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Growth attributes of two varieties of *Sesamum indicum* (L.) under different light intensities

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Abstract
Solar radiations are among the most important abiotic factors for agricultural Production. Light plays a vital role through its direct effects on morphology, biomass as well as yield produced by plants. The present study was analyzed to assess the effect of three different light intensities on the growth performance and reproductive attributes of two varieties of Sesame *viz*. GT-10 and JTS-8. Comparative performance was studied with respect to plant height, branch number / plant, leaf number / plant, shoot / root ratio, and leaf area, dry weight of plant, RGR, NAR, LAR, SLA, LWR, and number of seeds per plant. Plant height leaf area and increased significantly under shading. The dry matter accumulation was maximum in full sun light which diminished with shading. Comparatively JTS-8 appeared better in growth performance and GT-10 in yield under different light conditions.

Keywords: Light intensities, Sesame, Growth performance, Reproductive attributes

Introduction

Light has a wide range of effects on plant development and morphogenesis. There have been various examples of photomorphogenic responses to varying light intensities (Crookston *et al*., 1975) [6]. The effect of photoperiod on dry matter distribution inside the plant has been described by several researchers (Allard *et al*., 1991, Cockshull and Hughes 1969, Singh, 1994) [1, 5, 16]. The total amount of light reachable from the sun in a particular environment affects plant development. Light intensity influences crop core functions such as physiology, biochemistry, and cell division (Kong *et al*., 2016 and Wu *et al*., 2018) [11, 18]. Sesame (*Sesamum indicum* L.) is India's oldest indigenous oilseed crop, with the longest cultivation history. Till is a vernacular term for sesame or gingelli. Sesame has been grown in almost every state in India. Climate change is prompting crop production to fluctuate, which may have an influence on the economic and cultural settings of the oilseed sector, especially sesame. Environmental risks (biotic and abiotic aspects) have an impact on sesame production and, therefore, yield (particularly oil content). Sesame is grown in a variety of agro ecological conditions. Aside from eating, sesame has several potential applications in pharmaceutics, industry, and as a biofuel. The yield of sesame varies greatly depending on the growing location, cultural practices, and cultivar (Brigham 1985) [3]. Sun radiations are one of the most significant abiotic variables for agricultural output (Yang *et al*., 2014) [20]. Under high solar radiation circumstances, shade at an early stage of plant development boosted cell division and volume in leaves, as well as entire plant dry matter, and also positively benefited fruit growth and production (Schoch 1972) [15]. Crop growth and production are influenced by the quantity of solar radiation received throughout the growing season (Cockshull *et al*., 1992) [4]. Solar radiation levels throughout the year have been utilized as a significant variable to identify places or seasons suited for horticulture summer crops based on this notion. Changes in light not only alter plant shape, physiology, and microstructure, but also have a significant impact on productivity. As the solar radiation, which provides energy for the photosynthesis is reduced it affects the photo-equilibrium of the photoreceptor phytochrome, which in turn affects phenology as well as reproductive biology via altered chloroplast development, delayed onset of flowering and reduced aboveground dry matter (Gundel *et al*., 2014) [8]. Plant height, number of nodes, and leaf size rose as light intensity was lowered. Shading, on the other hand, hindered the growth of lateral shoots on the plant's main stem below the first terminal bloom. Fruit set, number of fruits per plant, fruit placement on the plant, fruit development, and yield were all influenced by changes in plant growth caused by shade (Rylski *et al*, 1986) [14]. Shade influences not just the amount of light that plants get, but it also modifies the microclimate by lowering temperatures and lowering water loss through dropped soil evaporation and crop transpiration, all of which are vital for plant growth.

Materials and Methods

On the 24th of February 2023, seeds of the two varieties of sesame, GT-10 and JTS-8, were sowed in clay pots filled with a mixture of powdered field soil, sandy soil and farmyard mixture in the ratio of 5:2:3. After the germination of sesame seeds plants per pot were maintained up to maturity and every treatment. The pots were watered daily to their full potential. Bamboo tents covered in white muslin fabric and mosquito nets were used to generate artificial shade on plants. There were three distinct light regimes:

SI - Full light under natural day condition
SII - Light under netted cloth cover
SIII - Light under muslin cloth cover

Harvesting happened after 84 days, with three plants extracted from each of the three light regimes, with its undamaged roots. The adhered dirt particles were rinsed with a tiny spray of water. With scissors, the roots stem, and leaves were separated. The area of the leaves was determined by drawing an outline of them on graph paper. Plant pieces (roots, stems, and leaves) were dried individually in butter bags in an oven at 80 °C for 48 hours and kept in desiccators before weighing. Total time of distinct development phases, number of blooming shoots, flowers, fruits per plant, seeds per fruit, and growth indices such as SLA, LAR, NAR, RGR, and others were all recorded.

The following derived growth parameters were calculated as:-

(1) Relative Growth Rate (RGR)

$$= \frac{\log_e W_2 - \log_e W_2}{(t_2 - t_1)}$$

Where,

W_1 and W_2 are total plant dry weight at the time t_1 and t_2 respectively and t_2-t_1 is 7 days (one week).

(2) Net Assimilation Rate (NAR)

$$= \frac{(W_2 - W_1)\log_e L_2 - \log_e L_1}{(t_2 - t_1)(L_2 - L_1)}$$

Where,

L_1 and L_2 are total leaf area and W_1 and W_2 are total plant dry weight at times t_1 and t_2 respectively.

(3) Leaf Area Ratio (LAR)

$$= \frac{Total\ leaf\ area}{Total\ plant\ dry\ weight}$$

(4) Specific Leaf Area (SLA)

$$= \frac{Total\ leaf\ area}{Total\ leaf\ dry\ weight}$$

(5) Shoot /Root ratio **(S**/R ratio**)**

$$= \frac{Total\ dry\ weight\ of\ shoot}{Total\ dry\ weight\ of\ root}$$

Results

As seen in table-1 and fig-1 to 3 shading caused elongation of the main stem in all the two varieties but there were lesser branches in the shaded condition. The numbers of leaves were higher in SIII in both varieties (GT-10 and JTS-8).

The dry matter accumulation was maximum in full light which diminished with shading. JTS-8 had maximum dry weight and GT-10 had the minimum one. Comparatively JTS-8 appeared better performing in a different light condition (Shown in Table 2 and fig- 4).

The increase in leaf area was maximum in SIII in the both varieties. Overall JTS-8 had the maximum leaf area while GT-10 had the minimum one. In case of both GT-10 and JTS-8 leaf area was minimum in SI (shown in table 2 and fig-5). The increase in leaf area in GT-10 and JTS-8 with reduction of light from SII to SIII showed its non-adaptability to shading. In general the leaf area increased with shading in both the varieties.

The relative growth rate (RGR) was maximum in SII condition in both varieties JTS-8 and GT-10. It was observed minimum in SIII condition in case of GT-10 while in case of JTS-8 it was noticed minimum in S1 condition. RGR in general decreased with shading. The net assimilation rate (NAR) was maximum in full sunlight (SI) and minimum in SIII in both varieties (Table-3 and fig-6 to 7).

The leaf area ratio (LAR) increased with reduction in light, being maximum in SIII for both varieties (table-4 and fig-8). In both varieties, usually the specific leaf area (SLA) grew as the amount of light decreased, reaching its maximum in SIII for every harvest (table-4 and fig-9).

The greatest leaf weight ratio (LWR) was observed in SII for both varieties (GT-10 and JTS-8) while it was lowest in SI condition for both varieties as can be seen in table-5 and fig-10.The shoot/root ratio increased with shading being maximum in SIII condition for both varieties (Table-5 and fig-11). This feature is of significance with regard to shade tolerance.

Treatment under SIII condition (severe shading) had significant negative effect on seed yield and yield related parameters. The minimum number of flowers, fruits, seed yield and weight of 100 seeds (gm.) of Sesame were observed in SIII conditions.(as seen in table-6).

Table 1: Morphological growth attributes of Sesame varieties (GT-10 and JTS-8) under different light intensities

Harvest	Varieties	Stem Height (cm)			No. of Branches/ Plant			No. of Leaf / Plant		
		S I	S II	S III	S I	S II	S III	S I	S II	S III
1.	GT-10	3.80	5.00	5.19	01	01	01	04	04	04
	JTS-8	5.10	5.20	7.14	01	01	01	04	04	04
2.	GT-10	5.50	6.90	10.42	01	01	01	04	04	06
	JTS-8	7.90	8.60	11.15	01	01	01	04	04	06
3.	GT-10	13.40	15.00	18.15	04	03	01	05	08	14
	JTS-8	17.60	23.00	28.39	05	03	02	14	16	16
4.	GT-10	27.00	29.50	31.30	05	04	03	12	18	22
	JTS-8	49.23	56.00	68.81	06	03	02	18	23	28
5.	GT-10	56.00	68.09	70.82	06	06	04	32	40	48
	JTS-8	60.16	71.00	79.03	08	04	03	40	48	52
6.	GT-10	69.45	74.00	92.84	11	06	04	30	36	54
	JTS-8	83.00	85.20	103.39	13	09	05	42	40	58

Table 2: Morphological growth attributes of Sesame varieties (GT-10 and JTS-8) under different light intensities

Harvest	Varieties	Dry Weight of Plant (mg)			Leaf Area (cm^2)		
		S I	S II	S III	S I	S II	S III
1.	GT-10 JTS-8	33.00 29.00	31.00 22.23	27.12 19.81	6.12 6.83	6.52 7.98	13.49 8.43
2.	GT-10 JTS-8	189.84 205.00	163.00 173.00	124.21 147.76	28.71 43.15	39.74 45.74	43.56 70.58
3.	GT-10 JTS-8	865.00 960.00	184.00 778.00	140.97 647.00	108.29 126.94	113.61 132.54	136.98 162.13
4.	GT-10 JTS-8	2210.00 3962.00	1731.00 3612.00	1266.94 2817.50	136.35 239.47	197.68 266.06	236.99 352.83
5.	GT-10 JTS-8	6867.00 11,084.00	5401.00 7145.00	3927.00 4983.96	246.05 486.60	291.51 522.80	317.44 596.21
6.	GT-10 JTS-8	12640.00 14910.00	10187.00 11341.00	6544.51 7843.12	387.58 572.66	398.68 649.87	444.61 800.50

Table 3: Derived growth parameters of Sesame varieties (GT-10 and JTS-8) under different light intensities

Treatment Between Harvest	Varieties	RGR (mg /mg/ week)			NAR (mg/cm^2/ week)		
		SI	SII	SIII	SI	SII	SIII
1 - 2	GT-10 JTS-8	1.75 1.96	1.66 2.23	1.52 2.01	10.69 7.33	7.19 8.47	0.19 4.36
2 - 3	GT-10 JTS-8	1.52 1.54	0.12 1.33	0.12 1.48	11.36 10.75	0.29 6.99	0.20 1.80
3 - 4	GT-10 JTS-8	0.94 1.42	2.24 1.54	2.20 1.47	11.02 16.80	10.12 14.85	6.19 8.87
4 - 5	GT-10 JTS-8	0.57 1.03	1.38 0.68	1.45 0.57	9.23 20.46	21.34 9.21	15.41 4.71
5 - 6	GT-10 JTS-8	1.17 0.29	0.39 0.46	0.19 0.45	27.69 7.55	9.60 7.26	2.96 4.05

Table 4: Derived growth parameters of Sesame varieties (GT-10 and JTS-8) under different light intensities

Harvest	Varieties	LAR (cm^2/ mg)			SLA (cm^2/mg)		
		S I	S II	S III	SI	SII	SIII
1.	GT-10 JTS-8	0.18 0.23	0.21 0.35	0.49 0.42	0.47 0.73	0.29 0.46	1.63 1.37
2.	GT-10 JTS-8	0.15 0.24	0.24 0.22	0.35 0.47	0.42 0.82	0.33 0.33	1.01 1.76
3.	GT-10 JTS-8	0.12 0.13	0.61 0.17	0.97 0.25	0.42 0.27	1.09 0.25	3.86 0.79
4.	GT-10 JTS-8	0.06 0.06	0.11 0.07	0.18 0.12	0.15 0.21	0.30 0.20	0.58 0.36
5.	GT-10 JTS-8	0.06 0.04	0.04 0.07	0.05 0.11	0.18 0.11	0.13 0.21	0.20 0.51
6.	GT-10 JTS-8	0.03 0.03	0.03 0.05	0.06 0.10	0.12 0.12	0.12 0.26	0.22 0.24

Table 5: Derived growth parameters of Sesame varieties (GT-10 and JTS-8) different light intensities

Harvest	Varieties	LWR (mg/mg)			S/R ratio		
		S I	S II	S III	S I	S II	S III
1.	GT-10 JTS-8	0.39 0.32	0.70 0.76	0.30 0.30	4.00 1.80	2.00 1.15	1.41 2.17
2.	GT-10 JTS-8	0.35 0.30	0.72 0.65	0.34 0.27	4.31 2.91	3.50 1.41	5.69 2.36
3.	GT-10 JTS-8	0.29 0.48	0.56 0.67	0.25 0.31	3.34 5.04	2.07 3.80	3.11 3.36
4.	GT-10 JTS-8	0.39 0.28	0.37 0.36	0.31 0.34	3.45 1.34	8.21 11.35	3.19 1.84
5.	GT-10 JTS-8	0.33 0.37	0.31 0.34	0.28 0.23	2.24 8.06	12.09 2.38	1.91 2.99
6.	GT-10 JTS-8	0.25 0.30	0.30 0.22	0.30 0.41	6.73 7.24	14.74 21.56	1.82 2.49

Table 6: Effect of different light intensities on reproductive attributes of Sesame varieties (GT-10 and JTS-8)

Varieties	Days of flowering Premordia after sowing			No. of Flower /plant			No. of fruit/ plant			No. of seeds/ plant			Wt. of 100 Seeds (gm.)		
	SI	SII	SIII	SI	SII	SIII	SI	SII	SIII	SI	SII	SIII	SI	SII	SIII
GT-10	26	29	29	09	07	06	66	54	40	4158	3402	2520	0.317	0.282	0.267
JTS-8	24	27	27	07	06	04	51	42	32	3315	2730	2080	0.272	0.236	0.211

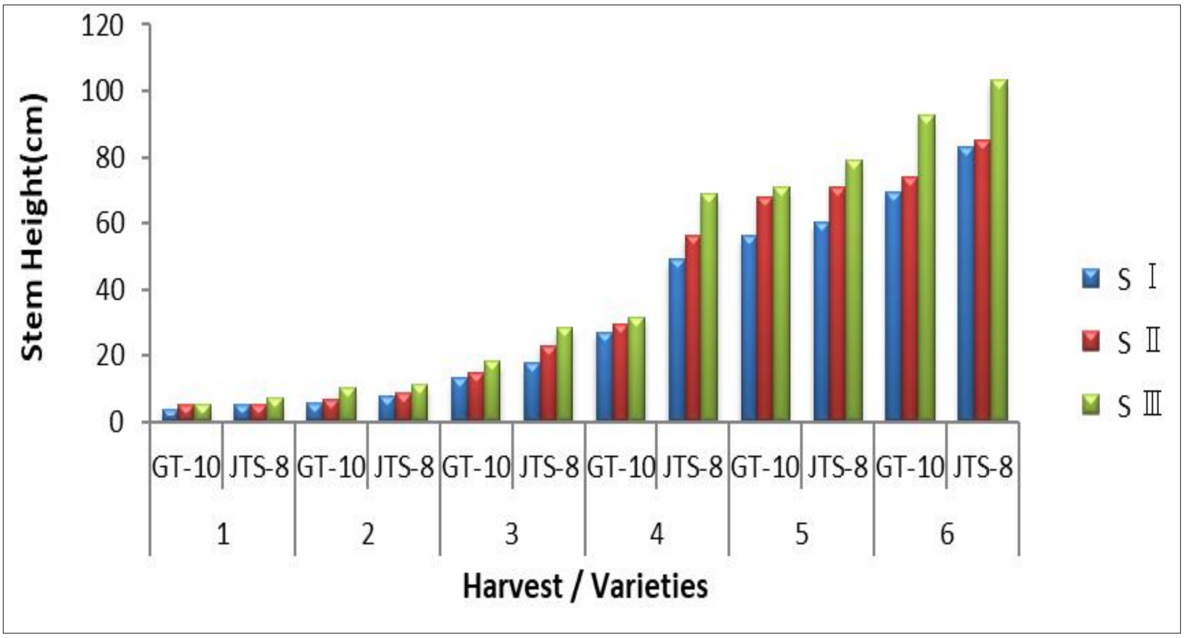

Fig 1: Effect of different light intensities on stem height of Sesame varieties (GT-10 and JTS-8)

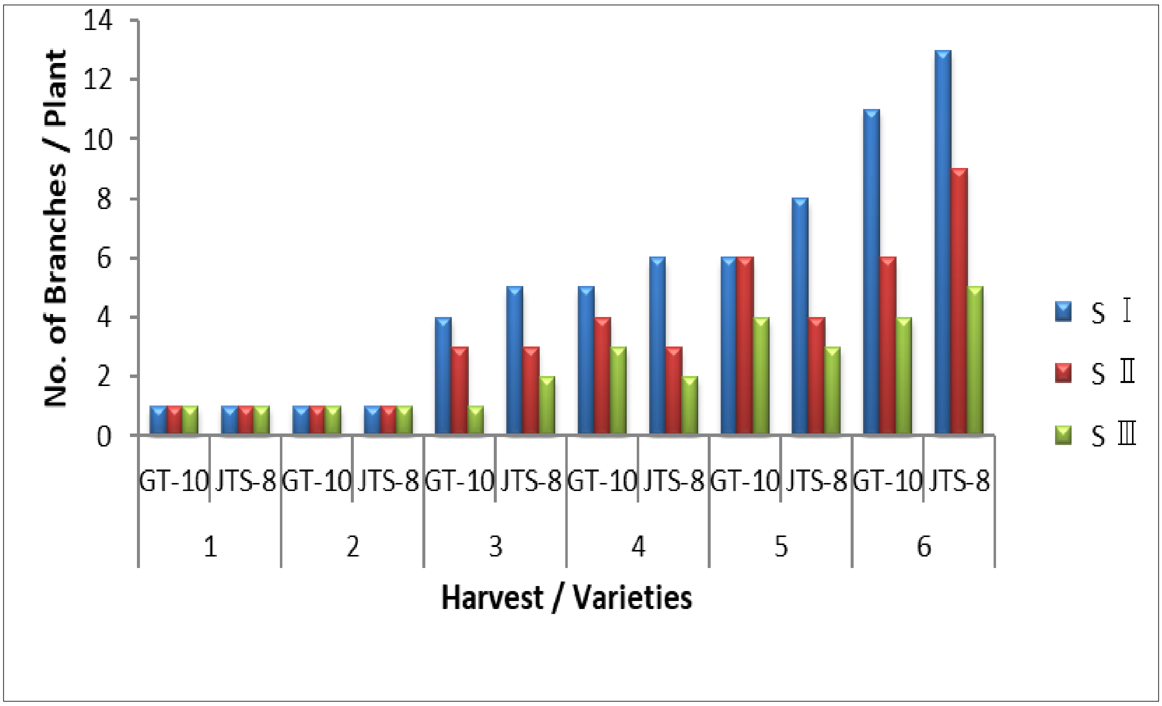

Fig 2: Effect of different light intensities on branch numbers of Sesame varieties (GT-10 and JTS-8)

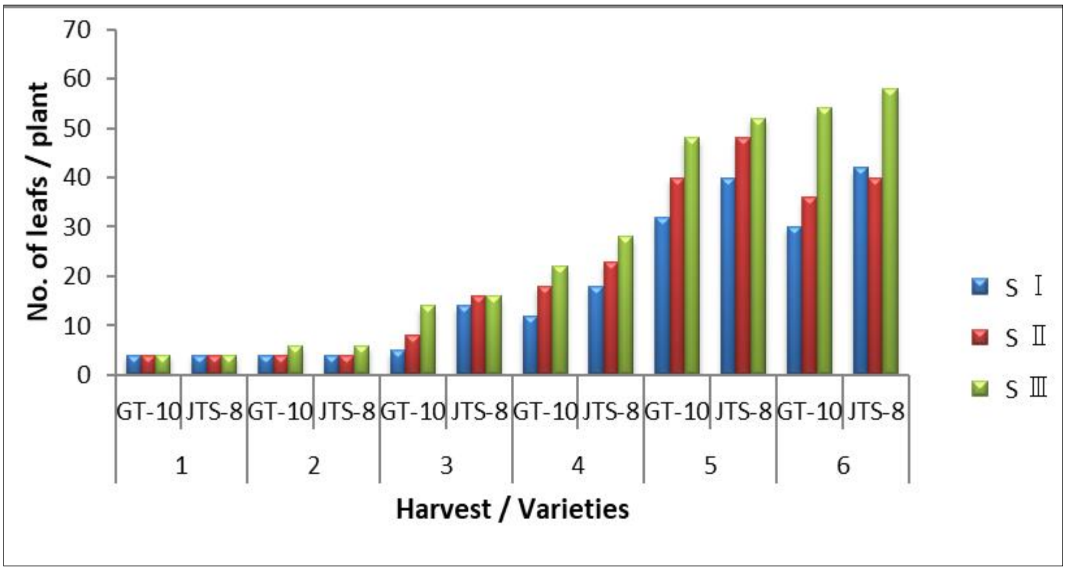

Fig 3: Effect of different light intensities on leaf number of Sesame varieties (GT-10 and JTS-8)

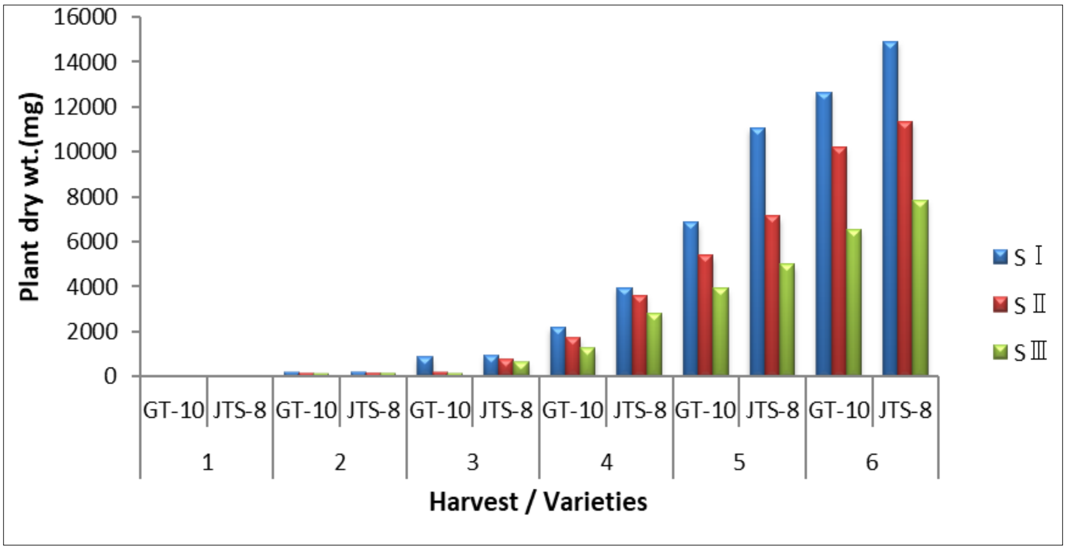

Fig 4: Effect of different light intensities on plant dry weight of Sesame varieties (GT-10 and JTS-8)

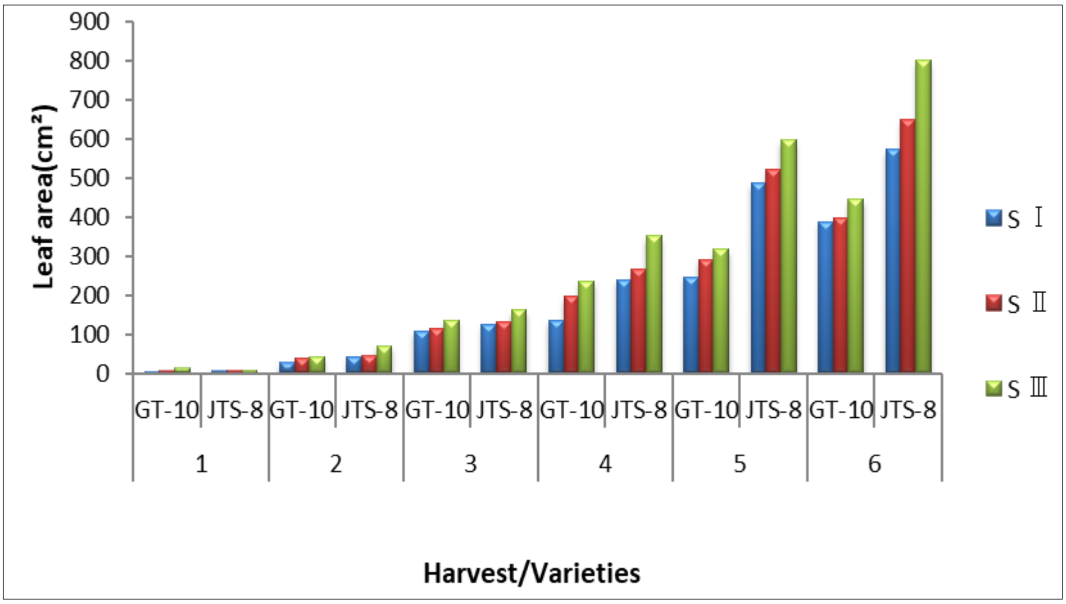

Fig 5: Effect of different light intensities on leaf area of Sesame varieties (GT-10 and JTS-8)

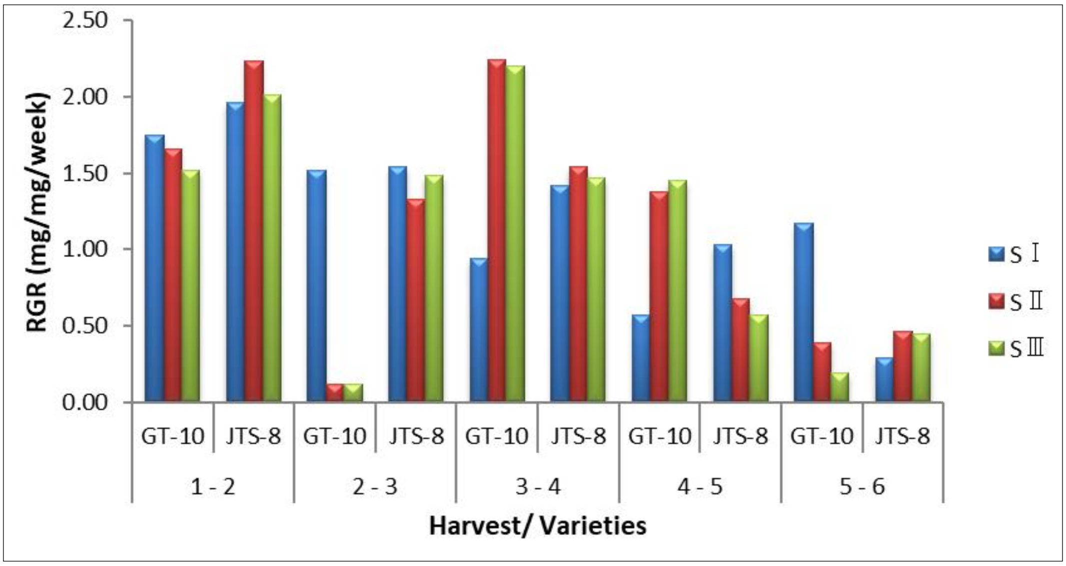

Fig 6: Effect of different light intensities on RGR of Sesame varieties (GT-10 and JTS-8)

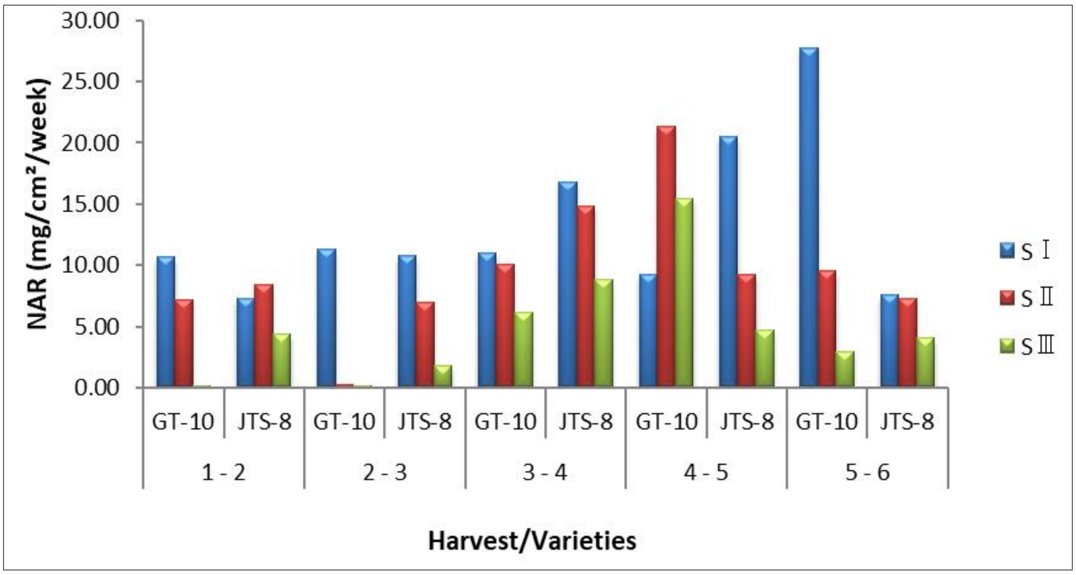

Fig 7: Effect of different light intensities on NAR of Sesame varieties (GT-10 and JTS-8)

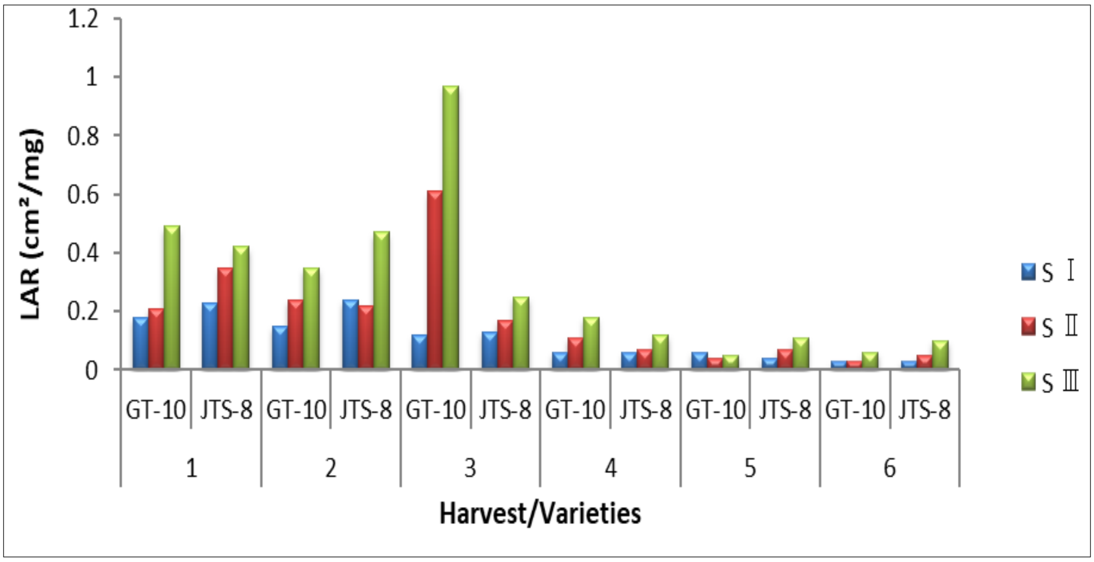

Fig 8: Effect of different light intensities on LAR of Sesame varieties (GT-10 and JTS-8)

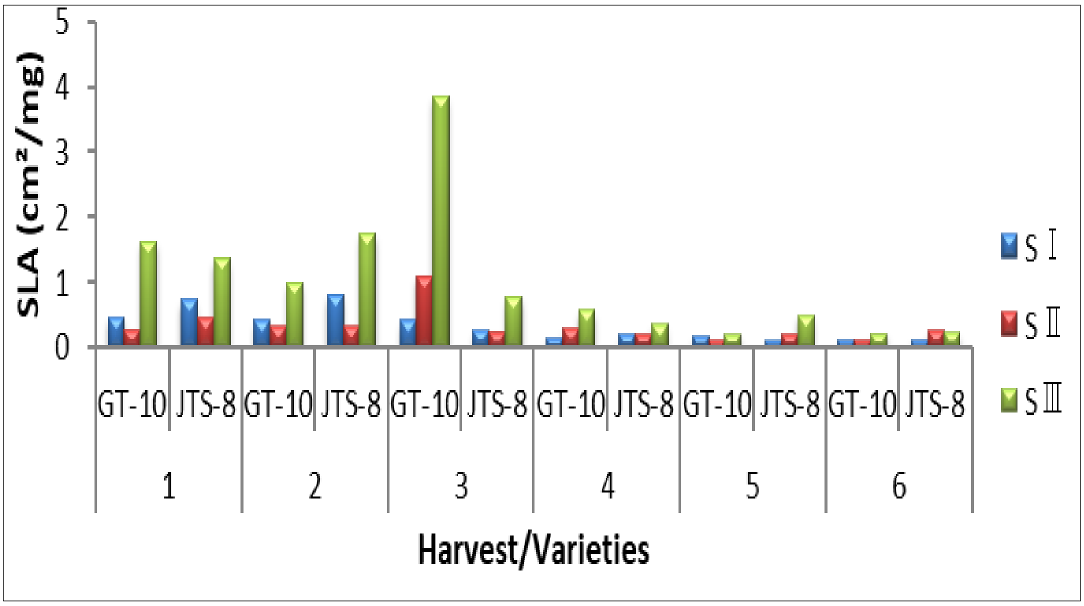

Fig 9: Effect of different light intensities on SLA of Sesame varieties (GT-10 and JTS-8)

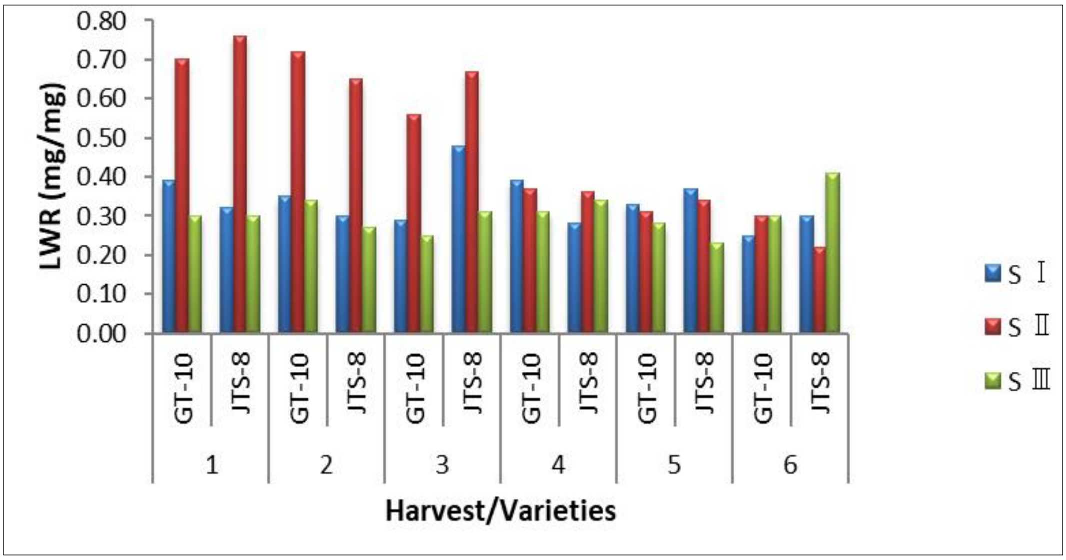

Fig 10: Effect of different light intensities on LWR of Sesame varieties (GT-10 and JTS-8)

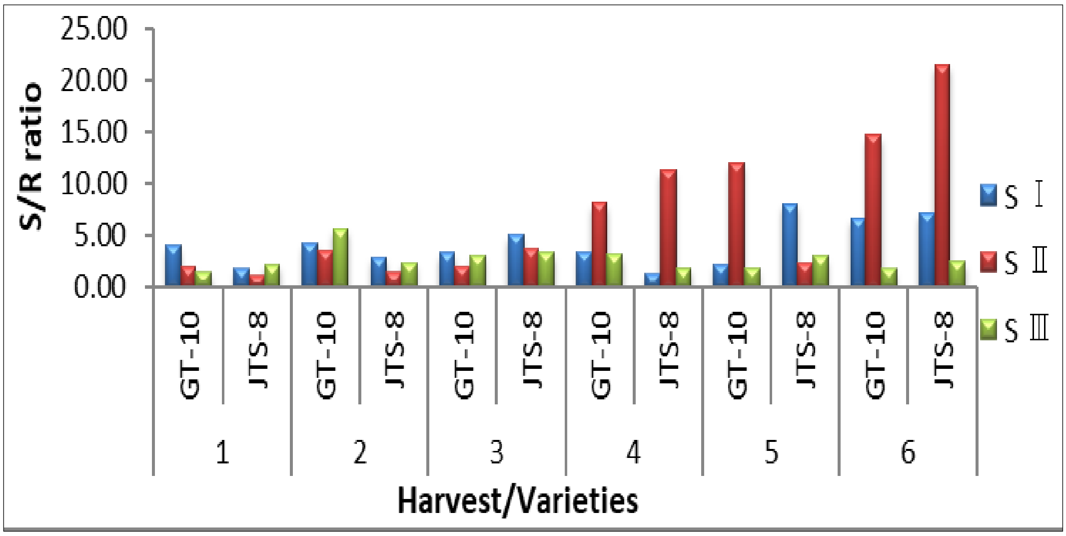

Fig 11: Effect of different light intensities on S/R ratio of Sesame varieties (GT-10 and JTS-8)

Discussion

The data clearly show that in the present study of two varieties of sesame (GT-10 and JTS-8) under different light intensities in Bhagalpur district, both varieties main stems grew longer as a result of the lack of light, branch initiation seemed to be inhibited and shading also increases leaf number in both the varieties. The maximum dry weight was of found under full-light conditions, whereas lower light levels produced minimum dry weight. This is might be due to the lower photosynthetic rate and biomass accumulation, similar to our result previously, in case of soybean, it has been found that severe shading conditions significantly decreased the yield and yield components as compared to normal conditions (Wu *et al*., 2016 and Iqbal *et al*., 2019) [19, 9]. Previously, researchers have found that biomass accumulation is directly associated with the availability of light intensity and reductions in light decreased the biomass production (Maddonni and Otegui 2004) [12]. The dry matter accumulation pattern has generally been reported to be more in the natural light for many plants (Evans *et al*., 1961 and Naidu *et al*., 1993) [7, 13]. Similar to our findings researchers have reported that optimum light intensity increased the assimilation of plant-biomass (Jasdanwala *et al*., 1988) [10]. For instance, researchers have concluded that assimilate demands of sesame plants increased while photosynthetic rate decreased under increased shade conditions (Su *et al*., 2014 and Yang *et al*., 2017) [17, 21]. Importantly, sesame plants under treatment SIII obtained superior morphological characters than SI and SII, suggesting that under SIII sesame plants can maintain their optimum growth. The contrasting effect of light and shade in general was in consonance with earlier observations (Blackman *et al*., 1951) [2].

Conclusion

Moreover, light enrichment condition significantly increased the pod number and seed yield of sesame. Hence, pod number and seed number of sesame plants might be improved in adequate light (SI and SII, respectively), these results implied that optimum light availability at sesame canopy can significantly improve the morphological parameters, photosynthetic and chlorophyll florescence characteristics which in turn considerably increased the seed yield of sesame plants by increasing the pod number and seed number. The significant impacts of shade condition on sesame have been studied previously, but rarely researchers have investigated the effects of different shade condition on sesame plants to understand the threshold level of shade for the better growth and development. In addition, as compared to SIII, treatment SI and SII significantly improved the photosynthetic and chlorophyll florescence characteristics of Sesame plant which in turn considerably increased the seed yield and yields components. Overall, these results implied that agronomist should have to develop an appropriate planting pattern where the obtained higher seed yield of sesame crop under full sunlight condition. These findings showed that GT-10 variety of Sesame performed better than JTS-8 under full sunlight conditions in terms of reproductive growth attributes.

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Conflict of interest

The authors declare that there is no conflict of interest regarding publication of this manuscript.

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