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Research Article

Designing model plant architecture through assessment of qualitative and quantitative traits in sesame (*Sesamum indicum*L.)

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Abstract

The objective of this research work was to characterize sesame germplasmto generate information on different traits carried by each accessionand to identify novel morphotypes with morphological descriptors desirable for designing model plant architecture.A total of ninety germplasm lines were raised in a randomized block design with three replications and characterized for ninequalitative and thirteen quantitative morphological descriptors.A great variation was observed among sesame germplasm lines for 19 morphologic and agronomic traits while three characters were found to be monomorphic as the plants with indeterminate growth habit, white flower colourand shattering nature. The mean of different qualitative morphotypes for yield and its attributing traits suggested that branched plants forming opposite leaf arrangement and having hairy and tetra carpellated multi capsules per leaf axil with seeds of white colour would be desiredmodel plant architecture in sesame. Similarly, morphological framework of accessions giving the highest and lowest yield as well as pattern of seed yield with high and low level of expression of yield components indicated that higher seed yield per plant, capsules per plant, oil content, harvest index, primary branches per plant and early maturity were desired in model plant. Also noted that, increase in harvest index to the extent of 50 per cent is possible and yield can be increased by improving source-sink balance.These results have an important implication for sesame germplasm characterization and designing model plant architecture.

Keywords

Characterization, germplasm, sesame breeding, plant types, morphological traits, seed yield

Introduction

Sesame (*Sesamum indicum* L.) is an important food, oil, medicinal and religious crop in India. It is also important for nutritional security, sustainable development and poverty alleviation of small and marginal farmers. Sesame contributes in several ways to human being like culinary preparation, cosmetic industry, decorative elements,margarine production,cooking oils*etc*. andcontains many essential nutrients that have beneficial and very positive effect on human health (Gharby *et al.,*2015). But the farmers often do not get attraction for expansion of cultivation as the crop suffers from low productivity which leads to low economic return.Sesame seed and oil has been in use as a food and healing oil for hundreds of years. It is a rich source of protein (18-25%) and fatty oil(50-60%) (Sabah El Khier,2008) with many medicinal properties and health benefits (Anilakumar *et al.,* 2010).Sesame oil is important in the food industries due to its distinct flavour (Elleuch *et al.,* 2010) and high level of polyunsaturated fatty acids (Hiremath *et al.*,2007). It is a good protector of ultra violet light, sun, wind and radiation; therefore, it is used in various cosmetics and also in baby and children skin care (Shah, 2016).

Sesame is a valued commodity being cultivated throughout the tropical and subtropical regions in India mainly as a *kharif* crop under rainfed area, however also as *rabi* crop in irrigated areas like Andhra Pradesh Tamil Nadu, Madhya Pradesh, Maharashtra and as a summer crop in irrigated landsof Odisha and West Bengal.Summer weather of Gujarat is also suitable to cultivate this crop as well (Monpara and Vaghasia, 2016). The crop is highly drought tolerant, grows well in most kind of soils, regions and is well suited to different crop rotations. In reality, sesame is mostly grown under moisture stress with low management input by small holders (Cagrgan, 2006).

India is world leader sesame producing country. Presently, average productivity of sesame in India is 417.2 kg/ha, which is less than one-third of the yield 1400.7 kg/ha in China (FAO, 2017). This indicates thatsesame production is below expectation and the potential could be considerably higher. The low production is due to a number of reasons such as low standards of husbandry, poor soils, occurrence of biotic and abiotic stresses and moreimportantly a lack of good varieties for the farmers in India.

Mostly, plant breeding is based on selection either directly for a primary trait (such as yield) in a target environment or indirectly for a secondary trait that must be putatively related to a higher yield potential to improved behaviour of the crop when grown in a stressful environment. This type of breeding is called as conventional or traditional breeding.Selection of appropriate typesby combining desirable traits through ideotype breeding found advantageous for developing novel sesame varieties (Baydar, 2005). But in such a breeding programme, it is essential to have the knowledge of genetic architecture of traits related to yield with special emphasis on certain characters (Bandila *et al.,* 2011). Trait-based approaches rather than yield alone may be more beneficial in sesame breeding, if such yield related traits have been well documented (Ranganatha *et al.,* 2012).

The value of characterizing and preserving natural variation in sesame was recognized by numerous investigators (Sharma *et al.,*2014;Yogranjan*et al.,*2015). Characterization of germplasm is essential to generateinformation on different traits carried by eachaccession and this assures the maximum utilization ofthe germplasm collection by the end users. Characterization permits the identification of unique entries who desire sources of genes for novel traits necessary for curators of gene banks and plant breeders (Sharma *et al.,*2014). Morphological traits are the oldest and most widelyused genetic markers, and they may still be optimalapplications for the description, classification and arrangement of germplasm collections (Yogranjan *et al.,*2015). Several strategies for characterization of sesame genotypes have been used such as morphological (Arriel *et al.,* 2007;Kumar, *et al.,* 2010;Furat and Uzun, 2010;Parameshwarappa*et al,* 2010; Chowdhury *et al.,* 2010;Bandila *et al.,* 2011), physiologica l(Banerjee and Kole, 2009), biochemical (Hiremath *et al.,* 2007; Gharby *et al.,*2015) and molecular markers(Uzunand Cagirgan, 2009; Kumar *et al.,* 2010)or combine study of bothmorphological and molecular markers (Suhasini, 2006; Tabatabaei *et al.,*2011;Parsaeian*et al.,* 2011;Kumar and Sharma, 2011; Pandey *et al.,* 2015).

Several studies on genetic divergence in sesame based on morphological and molecular characters are available in literature (Sharma *et al.,* 2014), however, sporadic attempts have been made particularly on evaluation of suitable plant frame, which may permitsselection of sesame plants with different agronomic performances and yield potential (Cagrgan, 2006; Pham *et al.,* 2010; Falusi*et al.,* 2015).An increase in yield is attributable to the change in plant type from primitive types which mainly include morphological changes, though they may be related to physiological function as well. The present study was taken up with the available landracesincluding indigenous and exotic linesof sesame on formation of basic morphological framework of a model plant through assessment of nine qualitative and 13 quantitative traits.

Materials and Methods

Ninety representative accessions from the large number of sesame germplasm available at the Agricultural Research station, Amreli, India comprised the basic plant material. Of these, 5 were exotic lines, 42 were indigenously developed/ Indian origin lines and 43 were landraces collected from different parts of Gujarat, India.

A field experiment was carried out at the Agricultural Research Farm, Junagadh Agricultural University, Amreli (21`36 N; 71`13 E), India, during rainy season (June to October) of 2015. The siteof the location was well drained with soil type of medium black having pH 7.5 to 8.3, Available N_2 175 to 210 kg/ha and C/N ratio 8 to 12. The annual rainfall for the 2015 was 750 mm. Mean temperature ranged from 27^0C to 33^0C during experimental period.The experiment was laid out in a randomized complete block design with three replications. The soil was amended by adding farm yard manure(5tonha^{-1}) and fertilized at the rate of 25Nand 25P_2O_5 kg ha^{-1}as basal dose, while 25N kg ha^{-1}was applied as topdressing at 30 to 35 days after sowing when sufficient moisture was available in the soil. Seeds were sown manually ina single rowplot of5 meter lengthwith 60cm spacing between rows, the seeds were treated with a fungicide before sowing to prevent soil and seed borne diseases. Intra row distance of 10cmwas maintained by thinning of seedlings at 15 days after germination. All recommended cultural practices were followed to raise the good crop.

Phenotypic traits were studied in all the ninety genotypes. All together 22 agro-morphological descriptors (IPGRI and NBPGR, 2004) were measured and analysed. Phenological measurements were recorded on a plot basis: days to 50% flowering -as the days from sowing to 50% of plants started flowering, days to maturity - as the days from sowing to 50% capsules turned yellow in the plot and reproductive period -as duration between days to anthesis and days to maturity.The agronomic traits measured were plant height (cm), primary branches per plant, capsules per plant, capsule length (cm), seeds per capsule, 1000- seed weight (g), oil content (%), biomass yield per plant (g), seed yield per plant (g) and harvest index(%)

onrandomly selected five plants from each plot. Oil content in seeds of selected plants was determined through NMR technique and expressed in term of percentage. Harvest index in per cent was calculated as: seed yield per plant (g)/biomass yield per plant (g) x 100.Nine qualitative traits like plant growth type, flower colour,branching habit, leaf arrangement, capsule fruiting per leaf axil, carpelsin capsule, seed coat colour,capsulehairiness and capsule dehiscence at ripening werevisually recorded and included in the analysis.

The mean values of five plants from each accession in each replication for the quantitative characters were subjected to analysis of variance of the design adopted (Gomez and Gomez, 1984). The genotypes were classified into different groups according to the values of various traits as well as they were categorizedaccording to six qualitative traits. Phenotype basedassessment wasalso performed.

Results and Discussions

The use of phenotypic characters in describing and classifying germplasm is the fundamental step in any characterization programme. Usually, morphological markers are the visually distinguishable phenotypic traitsand are equally expressed in all environments. In the present study, sesamegermplasm lines were classified according to the variation observed for nine qualitative traits by plant growth type: Determinate and Indeterminate, flower colour: White and Purple, branching habit:Uniculm and Branched, leaf arrangement: Opposite and Alternate,capsules per leaf axil: Single and Multi,carpels per capsule: Bi-,Tri- and Tetra-carpellate, seed colour: White, Brown and Black, capsule hairiness: Glabrous and Hairy and capsule dehiscence at ripening: Shattering and Non-shattering(Table1).Variation for qualitative morphological descriptors revealed marked differences within the traits studied, except plant growth type,flower colour and capsule shattering at ripening, which suggests that accessions included in this study were all of indeterminate type,having white flower of purple shading and shattering nature. Parameshwarappa *et al.* (2009) and Furat and Uzun(2010) also reported monomorphic variation in their materials ofsesame asindeterminate plant growth type, white flower of purple shading and capsule shattering.

Frequency distribution of genotypes under various categories of qualitative traits(Table 1) reveals that accessions with branched habit were most frequent(87.77%),while frequency of uniculm(non-branching) was low(12.23%). Distinctness in branching habit trait may be due to the results of human interference or a natural adaptation mechanism.Branching habit appears to have an advantage with productivity. More branches by forming more capsules per plant are one of the important characters for enhancing productivity in sesame. On the other hand, cultivars having non-branching habit (uniculm) make it suitable for mechanize harvesting. Also, increasing plant density by narrowing plant spacing of uniculm types increases the productivity per unit area. Among the 90 accessions screened, 50 accessions (55.56%) had alternate leaf arrangement and 40 accessions (44.44%) had opposite leaf arrangement. Leaf is a photosynthetic apparatus and its arrangement as an alternate or opposite position on stem may be related to light interception. Besides this, this character is also considered as marker traits particularly in sesame for varietal identification at early stage before capsules formation.

Capsules' fruiting per leaf axil is the important characters for plant breeding programmes. Most of the accessions had single capsulefruiting per axil (82.22 %), while, 17.78 per cent accessions had multi-capsules per axil (Table 1). Since capsules per plant is the main responsible trait toward seed yield in sesame (Baydar, 2005), plants with more than one capsule fruiting per leaf axil would be an important targeting trait ofenhancing seed yield in sesame.With respect to the carpels per capsule,83 accessions were of bicapellate (92.22%), 4 of tricarpellate(4.45%) and 3 of tetra carpellate (3.33%). These types of capsule structure has some yield advantage properties as earlier reported that more carpellate types produced more seeds per capsule(Furat and Uzun, 2010) and seeds per capsule are a major contributing character toward the divergence followed by capsules per plant (Bandila*et al.*, 2011).

The physical appearance of seed colour is an important marketing factor and consumer's acceptability of sesame type.In our study, we grouped 67 accessions as white seeded (74.44%), 15 as brown seeded (16.67%) and 8 as black seeded (8.89%). Seedcoat colourin sesame being a marker of evolution,seems to be associated with seed biochemical properties, antioxidant content and level of disease resistance (Bedigian, 2010). Kanu (2011) reported that white sesame seeds have higher oil, protein and moisture ratios as compared to black seeded sesame.

Hairiness in sesame can be seen in many parts of the plant.However, we included only capsule hairiness in ourstudy(Table 1).Among the accessions studied, 31 accessions had glabrous capsules (34.44%) and 59 had hairy capsules(65.56%).The hairiness of stem, leaf and capsule would be important component of variability in the germplasm of sesame. This trait could be evaluated as advantages for insect pests and diseases of sesame in addition to being a marker for varietal identification.

The distributions of sesame genotypes in various class intervals for 13 quantitative traits are given in Table 2. In general, genotypes showed normal distribution for most of the characters. In case of components of duration, the maximum number of genotypes appeared in the class representing earliness for days to flowering (35-40d) and maturity (75-85 d), while genotypes for reproductive period showed normal distribution with the maximum number in themiddle class (45-55 d). This tendency of frequency distribution for earliness and reproductive period may be explained as breeder'sinterference by selectingforearly types without disturbing span of reproductive period.Other quantitative traits showed more or less normal distribution of frequency (Table 2), the highest number of accessions were fallfor plant height in the class(85-95 cm), for primary branches per plant in the class (2-3 no.),for capsules per plant in the class (25-35 no.),for length of capsule in the class (2.5-3.0 cm),for seeds per capsule in the class (50-60 no.),for 1000-seed weight in the class (3.0-3.5 g),for oil content in the class (47.5-50.0 %),for biomass yield per plant in the class (9-14 g),for harvest index in the class (20-30 %) and for seed yield per plant in the class (2.3-3.3 g). Significant variation was observed among the accessions for almost all the quantitative traits (ANOVA not shown), however, variation was found more greater for capsules per plant, seeds per plant, biomass yield per plant, harvest index and seed yield per plant (Table 2), importantly they should take in to consideration while developing suitable plant types.

The morphological characters of plant are considered to be the important step in the description and classification of sesame germplasm (Bedigian, 2010; Pandey *et al.,* 2015). These morphological traits are usuallyused as markers for other qualitative or quantitative traits of plants. In the present study, attempt has been made to establish the relationships among these traits to characterizing model plantarchitectureinsesame.
Mean data of some important yield attributing traits of sesame genotypes by classifying according to morphogenetic characters (Table 3) indicates thatthe types with brancheshadaveraged highercapsules, biomass yield and seed yield per plant. On the contrary, uniculm type sesame possessed higher seeds per capsule, 1000-seed weight and lower seed yield per plant. Evidently, branched type genotypes with higher number of capsule per plant should be of prime importance in sesame breeding programmes. Slightly higher harvest index was recorded in uniculm types compare to branched types. Baydar, (2005) also reported high harvest index in the non-branched than branched types.No doubt, sesame varieties with uniculm habit do have a production advantages for mechanized cultivationbecause of their uniform maturity, can allow for higher plant density per unit area and thereby higher seed yield per hectare than branched varieties.When sesame genotypes classified according to leaf arrangement, the mean data of yield component traits indicated greater seed yield of opposite types than alternate types. Opposite types also had higher number of capsule, biomass yield and harvest index. Production of more capsules per plant inopposite compared to alternate leaf arrangement types may probably due to itsmore than one fruit per node formation characteristic.

So far, capsule fruiting per leaf axil, mean seed yield per plant of multi-types was higher along with higher capsules per plant, seeds per capsule, oil content and biomass yield per plant than those of single-types (Table 3). Theoretically, multi-capsular or varieties with high density of capsule per leaf axil is believed to have more capsules per plant which potentially resulted in higher seed yield (Baydar, 2005 and Pharm *et al.,* 2010). Our results are in agreement with those of Nura *et al.* (2017) who reported emergence of multiple capsules instead of one per leaf axil providing subsequent increase in the number of capsules and hence seed yield per plant. The comparison of bi-, tri- and tetra-carpellatetypes for yield and yield contributing characters reveals that harvest index was decreased with increasing number of carpellates per capsule. Tetracarpellate types had higher seed yield per plant than bi- and tricarpellated types along with greater expression of capsules per plant, seeds in a capsule, oil content and biomass yield per plant.Low harvest index in tetracarpellate than bicarpellate types as observed in this study was also reported earlier (Baydar, 2005) in sesame. Indeed, tetracarpellated types produces higher seed yield but there is a possibility that excess capsule burden on plant may cause plant to lodge (an important agronomic problem in sesame). In this regard, high seed yield potential of the tetracarpellate types should be evaluated for resistance to lodging.

Mean of white seeded accession was higher than mean of both brown and black seeded accessions for capsules per plant, capsule length, 1000-seed weight, oil content, biomass yield and seed yield per plant. Black seeded types had a merit for harvest index.Our results are in accordance with those of Were *et al.* (2006) and Kanu (2011), whoreportedhigher oil content in white seeded sesame.However, many researches had different opinions about relationship between seed coat colour and oil content (Bedigian, 2010). He opined that still there was a deviation from the generalization that cultivarswith white seed contain higher oil.In fact, whetherthey contain higher oil or not,white seeded varieties with long lasting luster have a great preferencein most of the sesame producing countries including India(Pandey *et al.*, 2013).In case of capsule hairiness, hairy capsule types possessed several positive yield attributing traits such as greater seed yield and biomass per plant,more capsule number and capsule size as well as slightly higher seeds per capsule and oil content.

Since studied sesame germplasm lines were all indeterminate types with purple shadedwhite colourflowers and capsule shattering nature, the performance of different morphotypes for yield and its attributing traitssuggests that plant with branches, having hairy and tetracarpellated multi capsules per leaf axil as well as possesses seeds of white colour and forming opposite leaf arrangement on it would be desirable model plant architecture in sesame breeding.

An alternative method of identifying the model plant characteristics is to compare the agro-morphological features of all lines giving highest andlowest yields and to determine the characters responsible for the difference in yield potential of these lines. Difference in number of capsules per plant, biomass yield per plant, harvest index and seeds per capsule could largely be accounted for by difference in yield potential(Table 4),though early maturity and short reproductive duration also played significant role for this difference. Earlier studies indicate that capsule number per plant is a primary determinant for high seed yield in sesame (Bandila *et al.*, 2011; Monpara and Khairnar, 2016). In fact, sesame seeds grow in a capsule; therefore, more capsules on the plant are likely to yield more seeds (Langham, 2007). Moreover, Pandey *et al.*(2015) and Ramazani (2016) observed significant contribution of seeds per capsule and seed weight toward seed yield. Thus, our results match well with the earlier reports. Classification based on morphotype mean values of agronomic traits in the present study also indicated that higher seed yield of particular type was due tohigher number of capsule and biomass yield per plant (Table 3). The comparison of seed yield pattern according to high and low expression of yield attributing traits is shown in Table 5. The significantly the highest magnitude of difference for yield potential was observed for seed yield per plant itself. Other traits like capsules per plant, oil content, harvest index and primary branches also contributed significantly for this difference. Late starts of flowering and early maturity werefound to be important as yield components.

Mean expression of different agronomic traits of genotypes falling under various class interval of harvest index (Table 6) reveals that increase in harvest index up to the level of 50 per cent was associated with improvement in seed yield, capsules per plant and 1000-seed weight, whilerevers trend as reduction in biomass yield, oil content, capsule length, reproductive period, days to 50% flowering and days to maturity was realized. Other characters had not shown such consistent trends.Beyond 50% level of harvest index, a decrease in capsules per plant, 1000-seed weight and seed yield per plant was noticed. Thus, results suggest that harvest index up to 50%can possibly be achieved in sesame byimproving source and sink balance. Further study is required to confirm this relationship between various levels of harvest index and yield attributing traits.

The accessionsidentified for the highest biomass yield per plant, harvest index and seed yield per plant are listed in Table 7.Indigenous culture IC 204796 and IC56196 had the highest biomass yield and seed yield per plant, respectively, the Borda 3 was local landrace and having the highest harvest index among the genotypes studied. The results indicated that an accession showing high biomass yield was poor in harvest index and best harvest index accession was the lowest in biomass yield.Since seed yield is a function of biomass yield and of partitioning biomass to seeds, i.e. harvest index,one can hypothesize that selecting parents of large biomass (and related traits like plant height, lateness, branch number, *etc*.) and crossing to lines with high expression of harvest index (and related traits like capsule number, seeds per capsule, 1000-seed weight, *etc*.) would likely to be complementary for yield improvement.For this reason, it is important in the sesame breeding to combine high yield potential with high harvest index thatwould bean important strategy.

Results of studied germplasm accessions provide an evident thaton the basis of morphotype assessment, model plant architecture can be characterized by a branched plant of opposite leaf arrangement with tetracarpellated multi capsules per leaf axil and hairy capsules containing white seeds.The appropriate sesame types can be developed by well-planned breeding strategies such as establishing the combination of the useful qualitative and quantitative characters in segregating populations. Comparative assessment of yield components indicated that seed yield per plant, capsules per plant, oil content, harvest index, primary branches per plant, late flowering and early maturity can help suggest model plant architecture;though, the genotypic variation for oil content, primary branches per plant and days to flowering was low comparedto other traits. Strategic breeding programme combining high biomass with high harvest index wouldresult in genetic gain for seed yield in sesame. However, further study with addition of characters related to biotic and abiotic stress for their desirabilityand evaluation of the environmental effects is required to be investigated.

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Table 1.Frequency distribution of various qualitative traits in sesamegermplasm lines

Characters	Type	Number of lines	Frequency (%)
Plant growth type	Determinate	-	-
	Indeterminate	90	100.00
Flower colour	White*	90	100.00
	Purple	-	-
Branching habit	Uniculm	11	12.23
	Branched	79	87.77
Leaf arrangement	Opposite	50	55.56
	Alternate	40	44.44
Capsule fruiting per leaf axil	Single	74	82.22
	Multi	16	17.78
Carpels in capsule	Bicarpellate	83	92.22
	Tricarpellate	4	4.45
	Tetracarpellate	3	3.33
Seed coat colour	White	67	74.44
	Brown	15	16.67
	Black	8	8.89
Capsule hairiness	Glabrous	31	34.44
	Hairy	59	65.56
Capsule dehiscence at ripening	Shattering	90	100.00
	Non-shattering	-	-

*white with purple shading

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Table 2. Frequency distribution of various quantitative traits in sesamegermplasm lines

Characters	Class interval	Number of lines	Frequency (%)
Days to 50% flowering (d)	35.00-40.00	55	61.11
	40.10-45.00	35	38.89
Reproductive period(d)	35.0-45.0	34	37.78
	45.1-55.0	35	38.89
	55.1-65.0	21	23.33
Days to maturity(d)	75.0-85.0	60	66.67
	85.1-95.0	13	14.44
	95.1-105.0	17	18.89
Plant height (cm)	75.0-85.0	8	8.89
	85.1-95.0	35	38.89
	95.1-105.0	25	27.78
	105.1-115.0	19	21.11
	115.1-125.0	3	3.33
Primarybranches/ plant(no.)	1.0-2.0	31	34.44
	2.1-3.0	52	57.78
	3.1-4.0	7	7.78
Capsules/Plant(no.)	15.0-25.0	11	12.22
	25.1-35.0	35	38.89
	35.1-45.0	29	32.22
	45.1-55.0	15	16.67
Length of capsule (cm)	1.50-2.00	2	2.22
	2.01-2.50	32	35.56
	2.51-3.00	54	60.00
	3.01-3.50	2	2.22
Seeds/ capsule(no.)	35.0-40.0	1	1.11
	40.1-50.0	17	18.89
	50.1-60.0	43	47.78
	60.1-70.0	20	22.22
	70.1-75.0	9	10.00
1000-seed weight (g)	2.00-2.50	2	2.22
	2.51-3.00	26	28.89
	3.01-3.50	57	63.33
	3.51-4.00	5	5.56
Oil content (%)	45.0-47.50	11	12.22
	47.51-50.00	52	57.78
	50.01-52.50	25	27.78
	52.51-55.0	2	2,22
Biomass yield/ plant (g)	4.00-9.00	24	26.67
	9.01-14.00	35	38.89
	14.01-19.00	25	27.78
	19.01-24.00	6	6.67
Harvest index (%)	10.0-20.0	4	4.44
	20.1-30.0	46	51.11
	30.1-40.0	35	38.89
	40.1-50.0	2	2.23
	50.1-550.0	3	3.33
Seed yield/ plant (g)	1.30-2.30	14	15.56
	2.31-3.30	31	34.43
	3.31-4.30	25	27.78
	4.31-5.30	14	15.56
	5.31-6.30	6	6.67

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Table 3. Mean values of some important yield attributing traits by phenotype in sesame germplsm lines

Genotypes	Capsules/ Plant(no.)	Capsule length(cm)	Seeds/ capsule(no.)	1000-seed weight (g)	Oil content (%)	Biomass yield/ plant(g)	Harvestindex (%)	Seed yield/ plant (g)
Branching habit								
Uniculm	31.26	2.59	59.06	3.19	49.38	10.58	29.72	2.91
Branched	36.02	2.55	56.59	3.10	49.28	12.42	29.47	3.51
Leaf arrangement								
Opposite	35.92	2.52	56.58	3.06	49.18	12.32	29.94	3.53
Alternate	34.64	2.62	57.91	3.17	49.52	12.12	29.18	3.32
Capsule fruiting per leaf axil								
Single	35.29	2.56	56.49	3.12	49.23	12.02	29.94	3.40
Multi	36.10	2.53	58.72	3.08	49.55	13.01	28.40	3.64
Carpels in capsule								
Bicapellate	35.72	2.57	57.46	3.11	49.20	12.23	29.94	3.46
Tricapellate	26.97	2.47	50.77	3.05	49.59	9.48	26.25	2.45
Tetracapellate	36.18	2.57	57.56	3.11	52.64	16.01	24.88	4.06
Seed coat colour								
White	36.39	2.57	55.98	3.12	49.41	12.56	29.55	3.56
Brown	33.01	2.54	59.39	3.10	48.76	10.55	28.64	2.88
Black	31.98	2.47	59.81	3.06	49.32	12.19	30.74	3.47
Capsule hairiness								
Glabrous	33.89	2.55	56.86	3.16	49.29	10.68	30.19	3.11
Hairy	36.12	2.57	57.33	3.08	49.35	13.04	29.30	3.61

Table 4. Comparison of yield attributing traits for highest yielding and lowest yielding germplasm lines in sesame (average data of 10 lines)

Sr.	Characters	Lowest yielding	Highest yielding	Difference
1	Days to 50% flowering (d)	39.43	39.43	0.00
2	Reproductive period (d)	52.20	47.50	4.70*
3	Days to maturity (d)	88.80	84.30	4.50*
4	Plant height (cm)	96.65	97.64	-0.99
5	Primary branches/plant (no.)	1.98	2.28	-0.30
6	Capsules/plant (no.)	20.85	43.84	-22.99*
7	Capsule length (cm)	2.58	2.54	0.04
8	Seeds/capsule (no.)	50.94	56.61	-5.67*
9	1000-seed weight (g)	3.13	3.16	-0.03
10	Oil content (%)	49.37	50.17	-0.80
11	Biomass yield/plant (g)	6.19	15.98	-9.79*
12	Harvest index (%)	27.84	34.84	-7.59*
13	Seed yield/plant (g)	1.65	5.32	-3.67*

*Significant at P=0.05

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Table 5. Patten of seed yield(g) in lines with high and low level of expression of yield attributing traits (average of 10 lines)

Sr.	Characters	Low	High	Difference
1	Days to 50% flowering	3.22	3.97	-0.75*
2	Reproductive period	3.79	3.48	0.31
3	Days to maturity	3.66	3.19	0.47*
4	Plant height	3.60	3.85	-0.25
5	Primary branches/plant	2.82	3.70	-0.88*
6	Capsules/plant	2.35	4.16	-1.81*
7	Capsule length	3.33	3.00	0.33
8	Seeds/capsule	3.17	3.06	0.11
9	1000-seed weight	3.50	3.54	-0.04
10	Oil content	2.75	3.86	-1.11*
11	Biomass yield/plant	4.24	4.39	-0.15
12	Harvest index	3.11	4.17	-1.06*

*Significant at P=0.05

Table 6. Relationship of sesame traits with different classes of harvest index studied

Sr.	Characters	Class interval of harvest index				
		10.0-20.0	20.1-30.0	30.1-40.0	40.1-50.0	50.1-55.0
1	Days to 50% flowering (d)	40.58	39.40	39.94	38.17	40.33
2	Reproductive period(d)	52.00	49.57	48.93	44.67	44.22
3	Days to maturity(d)	89.83	85.70	85.57	80.00	81.89
4	Plant height (cm)	101.50	97.50	96.17	97.73	97.77
5	Primary branches/plant	1.84	2.33	2.22	2.14	2.38
6	Capsules/plant (no.)	35.11	35.28	35.38	45.26	34.59
7	Capsule length(cm)	2.63	2.55	2.54	2.52	2.73
8	Seeds/capsule(no.)	61.28	55.90	56.88	62.99	62.22
9	1000- seed weight (g)	3.12	3.13	3.18	3.32	2.97
10	Oil content (%)	49.34	49.34	49.33	47.58	49.19
11	Biomass yield/plant (g)	15.65	13.75	10.44	8.62	6.57
13	Seed yield/plant (g)	2.71	3.43	3.50	3.85	3.51

Table 7. Comparison of sesame germplasm linesidentified for the highest biomass, harvest index and seed yield

Genotypes	Biomass yield/ plant (g)	Harvest index (%)	Seed yield/ plant (g)
IC 204796	**23.48**	13.33	3.13
BORDA 3	6.06	**54.70**	3.23
IC 56196	19.66	31.60	**6.20**

Bold value is the highest expression of that particular trait in the germplasm studied