorophyll content (12.56 µg cm^{-2}) while there was no significant difference among the other five cultivars (cv. KU18, CM07, UB3, Kanchanaburi and Buriram) ($P>0.05$) (Table 1), also there was no interaction observed between treatment combinations (Table 2).

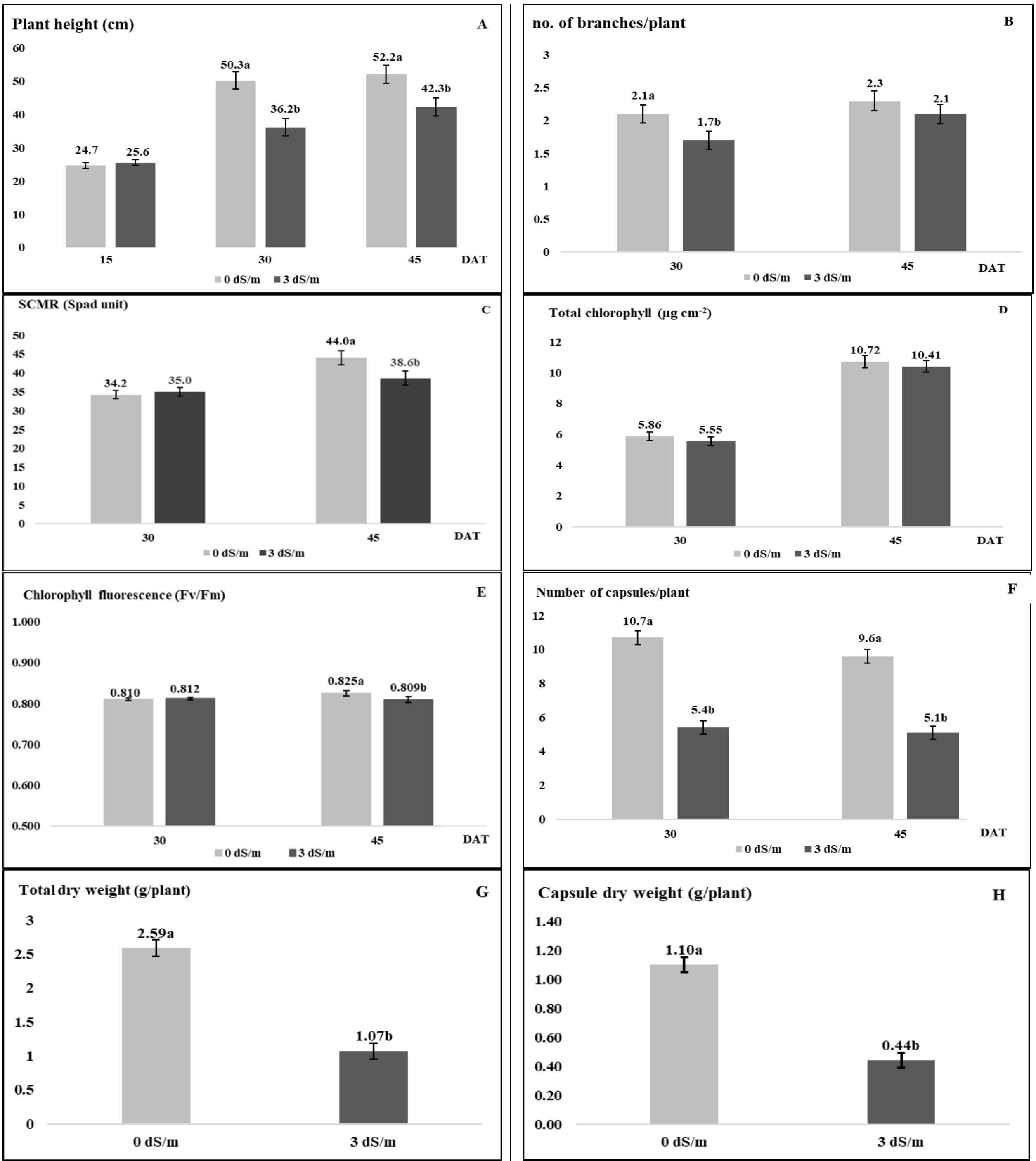
Chlorophyll fluorescence (Fv/Fm): The result showed that there was significant different on chlorophyll fluorescence between non-saline and saline soil at 45 DAT, plants grown under non-saline soil had higher fluorescence than sesame grown under saline soil (0.825 and 0.809 respectively), and no significant differences were observed at 30 DAT (Fig. 1 E). However, no significant differences were observed among sesame cultivars both at 30 and 45 DAT (Table 1) and also there was no interaction between treatment combinations (Table 2).

Effect of salinity levels on yield and yield component of sesame

Number of capsules: The number of capsules was affected by type of soil as the number was about 50 percent less in plants grown under saline soils as compared to plants in non-saline soil both at 30 (5.4 and 10.7 capsules respectively) and 45 DAT (5.1 and 9.6 capsules, respectively) (Fig. 1F). A significant difference on number of capsules was observed among the cultivars, with KKU2 recording the highest number of capsules both in 30 and 45 DAT (16.1 and 11.9 capsules, respectively) but was not significantly different from Kanchanaburi at 45 DAT (Table 3). There was interaction between soil type and sesame cultivar ($P \leq 0.05$) and KKU2 grown under non-saline soil recorded the highest capsules than other treatments (21.3 capsules) followed by UB3 and Kanchanaburi grown under non-saline soil (11.0 and 10.8 capsules, respectively). Under saline soil, KKU2 had higher number of capsules than other cultivars (11.0 capsules) but it was lower compared to the same cultivar under non-saline (Table 4).

Total dry weight: Saline soil affected total dry weight as there was significant difference between saline soil and non-saline soil. Total dry weight of sesame grown under non-saline soil was 2.5 times higher than that of plants grown under saline soil (2.59 and 1.07 g $plant^{-1}$, respectively) (Fig. 1 G). Total dry weight among cultivars was also significantly different, with KKU2, Buriram, Kanchanaburi and UB3 recording a higher weight of (2.47, 2.25, 2.21 and 2.06 g $plant^{-1}$, respectively) as compared to the other two cultivars (Table 3). Interaction between salinity levels and cultivars on this parameter was observed, as KKU2 grown under non-saline soil had highest total dry weight (4.08 g $plant^{-1}$) however, this cultivar had lowest total dry weight when grown under saline soil (0.85 g $plant^{-1}$). All the cultivars recorded a lower weight when grown under saline conditions as compared to when grown under non-saline conditions (0.40-1.54 g $plant^{-1}$) (Table 5).

Capsules dry weight: This parameter was significantly affected by soils and cultivars. Capsules dry weight for plants



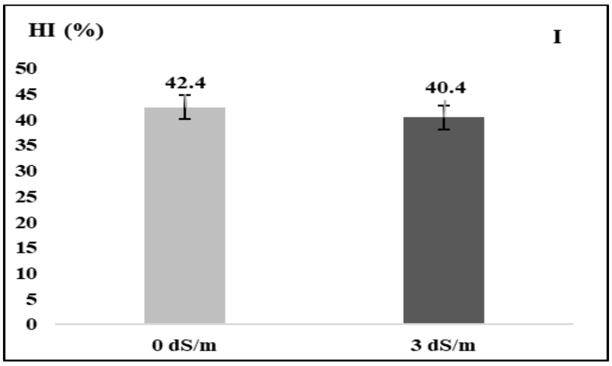


Fig. 1 The effect of salinity level (Factor A) on plant height (A), no. of braches plant^{-1} (B) SCMR (C), total chlorophyll content (D), Chlorophyll fluorescence (Fv/Fm) (E), no. of capsule plant^{-1} (F), total dry weight plant^{-1}(G), capsule dry weight plant^{-1} (H) and HI (I) of black sesame DAT; Days after transplanting, compare mean by LSD method.

Table 1. Some agronomic traits on plant height, number of branches per plant, SCMR, total chlorophyll content and chlorophyll fluorescence (Fv/Fm) of six cultivars in black sesame (Avg. between non-saline and saline soil).

cultivar (B)	Plant height (cm)			No. of branch pl^{-1}		SCMR (SPAD unit)		TCC ($\mu g\ cm^{-2}$)		Fv/Fm	
	15	30	45	30	45	30	45	30	45	30	45
	DAT			DAT		DAT		DAT		DAT	
KU18 (B1)	18.8c	30.2c	35.1b	1.3b	1.3b	32.0	36.5	5.38	10.05b	0.809	0.809
CM07 (B2)	26.6a	40.2b	41.8b	2.3a	2.7a	35.6	42.4	6.38	10.68b	0.812	0.817
KKU2 (B3)	23.1b	53.8a	58.7a	2.3a	2.6a	36.5	46.8	5.49	12.56a	0.812	0.830
UB3 (B4)	27.7a	45.4ab	52.2a	1.9a	2.7a	34.7	38.4	5.60	10.52b	0.811	0.813
Kanchanaburi (B5)	26.6a	50.8a	56.1a	2.2a	2.5a	34.0	41.8	5.68	10.13b	0.809	0.818
Buriram(B6)	28.0a	38.9bc	39.7b	1.4b	1.6b	34.8	41.9	5.70	9.43b	0.813	0.817
F-test	**	**	**	**	**	ns	ns	ns	**	ns	ns

ns and **; not significant and significantly different at P≤0.01 respectively, compare mean by LSD method. DAT: days after transplanting; PH: plant height; TCC: total chlorophyll content

Table 2. Interaction effect between salinity level and cultivar on plant height, number of branches per plant, SCMR, total chlorophyll content and chlorophyll fluorescence of six cultivars in black sesame.

A × B		Plant height (cm)			No. of branch pl^{-1}		SCMR (SPAD unit)		TCC ($\mu g\ cm^{-2}$)		Fv/Fm	
		15 DAT	30DAT	45 DAT	30 DAT	45 DAT	30 DAT	45DAT	30DAT	45 DAT	30 DAT	45DAT
A0	B1	16.1e	37.9	40.9	1.3e	1.3d	31.6	40.2	5.64	9.76	0.812	0.820
	B2	25.2cd	41.4	41.4	3.0a	3.5a	36.5	45.0	6.62	11.5	0.807	0.820
	B3	21.4d	63.3	65.9	2.7ab	2.7b	34.8	49.3	5.55	12.38	0.811	0.842
	B4	27.3bc	56.1	57.2	2.3a-c	2.3bc	34.1	44.4	5.75	11.17	0.808	0.830
	B5	31.8a	60.7	61.8	2.3a-c	2.5bc	33.4	43.6	6.33	10.5	0.812	0.824
	B6	26.3bc	42.3	46.2	1.3e	1.8cd	34.6	41.5	5.28	9.02	0.808	0.816
A1	B1	21.4d	22.4	29.3	1.3e	1.3d	32.4	32.7	5.13	10.35	0.807	0.799
	B2	28.0a-c	39.1	42.1	1.7c-e	1.8cd	34.7	39.8	6.14	9.89	0.816	0.814
	B3	24.8cd	44.3	51.5	2.0b-d	2.5bc	38.3	44.3	5.42	12.74	0.814	0.819
	B4	28.2a-c	34.8	47.2	1.5de	3.0ab	35.3	32.4	5.45	9.87	0.814	0.796
	B5	21.4d	41	50.5	2.0b-d	2.4bc	34.6	40.0	5.03	9.77	0.806	0.812
	B6	29.8ab	35.5	33.3	1.5de	1.5d	35.0	42.3	6.12	9.83	0.817	0.817
F-test (A × B)		**	ns	ns	*	**	ns	ns	ns	ns	ns	ns
CV (%)		10.4	17.9	17.1	22.0	20.1	9.9	13.8	14.9	11.0	1.0	2.4

ns, * and **; not significant, significantly different at p ≤ 0.05 and p≤ 0.01 respectively, compare mean by LSD method
A represent salinity level; A0; 0 ds/m, A0; 3 ds/m and B represent cultivar of black sesame; B1; KU18, B2; CM07, B3; KKU2, B4; UB3, B5; Kanchanaburi and B6; Buriram.
TCC: total chlorophyll content.

Table 3. Some agronomic traits on Number of capsules per plant, TDW, CDW and HI of six cultivars in black sesame (Avg. between non-saline and saline soil).

cultivar (B)	Number of capsules per plant		TDW ($g\ pl^{-1}$)	CDW ($g\ pl^{-1}$)	HI (%)
	30 DAT	45 DAT			
KU18 (B1)	3.2d	3.0e	0.64c	0.25d	43.8ab
CM07 (B2)	5.5c	4.6d	1.36b	0.52c	37.7bc
KKU2 (B3)	16.1a	11.9a	2.47a	0.81b	34.4c
UB3 (B4)	7.4b	8.0b	2.06a	0.95b	45.5a
Kanchanaburi (B5)	8.8b	10.5a	2.21a	0.95b	40.0abc
Buriram (B6)	7.2b	6.3c	2.25a	1.15a	47.0a
F-test	**	**	**	**	*

* and **; significantly different at at P≤0.05 and P≤0.01 respectively, compare mean by LSD method.
TDW; Total dry weight, CDW; Capsule dry weight, HI; Harvest index.

Table 4. Interaction effect of cultivars and salinity levels on number of capsules per plant (NCP), TDW, CDW and HI of six cultivars in black sesame.

cultivar (B)	NCP at 30 DAT		NCP at 45 DAT	
	A0; 0 dS/m	A1; 3 dS/m	A0; 0 dS/m	A1; 3 dS/m
KU18	3.8f	2.5f	3.9gh	2.0i
CM07	7.5cd	3.5f	6.8def	2.3hi
KKU2	21.3a	11.0b	17.3a	6.5def
UB3	11.0b	3.8f	10.5bc	5.5efg
Kanchanaburi	10.8b	6.8de	11.9b	9.1cd
Buriram	9.8bc	4.7ef	7.2de	5.3fg
F-test (A*B)	**		**	
CV (%)	16.9		14.9	

**; significantly different at P≤0.01, compare mean by LSD method.

Table 5. Interaction effect of cultivars and salinity levels on total dry weight (TDW), capsules dry weight (CDW) and HI of six cultivars in black sesame.

cultivar (B)	TDW (g pl^{-1})		CDW (g pl^{-1})		HI (%)	
	0 dS/m	3 dS/m	0 dS/m	3 dS/m	0 dS/m	3dS/m
KU18	0.88ef	0.40f	0.31ef	0.20f	34.8d	52.8ab
CM07	1.66c	1.05de	0.65c	0.38def	39.6cd	35.9d
KKU2	4.08a	0.85ef	1.31b	0.31ef	33.0d	35.9d
UB3	2.70b	1.42cde	1.33b	0.57cd	49.4bc	41.5cd
Kanchanaburi	3.22b	1.20cde	1.19b	0.70c	37.3d	42.8bcd
Buriram	3.00b	1.54cd	1.78a	0.51cde	60.4a	33.6d
F-test (A*B)	**		**		**	
CV (%)	19.6		16.8		15.5	

**; significantly different at P≤0.01, compare mean by LSD method.

grown under non-saline soil was about two times higher than those grown in saline soil (1.10 and 0.44 g $plant^{-1}$, respectively) (Fig. 1H). Buriram (1.15 g $plant^{-1}$) had highest capsules dry weight as compared to the other five cultivars (Table 3). An interaction between treatments was found in this study (P≤0.01), with Buriram grown under non-saline soil had highest capsule dry weight (1.78 g $plant^{-1}$) and this result indicated that saline soil strongly affected capsule dry weight because sesame grown under saline soil showed lower weights compared to those grown under non-saline soil except for KU18 that recorded lower capsule dry weight for plants grown in both under saline and non-saline soil (0.20 and 0.31 g $plant^{-1}$, respectively) (Table 5).

Harvest Index (HI): This parameter was not significantly affected by salinity levels (Fig. 1I) but was influenced by sesame cultivars. The result revealed that Buriram had highest HI (47.0%) but was not significantly different from UB3, KU18 and Kanchanaburi that recorded HI of 45.5, 43.8 and 40.0%, respectively (Table 3). There was interaction between treatment combinations, with Buriram grown under non-saline soil recording the highest HI (60.4%) compared to other treatments but was not significantly different to KU18 grown under saline soil (52.8%) (Table 5).

Discussion

The most common morphological classification for sesame is the seed color as it has a diverse array of seed color ranging from white to black with so many shades between i.e. white, red, brown, khaki, black (Cui et al., 2021). The seed color has been noted as the most important morphological feature in sesame as it has been associated with several nutritional factors like antioxidant activity and content, disease resistance (Zhang et al., 2013), thus consumers and farmers use seed color to select for preference. Studies have shown that the dark colored sesame seed is most preferred by farmers and consumers for its various nutritional and health benefits (Dossou et al., 2022). Many previous researches studied on effect of salinity on sesame with different seed color (yellow, brown, white and black seed) (Harfi et al., 2016), but they focused on root characteristics and effect of salinity stress was uncleared in commercially important black seed sesame especially for the agronomic traits which influence seed yield.

Plant height: In our study, plant height was affected by salinity levels both 30 and 45 DAT. Similar to previous results with Suassuna et al. (2017) and Bahrami et al. (2016) who reported that saline stress reduced plant height, further Ali et al. (2005) found that plant height slightly decreased when salinity levels were increased, this was in agreement with our result except at 15 DAT where plant height showed no significant difference between saline soil and non-saline soil. In contrast to Gaballah et al. (2007) reported that low salinity level increased plant height while high salinity level reduced sesame height and there were significant differences between the cultivars for this trait. However, in our study, plant height was significantly different among cultivar at all stage (15, 30 and 45 DAT). A different conclusion was shared by Jaleel et al. (2008) who associated reduction in the plant height not to salinity but to drought stress caused by salt on water adjustment in plant tissues and cell enlargement as well as increase in leaf senescence and abscission.

Number of branches: Our results shows that slight salt stress negatively affected number of branches per plant at initial stage (30 DAT) but this was not observed 45 DAT. Also, various cultivars responded differently on this trait and interaction between soils and cultivar was observed. Similarly, Vadaliya Bhumika et al. (2018) reported that number of branches decreased with increasing the level of saline irrigation water. In contrast to Mamo et al. (2019) observed that number of branches was not significantly different when compared between saline and non-saline soil, number of branches ranged 5.06-6.33 branches, these results were higher than in our study (1.7-2.3 branches) probably due to the concentration of the salinity in the soils.

SCMR: SCMR has shown to be highly correlated with chlorophyll content in crops and their relationship were reported in previous studies such as in sugarcane (Jangpromma et al., 2010; Radhamani and Kannan, 2013; Radhamani et al., 2016; Bunphan et al., 2019), sweet sorghum (Bunphan et al., 2014), wheat (Udding et al., 2007) and maize (Markwell et al., 1995) etc. In our study, SCMR value were low in saline soils as compared to the non-saline soil (at 45 DAT but no differences were observed at 30 DAT) whereas, cultivars did not show any significant differences on SCMR.

Total chlorophyll content: The soil type did not have any effect on total chlorophyll content at 30 and 45 DAT, this result disagreed to Bazrafshan and Ehsanzadeh (2014) who reported that saline soils negatively affected total chlorophyll content, with higher saline concentration lowering total chlorophyll content.

Chlorophyll fluorescence (Fv/Fm): this trait was not affected by soil salinity, it ranged 0.809-0.825 and it was higher value than previous study (0.72-0.82) (Bazrafshan and Ehsanzadeh, 2014). However, Bazrafshan and Ehsanzadeh (2014) revealed that this trait was affected by higher NaCl concentration, as at 0 and 30 mM they were no significant differences but the differences were observed at 60 mM.

Number of capsules: Suassuna et al. (2017); Bahrami et al. (2016) and Aghajari et al. (2014) and Ali at al. (2005) who reported that saline stress reduced the number of capsules and theirs result were similar to ours. Reduction in the number of capsules per plant might have been influenced by the reduction of plant height which was affected by soil salinity (Bahrami et al., 2016). In our study, there were average number of capsules per plant under control (non-saline soil) was 50% higher than in saline soils a value closer to Vadaliya Bhumika et al. (2018) who recorded 32.5% between control and saline soils. Whereas Gaballah et al. (2007) recorded an increase in number of capsules when plants were exposed to moderate saline soils, but a reduction was observed under high salt levels.

Total dry weight: In our study, total dry weight decreased by over 50% when plants were grown in saline soils (3 dS m^{-1}) when compared to control (non-saline soil). Similar, Ali et al. (2005) observed that total dry weight was slightly lower for plants grown in salinity stress as compared to the control plants, the results are in line with ours but vary in magnitude. In contrast to Ramírez et al. (2005) noted that salinity levels did not affect to total dry matter (at 90 DAP) in salt-tolerance cultivars of sesame.

Capsules dry weight: In our current study, capsules dry weight was influenced by salinity levels, as capsules dry weight recorded over 50% loss in saline soils as compared to control. The results are similar Vadaliya Bhumika et al. (2018) who reported that capsules dry weight was lower in saline soils (8 ds m^{-1}) and that control plants showed highest capsule dry weight, however our results varied in terms of magnitude probably because of salinity level as in their study the salinity was higher.

Harvest Index (HI): Ali et al. (2005) reported that HI decreased with increasing salinity levels, and this disagreed with our study as we observed that HI was not significantly different between control and saline soil. However, HI of control in our study was slightly higher than Ali et al. (2005) by about 32% and 40% in salinity level (3 dS m^{-1} in our study and 6 dS m^{-1} reported in Ali et al., 2005). Observation between cultivars showed that there were significant differences for HI but this was not reported in Ali at al. (2005).

Materials and methods

Plant material

Six sesame cultivars namely KU18, CM07, Kanchanaburi, Buriram, Ubonratchathani3 (UB3) and KKU2 were used, cv. KU18 and CM07 were kindly donated from Faculty of Agriculture, Kasetsart University Bangkok Thailand, cv. Kanchanaburi and UB3 were obtained from Ubon Ratchathani Farm Crops Research Center, Thailand, cv. KKU2 was kindly donated from Khon Kaen University, Thailand. All the cultivars used in this study were black seeded and mostly developed in Thailand universities for the Thailand environmental conditions. The black seeded were selected based on the farmer's preference, as they have shown to prefer black seeded than brown and white seeded sesame. The preference has been based on the high antioxidant and nutrition of the black seeded sesame as compared to other seeds colors. The farmers and consumer preference based on seed color has been documented in literature by several researchers like Olmez et al. (2022) and Dossou et al. (2022) and the black colored seed has shown to be more preferred for its superior oil content, nutrition and antioxidant as compared to other colors.

Experimental design

The pot experiment was conducted in Buri Ram province, northeastern of Thailand. The study was conducted during rainy to early autumn season (July to November 2018). The randomized completed block design (RCBD) in 2 × 6 factorial schemes (12 treatments combination), with three replications and a total of 72 experimental units were used in this study.
Factor A was two levels of soil salinity (A_0 = no salt solution was added to soil in the pots and A_1 = 27.45 g NaCl was added to soil and salinity was found at 3 dS m^{-1}) and 3 dS m^{-1} is slightly saline soil as described by United State Salinity Laboratory Staff (USSL) (1954). Factor B was six cultivars of black seed sesame namely KU18, CM07, KKU2, UB3, Kanchanaburi and Buriram represented as B1, B2, B3, B4, B5 and B6 respectively. The pot measured 20 cm in diameter and 28 cm in height, each pot contained 9 kg of soil. The soil properties with pH 7.25, EC is 0.0067 dS m^{-1}, organic matter (OM) is 0.615%, exchangeable Na is 21.09 mg kg^{-1}, total N is 0.034%, total P and K are 58.25 and 172.58 mg kg^{-1} respectively and soil texture is sand thus the soil was referred to as low fertility soil in our study.

Agricultural practice

Soil was dug 0-20 cm deep from the field then was sun dried for 10 days and thereafter weeds and straw was removed and sifted to remove larger stones. Nine kilograms of soil was weighed and mixed with 27.45 g of NaCl to make saline soil (3 dS m^{-1}) and used to fill each individual pot of the saline soil treatment of 36 pots and others 36 pots had 0 g NaCl (control). The pots were then watered to field capacity 3 days intervals before transplanting sesame.

When sesame seedlings were 14-15 day they were then transplanted to 72 pots at 2 plants for each pot. Chemical fertilizer (N-P-K) formula 15-15-15 at rate 156.25 kg ha^{-1} was applied as basal fertilizer and top dressed at the same rate at 15 days after transplanting (DAT). All the experimental units were watered consistency from first days after transplanting with 3 days intervals until a week before harvesting.

Data collection

The following data were recorded at 15, 30 and 45 DAT; plant height was measured from the soil surface to the tip of an individual plant; number of branches per plant was recorded on primary branch. The spad chlorophyll meter reading (SCMR) was measured using by SPAD-502 meter (Minolta SPAD-502 meter, Tokyo, Japan) at 09.00-11.00 a.m. on fully expanded leaf. The chlorophyll content was measured following Moran (1982), briefly, a small leaf disc with the area 1 cm^2 was cut using cork border, the leaf disc was then placed in a vial containing 5 ml DMF (N, N-dimethyl formamide) and incubated at 4 °C for 24 h in the dark. The chlorophyll extract was measured using a spectrophotometer and absorbance taken at 647 and 664 nm. The equations to calculate for total chlorophyll, Chl A and Chl B were as follows:

$$Chl\ A = 12.64 * A664 - 2.99 * A647$$
$$Chl\ B = -5.6 * A664 + 23.24 * A647$$
$$Chl\ T = \text{Chl A + Chl B}$$

Maximum yield of PSII (Fv/Fm) was measured using chlorophyll fluorescence meter (PAM-2000, Heinz Walz GmbH, Germany) in the middle of leaf and midrib was avoided. The leaf was dark-adapted for 30 mins using leaf clips (FL-DC, Opti-Science) before taking measurements, it was determined following the procedures of Maxwell and Johnson (2000).

While at harvesting (physiological maturity) the following data were collected; number of capsules per plant, total dry weight per plant, capsules dry weight per plant, harvest index (HI). For Total dry weight and capsules dry weight, samples were oven dried at 60º C for 72 hrs (or until constant dry weight) then the mass was recorded.

Statistical data analysis

All data recorded was analyzed using Statistix 10.0. An ANOVA (analysis of variance) was exercised to verify the overall significance of data. The least significance difference (LSD) test was employed to compare the means at 5% probability level (P≤0.05) (Steel and Torrie, 1980).

Conclusions

In previous studies, they classified that sesame is moderate sensitive to saline soil However, in our study we report performance of sesame in slightly salinity level and our results shows that the slight saline levels significantly affected most of the agronomic traits studied. This then confers a different conclusion to the salinity tolerance levels of sesame plants. Our results suggest that sesame is highly sensitive to even slight salinity level as our concentrations are deemed low in reference to other previous studies. Even though saline soils significantly affected growth and yield traits in sesame, the cultivar response varied thus suggesting that tolerance level varies among the cultivars. We therefore conclude that sesame plants are sensitive to salinity stress even at the low level but the level of sensitivity varies among cultivars, thus it is important to select the lesser sensitive cultivars to plant in saline soils with low fertility. In further research, white and brown seed color of sesame should be observed comparing to black seed under salinity levels and root characteristics should be investigated as well.

Acknowledgments

This research project was financially supported by Mahasarakham University. I am thankful the Department of Agricultural Technology, Faculty of Technology Mahasarakham University. The author would like to thank Faculty of Agriculture Kasetsart University, Kalasin University, Faculty of Agriculture Ubonrachathani University for kindly donated sesame seeds for our research.

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