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Research Article

Growth of sesame (*Sesamum indicum* L.) as affected by nitrogen and sulfur under semiarid climate

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Abstract

Field trail was conducted during kharif season, 2013 at Agronomy research farm the University of Agriculture, Peshawar to determine the effect of nitrogen and sulfur on the growth of sesame. The study was conducted in RCB design (control vs. rest) having three replications. Nitrogen (N) levels viz. 30, 70,110 and 150 and S levels viz. 10, 20 and 30 were used. Data were documented on Days to emergence, emergence m^{-2}, days to flowering, leaf area, leaf area index, plant height, days to maturity and plant at harvest. It was found from these results that higher leaf area plant^{-1} (384.2 cm^2) were gained from the plot that received 70 kg N ha^{-1}, while minimum (366 cm^2) were achieved from control plots. The application of N at the rate of 70 kg ha^{-1} resulted in optimum leaf area index (2.2), while control plots have lower leaf area index (1.95). Taller plants (187.1 cm) were observed in plot treated with 70 kg N ha^{-1} and dwarf plants (169 cm) were seen in control plots. In case of S the plant height increases up to (185.2 cm) in the plots that received 20 kg S ha^{-1} which was statistically comparable to 30 kg S ha^{-1} against control. Plants at harvest were not influenced significantly by any of the factor and control vs. rest. Days to emergence, Emergence m^{-2} was non-significantly affected by nitrogen and sulfur. Yield and yield components were significantly improved by the sole addition of N and S or in combination. Sesame production enhances and profitable with application of N and S at the rate of 70 and 20 kg ha^{-1} respectively in this study.

Keywords: Sesame; Nitrogen; Sulfur; RCB

Introduction

Sesame (*Sesamum indicum* L.) belongs to family Pedaliaceae. It is an annual and short day minor kharif oilseed crop. It is self-pollinated and indeterminate in nature. Its stem is erect and diversely in shaped.

Sesame plant is 60-120 cm tall and branched. Its fruit (pod) fluctuates from 2.5 to 8.0 cm in length and 0.5 to 2.0 cm in diameter. Pods mature form bottom to top. The lower pods become shattered at the time of topmost pods maturation. Sesame seed are small and ovate. Cream-coloured and black are their two distinct types. Cream-coloured seeds are preferred. Its flowering occurs normally in 42-45 days [1].

Sesame is an essential edible oilseed crop. The seed have all essential amino acids and fatty acids. It is a good source of vitamins and minerals. Its nutritious seed cake used for livestock feed [2]. This vital crop is the queen of vegetable oils producing crops. In most developing countries of Asia and Africa its cultivation is done for centuries; for its high content of better quality edible oil (42–54%) and protein (22 to 25%). Sesame is regarded as a drought tolerant crop [3]. Nitrogen and sulfur metabolism are linked to each other. Grain yield, uptake of N and Its concentration in straw and grains are increased by S-application [4]. In 2009 77.78 billion Rs. have been spent on importation of 1.246 million tons of edible oil. The local production of edible oil was 0.680 million tons. In Pakistan, sesame was cultivated on an area of 77.6 ha with an annual production of 31.1 tones and an average yield of 401 kg ha^{-1}, whereas in Khyber Pakhtunkhwa sesame was cultivated on an area of 0.1 ha with an annual production of 0.1 tones and an average yield of 1000 kg ha^{-1}[5]

Nitrogen is a good source for the metabolism of carbohydrates and protein. It helps in the division and enlargement of cell. It was reviewed that N helps in improving leaf area and dry matter [6]. The submission of 250 kg ha^{-1} N to sesame notably improved its height, dry matter and yield [7]. The number of capsules $plant^{-1}$ of sesame increased from 31 to 42 with the application of 90 kg nitrogen ha^{-1} from 0 kg nitrogen ha^{-1}[8].

The total cultivable area of sesame is declining because of low yields together with harvesting problems. Better agronomic practices have been reported but yet its production is very low. Other major production restrains are low yielding cultivars, poor soil fertility, weeds, pests, diseases and poor agronomic practices [9].

The roots proliferation and density increases with adequate supply of nitrogen; as it is beneficial in cell division and enlargement which helps in widespread exploration and supply of nutrients and water for the growth and development of plants [10]. Sesame yields increases with the application of nitrogen and sulfur [11]. Similar responses were also reported where high yields were obtained from the application of nitrogen and potassium in India [12].

The importance of sulfur fertilization in increasing sesame production and other crops has been well documented but still it is difficult to determine the quantities to apply under water stress conditions. Sulfur (S) is one of the essential macro elements of plant and is regarded as the fourth key element after N, P and K [13]. The lack of iron and sulfur seizes plant growth. Iron and sulfur application have a positive impact on growth, yield, yield components and nutrient uptake of sesame [14].

The production and yield of sesame is very low in Pakistan even in the presence of favorable soil and climatic conditions. Along with the variety of factors of crop production proper sowing dates, nitrogen levels and improved sesame cultivars play a key role in boosting its production.

Keeping in view the above constraints, the present study was premeditated to point out the effect of nitrogen and sulfur levels on the yield and yield components of sesame at the agro-climatic conditions of Peshawar in order to achieve the desired goal of the sesame producers.

Materials and methods

Site description

The experiment entitled "growth of sesame (*sesamum indicum* L.) as affected by nitrogen and sulfur under semiarid climate" was conducted at Agronomy research farm, The University Agriculture Peshawar, during kharif 2013. The experiment was laid out in randomized complete block design (RCBD) having three replications. A subplot size of 2.7 m x 3 m was used. Each sub plot consisted of 6 rows having 45 cm row-to-row distance. Field was irrigated on 23-06-2013 and land was prepared on 28-06-2013. Sowing was done on 29-06-2013 (Morning). Phosphorus was applied at the rate of 60 kg ha^{-1}. Seed rate 4 kg ha^{-1}. All other agronomic practices were carried out homogeneously for all the experimental units all over the growing season. Emergence was started on 02-07-2013 three days after sowing. First irrigation was given 2 days after emergence. Irrigation was done 5 times in the whole growing season. A serious attack of bacterial leaf blight was observed twice, first 15 days after emergence, second 35 days after emergence and was treated with lambda cylothrin EC-200.

Treatments of the experiment

	N kg ha^{-1}	S kg ha^{-1}
T1 =	N0S0	0: 0 (Control)
T2 =	N1S1	30:10
T3 =	N1S2	30:20
T4 =	N1S3	30:30
T5 =	N2S1	70:10
T6 =	N2S2	70:20
T7 =	N2S3	70:30
T8 =	N3S1	110:10
T9 =	N3S2	110:20
T10 =	N3S3	110:30
T11 =	N4S2	150:10
T12 =	N4S2	150:20
T13 =	N4S3	150:30

Statistical analysis

Data was analyzed according to randomized complete block design and least significant differences test were used for mean separation when F- value were significant [15].

Results and discussion

Days to emergence

Statistical analysis of data (Table 1 and 2) proved that nitrogen (N) and sulfur (S) have no significant effect on days taken by plants to emerge. Similarly the interaction of N and S and control vs rest were also of no significant value on days to emergence (Table 3 and 4).

Table 1. Effect of Nitrogen on yield and yield components of sesame

Nitrogen levels	Days to emergence	Emergence m^{-2}	Days to 50% flowering	Leaf area (cm^2)	Leaf area index	Days to maturity	Plant height (cm)	Plants at harvest
30	5.3	126.1	53.8c	366.7c	2.0b	106.1b	178.7b	160905.4
70	6.2	128.8	54.2bc	384.2a	2.2a	104.6b	187.1a	147668.0
110	6.8	130.2	56.1a	378.0b	2.1b	110.6a	186.3a	165843.6
150	5.3	126.7	55.8ab	378.3b	2.1b	109.8a	179.1b	147530.8
LSD(0.05)	Ns	Ns	1.71	4.80	0.093	2.55	4.84	Ns

Table 2. Effect of Sulfur on yield and yield components of sesame

Sulfur levels	Days to emergence	Emergence m^{-2}	Days to 50% flowering	Leaf area (cm^2)	Leaf area index	Days to maturity	Plant height (cm)	Plants at harvest
10	6	125.8	55.2	375.7a	2.1	108.5	178.5b	162345.7
20	5.4	128.7	55	376.5a	2.2	107.6	185.2a	152211.9
30	6.3	129.3	54.8	379.9a	2	107.2	184.6a	151903.3
LSD (0.05)	Ns	Ns	Ns	4.16	Ns	Ns	4.19	Ns

Table 3. Effect of nitrogen and sulfur on control vs. rest of sesame

Cont.vs Rest	Days to emergence	Emergence m^{-2}	Days to 50% flowering	Leaf area (cm^2)	Leaf area index	Days to maturity	Plant height (cm)	Plants at harvest
Control	4	128	52b	366b	1.95b	108a	169b	164609
Rest	6	128	55a	377a	2a	111a	183a	155487
LSD(0.05)	Ns	Ns	*	**	*	*	**	Ns

Table 4. Effect of Nitrogen and Sulfur interaction on yield and yield components of sesame

N levels	S levels	Days to emergence	Emergence m^{-2}	Days to 50% flowering	Leaf area (cm^2)	Leaf area index	Days to maturity	Plant height (cm)	Plants at harvest
30	**10**	5.7	121	55.3	369.1	2	107	171.5	159259.3
	20	4.7	128.3	54.3	362.3	2.1	105	179.5	162551.4
	30	5.7	129	53	368.8	2	106.3	185.1	160905.4
70	**10**	6	125	52.7	382.5	2.2	104.7	181.5	160493.8
	20	6	127.3	52	388.0	2.4	103.3	192.5	116255.2
	30	6.7	134	56.7	382.0	2.1	105.7	187.4	166255.2
110	**10**	6.3	132.3	55.3	372.9	2.1	112	188.6	166666.6
	20	6.3	131.7	56	377.5	2.1	110	185.5	165020.5
	30	7.7	126.7	57	383.7	2.1	109.7	184.7	165843.6
150	**10**	6	125.0	57.3	378.4	2.1	110.3	172.4	162962.9
	20	4.7	127.3	57.7	378.2	2.1	112	183.5	165020.5
	30	5.3	127.7	52.3	378.5	2.1	107	181.4	114609.1
LSD (0.05)		Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns

Emergence m^{-2}

Analysis of data highlighted in Table 1 and 2 explained that emergence m^{-2} was non-significantly influenced by N and S. Control vs rest and interaction between N and S (Table 3 and 4) were also found non-significant.

Days to flowering

Data pertaining days to flowering as affected by N is presented in Table 1. Statistical analysis of the data clearly shows that days to flowering were significantly affected by N while none significantly affected by sulfur (Table 2). Control vs rest were found significant (Table 3) and N × S were non-significant (Table 4). Plants took more days to flowering (55 days) in treated plots and less days to flowering (52 days) were recorded from control plots. In case of N most days to flowering (56.1 days) were taken by plants when N was applied at 110 kg S ha^{-1} while fewer days to flowering (53.8days) were recorded at 30 kg N ha^{-1}. There was noteworthy effect of N on days to flowering because increasing nitrogen levels facilitates the vegetative growth and thus delays flowering and reproductive stage. Our results are in line with that of [16]. He reported that application of 120 kg N ha^{-1} significantly increased number of days to 50% flowering, while control and 60 kg N ha^{-1} were the first to flower. S increases the NUE (nitrogen use efficiency) and decreases the number of days to 50% flowering **[17]**.

Leaf area (cm^2)

Data regarding leaf area were significantly influenced by nitrogen and sulfur (Table 1 and 2). The interaction of N and S had no significant value while control vs. rest was found significant (Table 3 and 4). Treated plots produced more leaf area (377 cm^2) against control (366 cm^2). Highest leaf area (384.2 cm^2) was noted in plots treated with 70 kg N ha^{-1} whereas lower leaf area (362.3 cm^2) was evidenced at 30 kg N ha^{-1}. In case of sulfur extravagant leaf area (379.9 cm^2) were documented in plots in which 30 kg S ha^{-1} was added which were statistically at par with 20 kg S ha^{-1} while less leaf area (375.7 cm^2) were noted at 10 kg S ha^{-1}. Our results are in compliance with that of **[16]** who reported that every increase in the rate of nitrogen application significantly increased number of leaves $plant^{-1}$ to the highest level of applied N. Application of 60 kg N ha^{-1} produced significantly higher number of leaves $plant^{-1}$and beyond 120 kg N ha^{-1}, number of leaves $plant^{-1}$ were highly reduced. Therefore it is cleared that N contribute to enlarge the leaf area $plant^{-1.}$ Increment in nitrogen fertilizer have been reported to boost leaf size and chlorophyll content **[16]**.

Leaf area index

Observations from the presented mean values of Table 1 and 3 showed significant differences of leaf area index (LAI) regarding N application and control vs. rest. Sulfur and N × S have no positive impact on LAI in statistical way (Table 2 and 4). Nitrogen increased LAI (2.2) at 70 kg N ha^{-1} while decrease in LAI (2.0) occurred at 30 kg ha^{-1}. In this way treated plots had high LAI (2) against control (1.95). Each increment in N deliverance significantly improved LAI in sesame **[16]**. Application of N had a significant effect on number of leaves **[18]**. Nitrogen increases the number of leaves and ultimately increases the leaf area and leaf area index (LAI). The growth, development and yield of sesame as influenced by nitrogen applications observed that maximum leaf area index were recorded at higher nitrogen levels **[19]**

Days to maturity

Analysis of variance of Table 3 and 1 exhibited that the different N levels and control vs. rest had a significant effect on days to maturity. The deliverance of S and its interaction with N were found insignificant (Table 2 and 4). The maturity of plants was delayed (110.6 days) by N at 110 kg ha^{-1} while 70 kg N ha^{-1} enhanced maturity (103.3 days). In control plots the maturity took more days (111) than treated plots (108). This is because that sulfur increases NUE and decrease number of days to maturity while beyond 70 kg N ha^{-1} and 20 kg S ha^{-1} high biomass accumulation occur due to increase in photosynthesis and cause delay in maturity.

Plant height (cm)

Statistical Analysis of the data of Table 1 and 2 showed that plant height was significantly affected by the assorted levels of N and S. Control vs. rest was also found significant (Table 3). The interaction (N × S) was found non-significant (Table 4). It was evidenced from the results taller plants (187.1 cm) were resulted from 70 kg N ha^{-1} applied while dwarf plants (169 cm) were observed in plots treated with 30 kg N ha^{-1}. The plant height increased up to 185.2 cm at 20 kg S ha^{-1} while the plant height decreased (169 cm) at 10 kg S ha^{-1}. Similarly, in treated plots taller plants (183 cm) were documented while dwarf plants (169 cm) were noted in control plots. Our findings are in agreement with the findings of other researchers i.e. **[18]**. They showed that S addition improved biomass and grain yield because of positive interaction between N and S. In this way NUE (nitrogen use efficiency) enhanced and eventually maximize the plant height **[16]**. Plant height, number of branches and leaves plant^{-1} improved with augmented S levels **[20]**

Plants at harvest (ha^{-1})

The analysis of data regarding plants at harvest of Table 1, 2 and 3 exposed that various N and S levels and their interaction were non-significant in statistical way. Control vs. rest was also non-significant (Table 4).

Conclusions

From the results it is concluded that application of nitrogen at the rate of 70 kg ha^{-1} gave maximum leaf area, leaf area index, plant height and decrease the number of days to 50% flowering. Application of sulfur at the rate of 20 kg ha^{-1} gave maximum plant height, leaf area, leaf area index and minimum days to 50% flowering. Nitrogen at the rate of 70 kg ha^{-1} and 20 kg of S ha^{-1} were suitable nutrients combinations for improved growth yield characters of sesame viz increases leaf area, leaf area index and plant height while decreased days to 50% flowering.

Authors' contributions

Conceived and designed the experiments: A Ali & N Khan, Performed the experiments: A Ali & N Khan, Analyzed the data: Sohail, R Khan, Z Ullah, M Ali, M Junaid & MOU Awan, Provided reagents: I Ahmad, AUR Khalil, A Liaqat, F Nawaz & JA Shah, Wrote the paper: A Ali & N Khan.

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