DOI: 10.1515/cerce-2017-0028 **Original Article**
Available online: www.uaiasi.ro/CERCET_AGROMOLD/
Print ISSN 0379-5837; Electronic ISSN 2067-1865

Cercetări Agronomice în Moldova
Vol. L , No. 3 (171) / 2017: 83-94

IMPACT OF SOWING INTERVAL ON THE YIELD AND YIELD CONTRIBUTING TRAITS OF SESAME (*SESAMUM INDICUM* L.) UNDER THE TROPICAL CIRCUMSTANCE

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Received Apr. 18, 2017. Revised: June 30, 2017. Accepted: July 28, 2017. Published online: Oct. 18, 2017

ABSTRACT. The experiment was conducted to study the impact of sowing interval on the yield and yield contributing traits of sesame (*Sesamum indicum* L.), under the tropical circumstance, during 2016, at the research area present near Faculty of Agriculture, Lasbela University of Agriculture, Water and Marine Science, Uthal, Balochistan. Experimental treatments were comprising three varieties of sesame, SV_1 (TS-5), SV_2 (TH-6) and SV_3 (4002), and cultivated under different three sowing dates, at 15 days interval: S_1 = 1st sowing (15 March 2016), S_2 = 2nd sowing (1st April 2016) and S_3 =3rd sowing (15 April 2016). The results of various observations, i.e. plant height at maturity (cm), 1000-seed weight (g), seed mass (t ha^{-1}), yield index (%) rooting depth (cm) and root weight per plant was found to be significant both for the all the sowing dates and sesame genotypes. Non significant finding was observed in traits of biological yield per plant (g) and root-shoot ratio. Whereas interaction among all the treatment factors was non-significant. Maximum yield and yields contributing parameters was observed in S_3 = 3rd sowing (15 April 2016) and sesame genotype SV_1 (TS-5), followed by SV_2 (TH-6), while minimum yield was noted in S_3 = 3rd sowing (15 April 2016) and SV_3 (4002) sesame genotypes. On the basis of the coastal agroclimatic condition of district Lasbela, it was concluded that maximum yield production was achieved from the sesame variety (TS-5), as compared to other two sesame (TH-6 and 4002) varieties. Sowing date of sesame at 15th April 2016 was more productive, as compared to the other sowing interval. Coastal climatic condition is feasible for sesame cultivation, especially for the sesame variety (TS-5).

Keywords: seedmass; sowing dates; sesame cultivars; tropical environment.

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INTRODUCTION

Sesame (*Sesamum indicum* L.) is an annual, natural pollinated undeterminete, short daylight plant; usually, flowers appear during 43-46 days after sowing (Jan *et al.,* 2014). Sesameis the one of oldest crops in the Asia for greater than 5000 years (Anandakumar, 1994). Sesame is one of the oldest cultivated oil crops in the world. China and India are the world's largest producers of sesame crops, followed by Burma, Sudan, Nigeria, Uganda, Venezuela, Mexico, Turkey and Ethiopia (Mkamil & Bedigian, 2007). In Pakistan, sesame was occupied 84,000 hectares area with a production of 35,000 tons. Sesame production is not enough to meet the national demands of edible oil. Pakistan spends an amount of US $ 1354 million for import of edible oil. Pakistan ranks 22nd in case of production and world share of 0.7%. In Pakistan production of sesame is 1200 kg ha^{-1}, but average yield is 452 kg ha^{-1} and Pakistan ranks 58 in term of yield that is very low. Yield gap is 750 kg ha^{-1}, that is due to meager agro management practices (GOP, 2014).

Sesame sowing was not dependent on the rainwater for that reason the yield be effected due to different sowing date and variety characteristics in response to N application at the agro climatic situation as Peshawar (Ali & Jan, 2014). The productivity of sesame is low both in Ethiopia and other major growing countries due to poor farming practices and use of local varieties. Even though, these countries have good environmental conditions for sesame cultivation, the production is carried out mostly under small scale and rain fed conditions. The major production constraints in Ethiopia are lack of new technology and improved varieties, inappropriate use of fertilizers and pesticides (Tsehay, 2006). A study which was carried out in three major sesame producing regions of Ethiopia (Tigray, Amhara and Oromiya) indicates that low inherent soil fertility levels, coupled with its poor management and continuous growing of sesame on the same land for a long period of time, is considered as one of the reason for reduction of yield (Berhanu, 2008).

Nitrogen fertilizers was pertain the most pronounced effect on plant development and yield. In sesame nitrogen plays a very important function in protein combination, as part of chlorophyll and enzymes. About 45 kg N ha^{-1} was improved starting point yield of the sesame. Result was found that planting the sesame at distance of 104 cm by using the nitrogen at the rate of 90 kg ha^{-1} produce the maximum amount capsule per plant and yield per hectare (Malik *et al*., 2003). Agronomic practices showed that planting density influenced the maturity and yield of sesame (Nantongo, 2002). Yield of sesame was differed by plant space and produced of tall and little set of capitulate in length. Intra line increasing space of 12 cm was gave maximum capsule, weight per plant and 10000-seed mass (Haruna, 2011).

Bikran *et al.* (1986) was conducted an experiment on seed yield and yield of four branched and erect sesame varieties. They completed to branch of varieties to the seed weight showed a decrease next to increase of plant concentration starting 330-550 thousand under growth for each hectare, while the no branched variety showed a 34-37% seed yield raise. Function of 75 + 25.8 + 49.8 N P K kg ha^{-1} increased biometric parameter, capitulate attributes and yields sesame in West Bengal (Sarkar & Pal., 2005). Sridevi *et al.,* 2005 found that conjunctive use of inorganic and organic fertilizer with partial soil water content was increased seed yield of sesame.

Sesame yield response of different varieties to plant spacing under irrigated condition need to be known for practical purposes, as planting density is a major management variable used in matching crop requirements to the environmental offer of resources. Maximum yield of sesame can be achieved from the best spatial arrangement of plants for effective canopy development, water and nutrient utilization, pest control and little weeds crop competition (Gebre, 2006).

Planting sample is well thought out a significant part higher making knowledge which not a single indicator of improved yield, however what's more come to blows inside irrigate at what time the crop is sow on ridge. Sowing of sesame produce taking place point with 10 cm breathing gap set sandwiched among mount and ridge 70 cm not mutually present apex values used for figure shell $plant^{-1}$, seed mass for $plant^{-1}$ and 1000-seed mass. In the same way N fertilization have to be details in the direction of correct N level to explore the sesame yield to harvest its highest potential under Faisalabad environment (Malik *et al.*, 2003).

Different sesame varieties have different branching habit, some of them are more branching and others are less branching. Plant geometry is one of the most important components of systematic cultivation and manipulations that could increase yield performance. Due to proper space, plant can gain sufficient sunlight, water and nutrition from soil which can influence healthy yield of plant. Field experiment was conducted for the objective to evaluate the impact of sowing time interval on the yield and yield contributing traits of sesame crop, under the tropical circumstance of Pakistan.

MATERIAL AND METHODS

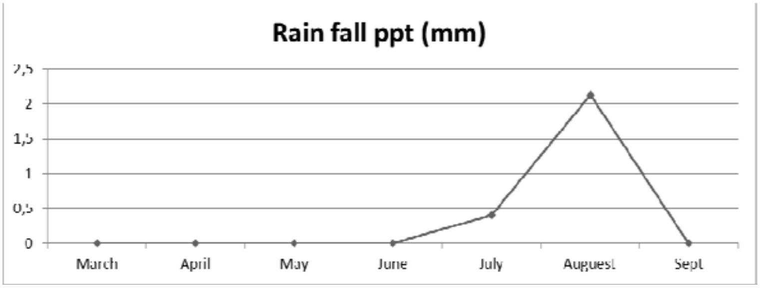
Lasbela is a coastal district of the arid zones of southern Balochistan. The field study was conducted on sesame oil seed crop recently, in the year 2016, at agronomy research area present near Faculty of Agriculture (LUAWMS), Uthal, Balochistan. The chemical analysis of experimental soil was carried out before plantation and after harvesting. The experimental soil was loamy in texture, with slightly alkaline pH as given in the *Table 1*.

The experimental design was RCBD with a factorial arrangement pertaining three replicates. The plot size (3 m x 5 m) was used for the experiment. There were three varieties of sesame (SV_1=TS-5, SV2=TH-6, SV_3=4002) used in the experiment, which were planted at three different sowing date (S_1=15 March, 2016, S_2 =1st April, 2016, S_3 =15 April, 2016), with an interval of 15 days. After the field capacity, a simple cultivator was used for the preparation of seed bed and flat sowing method is used for planting. Crop is cultivated on well prepared seed bed. Row to row distance and plant to plant distances were 45 cm and 15 cm, respectively. Each of the three treatments has received a suggested and uniform dose of fertilizer (N and P) at the rate of 60 N and P ha^{-1}. During cultivation, the plant to plant and row to row distance was maintained, with dibbler. Before sowing, a uniform dose of phosphorus fertilizer (DAP at the rate 60 kg ha^{-1}) was used, while half nitrogen fertilizer in the form of urea was applied with 1st irrigation in each treatment. Left over dose of nitrogen fertilizer was applied in two different split, 1st dose after 30 day and remaining at flowering. After 1st irrigation, the crops were irrigated at an interval 8 to 24 days till crop maturity depending upon the crop requirement and climatic conditions. Weeds were controlled manually by hoeing. During the growth period insecticides (Icon, at the rate 10 CS) was sprayed. All the other agronomic practice were carried out uniformly. A meteorological data of site was collected from meteorological department, during the crop whole season. Crop was harvested on the 12th Oct, 2016.

The following parameters, like i.e. plant height at maturity (cm), 1000-seed weight (g), seed mass (t ha^{-1}), biological yield / plant (g), yield index (%), rooting depth (cm), root weight / plant, root-shoot ratio were recorded by using standard procedures, during growing season. The different yield and growth data was analyzed statistically used Fisher's testing of difference method and least significant difference (LSD) analysis at 5% probability level as applying to analysis the difference between treatment means (Steel *et al.,* 1997). During the whole crop season, different month's meteorological data (*Fig. 1a, b, c, d, e*) were accessed from the meteorological department, situated in the vicinity of Lasbela University.

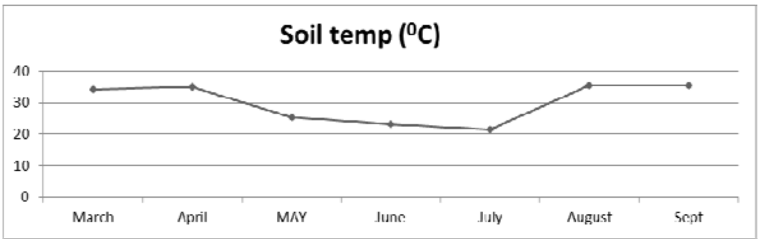
Table 1 - Chemical analysis of soil sample before sowing of the crop

Sr. No.	Determination	Unit	Value
1	pH	_	7.8
2	EC	$D\ S\ m^{-1}$	1.55
3	N	%	0.44
4	P	Ppm	1.61
5	K	Ppm	0.23
6	OM	%	0.30



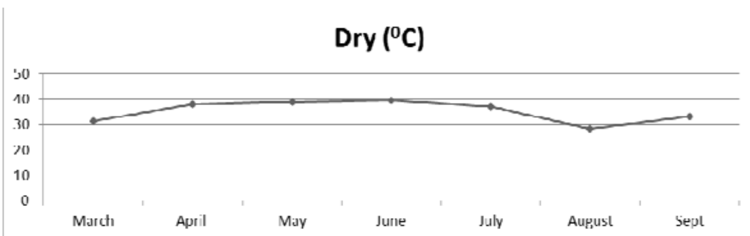
Where as X - axis represents the month and Y - axis showed the rainfall (mm) indicator.

Figure 1 - Rain fall variations during cropping season in 2016



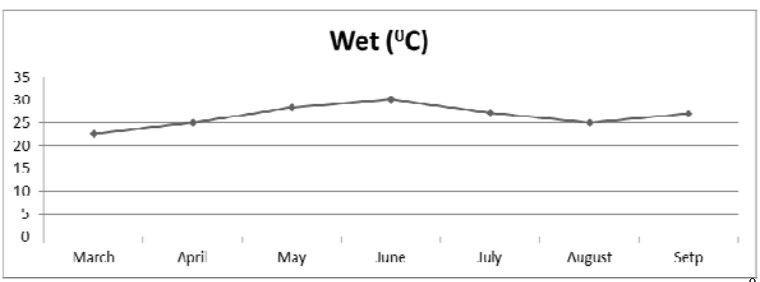
Where as X - axis represents the month and Y - axis showed the soil temperature in ^{0}C.

Figure 1b - Soil temperature variability during experimental season 2016



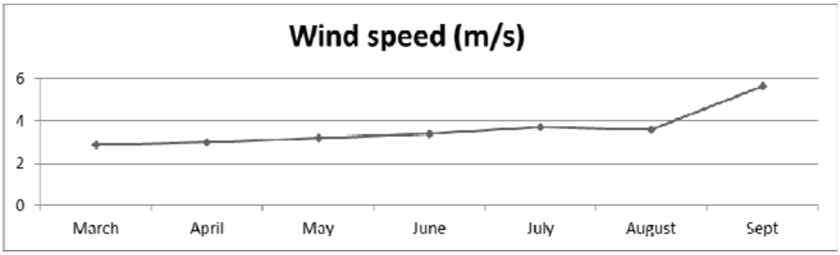
Where as X - axis showing the month and Y - axis represents the dryness in ^{0}C.

Figure 1c - Dryness data during the experiment in 2016



Where as X - axis represents the month and Y - axis showed the wet conditions ^{0}C.

Figure 1d - Wet conditions during conduct of experiment in 2016



Where as X - axis showing the month and Y - axis represents the wind speed in m/s.

Figure 1e - Wind speed conditions during conduct of experiment in 2016

RESULTS AND DISCUSSION

Plant height at maturity (cm)

Plant height at maturity, showed in *Table 2*, was statistically significant due to sowing and cultivar/variety/ genotype. Value of 3rd sowing (15 April, 2016) gave maximum plant height (95.44 cm), which was followed by 2nd sowing at (1st April, 2016). Least number of plant height (92.33 cm) was found in 1st sowing (15 March, 2016). Genotype of sesame, also, produced significant result as given in *Table 2*. Sesame variety SV_1=TS-5 produced maximum plant height at (100 cm) at the time of maturity and this trend of height (92 cm) was followed by other sesame variety (SV_2=TH-6). Low plant height (89.67 cm) was observed in sesame variety SV_3=4002. So, the gradual increasing in temperature and changed in photoperiod, enhanced the plant height and also planting intervals strongly influenced. These results are closely related to the finding of Tahir *et al.* (2012). Interaction among the sowing dates and sesame varieties was found to be non-significant, as shown in *Table 2.*

Table 2 - Impact of sowing dates and sesame cultivar on the plant height at maturity (cm)

Varieties	Sowing date			
	S_1=1st sowing (15 March, 2016)	S_2=2nd sowing (1st April, 2016)	S_3= 3rd sowing (15 April, 2016)	Mean
SV_1= TS-5	95.66	99.00	105.33	100 A
SV_2= TH-6	88.33	93.66	94.00	92 B
SV_3= 4002	87.00	93.00	89.66	89.67 B
Mean	92.33 a	93.889 a	95.444 a	

Where as any two closed value compared statistical and differ significantly at > 0.05 probability level. For sowing and sesame varieties: Standard Error for Comparison 1.8749; Critical Value for Comparison 3.9747

1000-seed weight (g)

Effect of sowing dates digit exemplify that 1000-seed weight in *Table 3* was significant. Maximum 1000-seed weight (3.9089 g) was a proof in 3rd sowing (15 April, 2016) and these leaning was followed by 2nd sowing (1st April, 2016) for 1000-seed weight. Minimum 1000-seed weight (3.8422 g) was pragmatic in 2nd sowing (1st April, 2016). Significant result was noted in case of sesame varieties as shown in *Table 3*. Sesame variety SV_1 = TS-5 turn out maximum 1000-seed weight (4.3601 g) and this affinity was followed sesame variety SV_2=TH-6. Least in sesame variety SV_3=4002 was produced low weight (3.4456 g) of 1000-seed. Meteorological data exerted as strong influence on the 1000-seed weight, in special reference of varieties traits and sowing time. These results are closely related to the finding of Tahir *et al*. (2012). Non significant interaction among the sowing dates and sesame varieties was found, as shown in *Table 3*.

Table 3 - Impact of sowing dates and sesame cultivar on the 1000-seed weight (g)

Varieties	Sowing date			
	S_1=1st sowing (15 March, 2016)	S_2=2nd sowing (1st April, 2016)	S_3=3rd sowing (15 April, 2016)	Mean
SV_1= TS-5	4.153	4.393	4.402	4.3601A
SV_2= TH-6	3.95	3.70	3.75	3.8044B
SV_3= 4002	3.38	3.426	3.436	3.4456C
Mean	3.8590 a	3.8422 a	3.9089 a	

Where as any two means value compared statistical differ significantly at > 0.05, probability level.
For sowing and sesame varieties: Standard Error for Comparison 0.1408; Critical Value for Comparison 0.2986

Seed mass t ha^{-1}

Significant data was found for sowing dates in case of seed mass as given in *Table 4* was 3rd sowing (15 April 2016) with a maximum seed mass (0.96 t ha^{-1}), which was followed by 2nd sowing (1st April 2016) date. Least seed mass t ha^{-1} (0.7 t ha^{-1}) was recorded in 1st sowing (1st March, 2016). As for as sesame varietal outcome was also confirmed very significant result as given in *Table 4*. Sesame variety SV_1=TS-5 was twisted as highest seed mass (0.86 t ha^{-1}) producing variety and this sequence was followed by the sesame variety SV_2=TH-6. Minimum seed mass (0.76 t ha^{-1}) was observed in sesame variety SV_3=4002. Slow, but sure increasing, temperature and photoperiod enhanced the seed mass (t ha^{-1}) and also on the sesame sowing and varieties. Interaction among the sowing dates and sesame varieties was found to be non significant, as shown in *Table 5*.

Biological yield per plant

Data of biological yield per plant (*Table 5*) was statistically non-significant for sowing dates and sesame genotypes. Non-significant results was indicated that biological mass per plant all the varieties similar biological mass, but variation was found in the other characteristics, which is directly involved in yield contribution. It may be also due to increasing temperature and photoperiod with the passage of time regarding sowing intervals. Interaction among the sowing dates and sesame varieties was found to be non-significant, as shown in *Table 5*.

Table 4 - Impact of sowing date and sesame cultivar on the seed mass t ha^{-1}

Varieties	Sowing date			
	S_1=1st sowing (15 March, 2016)	S_2=2nd sowing (1st April, 2016)	S_3=3rd sowing (15 April, 2016)	Mean
SV_1= TS-5	0.7	0.9	1.0	0.86 A
SV_2= TH-6	0.8	0.8	0.9	0.83 B
SV_3= 4002	0.6	0.7	1.0	0.76 C
Mean	0.7 c	0.8 b	0.96 a	

Where as any two means value compared statistical differ significantly at > 0.05 probability level.
For sowing and sesame varieties: Standard Error for Comparison 0.1925; Critical Value for Comparison 0.4080

Table 5 - Impact of sowing date and sesame cultivar on the biological yield per plant

Varieties	Sowing date			
	S_1=1st sowing (15 March, 2016)	S_2=2nd sowing (1st April, 2016)	S_3= 3rd sowing (15 April, 2016)	Mean
SV_1= TS-5	3.404	2.861	2.837	3.034 ns
SV_2= TH-6	3.142	3.386	3.067	3.198 ns
SV_3= 4002	3.17	3.285	3.048	3.168 ns
Mean	3.2393 ns	3.1776 ns	2.9843 ns	

Where as any two means value compared statistical differ significantly at > 0.05 probability level; ns = non-significant. For sowing and sesame varieties: Standard Error for Comparison 0.1338; Critical Value for Comparison 0.2836

Yield index (%)

Yield index percentage (*Table 6*) showed that sowing dates was statistically significant. 3rd sowing (15 April, 2016) was relent more yield index percentage (49.144), which was followed by 2nd sowing (1st April, 2016) for yield index. Less yield index percentage (46.181) was observed in 1stsowing (15 March, 2016). It was also found that varietal effect of sesame was also considerable as given in *Table 6*. Sesame variety SV_1=TS-5 perverse highest yield index percentage (50.063) and this trend was followed by the other sesame variety (SV_3=4002). As similar yield index (45.133) in sesame variety SV_2=TH-6 was minimum when it was calculated. Plodding increasing temperature and photoperiod improve the yield index percentage. Abebe & Workayehu (2015) revealed a comparable conclusion. Interaction among the sowing dates and sesame varieties was found to be non-significant, as shown in *Table 6*.

Roots depth (cm)

Significant results of roots depth was found for sowing dates as sum up in *Table 7*. Plants of 3rd sowing (15 April, 2016) was showed maximum roots penetrations at a depth of 32.26 cm, which was gradually noted in followed 2nd sowing (1st April, 2016). Least penetrations of roots were documented at a depth of 30.168 cm, in 1st sowing (15 March 2016). Sesame varieties were also showed significant variation in roots depth as given in *Table 7*. Sesame variety SV_1=TS-5 root penetrated at depth of 34.382 cm and similar trend roots depth trend was followed in sesame variety SV_3=4002. Minimum root depth (29.648 cm) of sesame variety SV_2=TH-6 was also found. Ongoing increasing temperature and photoperiod enhanced the rooting depth. These results are contrast, which was reported by Malik *et al.* (2003). Interaction among the sowing dates and sesame varieties was found to be non-significant, as shown in *Table 7*.

Table 6 - Impact of sowing date and sesame cultivar on the yield index (%)

Varieties	Sowing date			
	S_1=1st sowing (15 March, 2016)	S_2=2nd sowing (1st April, 2016)	S_3= 3rd sowing (15 April, 2016)	Mean
SV_1= TS-5	48.12	50.15	51.82	50.063A
SV_2= TH-6	44.38	44.90	46.11	45.133C
SV_3= 4002	45.94	47.47	49.5	47.640B
Mean	46.181 c	47.511 b	49.144 a	

Where as any two means value compared statistical differ significantly at > 0.05 probability level.
For sowing and sesame varieties: Standard Error for Comparison 0.3891; Critical Value for Comparison 0.8248

Table 7 - Impact of sowing date and sesame cultivar on the rooting depth (cm)

Varieties	Sowing date			
	S_1=1st sowing (15 March, 2016)	S_2=2nd sowing (1st April, 2016)	S_3=3rd sowing (15 April, 2016)	Mean
SV_1= TS-5	34.174	35.846	33.126	34.382A
SV_2= TH-6	27.401	31.359	30.182	29.648B
SV_3= 4002	28.927	29.04	33.494	30.489B
Mean	30.168 b	32.083 a	32.268 a	

Where as any two means value compared statistical differ significantly at > 0.05 probability level.
For sowing and sesame varieties: Standard Error for Comparison 0.4744; Critical Value for Comparison 1.0058

Root weight per plant (g)

Planting dates data indicated that root weight per plant, as was presented in *Table 8*, was statistically highly significant. 3rd sowing (15 April, 2016) was produced maximum root weight per plant (22.289 g), which was followed by 2nd sowing (1st April, 2016). Minimum root weight per plant (20.385 g) was observed at 1st sowing (15th of March, 2016). As well as sesame genotypes effect was also recorded significant result as specified in *Table 8*. Sesame variety SV_3=4002 warped maximum root weight per plant (22.837 g) and this point was followed by sesame variety SV_1=TS-5. Minimum root weight per plant (19.743 g) was observed in sesame variety SV_2=TH-6. Continued increasing temperature and day light enhanced the root weight per plant. These results are same which was supported by Malik *et al*. (2003). Interaction among the sowing dates and sesame varieties was found to be non-significant, as shown in *Table 8*.

Table 8 - Impact of sowing date and sesame cultivar on the root weight per plant (g)

Varieties	Sowing date			
	S_1=1st sowing (15 March, 2016)	S_2=2nd sowing (1st April, 2016)	S_3= 3rd sowing (15 April, 2016)	Mean
SV_1= TS-5	19.821	21.458	23.286	21.522B
SV_2= TH-6	18.497	19.124	20.12	19.743C
SV_3= 4002	21.836	22.856	23.816	22.837A
Mean	20.385 b	21.428 a	22.289 a	

Where as any two means value compared statistical differ significantly at > 0.05 probability level. For sowing and sesame varieties: Standard Error for Comparison 0.4158; Critical Value for Comparison 0.88

Table 9 - Impact of sowing date and sesame cultivar on the root shoot ratio

Varieties	Sowing date			
	S_1=1st sowing (15 March, 2016)	S_2=2nd sowing (1st April, 2016)	S_3= 3rd sowing (15 April, 2016)	Mean
SV_1= TS-5	1.3279	1.384	1.2593	1.3237 ns
SV_2= TH-6	1.30866	1.36166	1.26233	1.3309 ns
SV_3= 4002	1.354	1.291	1.2823	1.3092 ns
Mean	1.3301 ns	1.3457 ns	1.2680 ns	

Where as any two means value compared statistical differ significantly at > 0.05, probability level; ns = non-significant. For sowing and sesame varieties: Standard Error for Comparison 0.0565; Critical Value for Comparison 0.1198

Root-shoot ratio

Root-shoot ratio was found non-significant both for all sowing dates and sesame varieties, as given in *Table 9*. Fortnight planting interval in each sowing showed that early and late planting of three sesame genotypes on root and shoot ratio they were almost similarly increased. So, ultimately, increasing temperature and photoperiod within each sowing period improved the sesame root and shoot ratio simultaneously. Interaction among the sowing dates and sesame varieties was found to be non-significant, as shown in *Table 9*.

CONCLUSION

On the derivation of the coastal agroclimatic provision of district Lasbela it was find out that utmost yield production was accomplish from the sesame variety TS-5, as compared to other two sesame varieties (TH-6 and 4002). Sowing date of sesame at 15th April 2016 was more resourceful, as compared to the other planting interval. Coastal climatic condition is viable for sesame promotion, principally the sesame variety TS-5.

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