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# Assessment of genetic variability & some biochemical traits in Sesame (*Sesamum Indicum* L.) genotypes

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**Abstract**
Sesame (*Sesamum indicum* L) is the most cultivated oil crop in India. It has great diversity across the Indian biota. The existing variability would be utilized for the commercial purpose of sesame. The purpose of the study is to evaluate the morphological characterization and variability available in the sesame genotypes available in M.P. Ten sesame genotypes were grown during *Kharif* 2018 at M.G.C.G.V.V. Chitrakoot, Satna (M.P). The estimation of genotypic and phenotypic coefficient of variation along with heritability and genetic advance. Ten morphological traits were recorded for ten genotypes. High PCV and GCV are recorded for the trait No. of capsules / plant. High heritability and genetic advance was observed for the character Days to 50 % flowering. The traits with high heritability and high genetic advance as percent of mean are governed by the additive gene action where simple selection is effective for breeding programmes. capsules per plant had highest direct effect on seed yield per plant and Seeds per capsules had highest indirect effect via capsules per plant on seed yield per plant for number of capsules per plant, number of branches per plant, capsule length, number of seeds per capsule, capsule weight and test weight these traits should be given top priority during selection breeding and high indicating that some of characters affecting seed yield has to be included in the future study.

**Keywords:** genetic variability, PCV, GCV, heritability, path coefficient, biochemical

## Introduction
Sesame (*Sesamum indicum* L, Pedaliaceae.) is an important and perhaps the oldest and ancient oilseed crops known to man. It is cultivated extensively from tropical regions to the temperate zones in the world. It is fifth important edible oil crop in India after groundnut, rapeseed-mustard, sunflower and soybean. Sesame seed contains 50% oil, 23%, protein and 15% carbohydrate (Ranganatha *et al*., 2012) [11]. Which have remarkable antioxidant function, resisting oxidation and has a significant amount of oleic and linoleic acids (Abate and Mekbib, 2015) [1]. Sesame seed is consumed as a source of calcium, potassium, tryptophan and methionine. Sesame oil has highest antioxidant content and contains several fatty acids such as oleic acid (43%), linoleic acid (35%), palmitic acid (11%) and stearic acid (7%) (Yogranjan *et al*. 2015) [16] Genetic variation survives for agronomically vital characters in sesame but its production is still very low in India. Traditional sesame landraces as well as related wild species are an important source of genetic diversity for breeders and form the backbone of agricultural production. Selection for high yielding types with wider adaptability shall help in increasing the production both locally and globally. But the performance of crop is affected by such factors as climatic, nutrients, water availability, inter and intra specific competitions, pest and diseases, as well as socio-cultural and socioeconomic factors. The knowledge of genetic variability in germplasm will help in the selection and breeding of high yielding, good quality cultivars that will increase production. It is necessary to study variability in respect of quantitative characters with reference to genetic parameters such as genotypic and, phenotypic variances, heritability (broad sense) and genetic advance

## Materials and Method
This experimental study was conducted under normal soil and rain fed condition at M.G.C.G.V.V Chitrakoot, Satna (M.P) during 2018-2019. The experiment was laid out fallowing Randomized Block Design (RBD) with three replications during kharif 2018-19.The collection of 10 diverse varieties of Sesame (*Sesamum indicum* L.) consisted of the experimental material for the present study. The material was obtained from the ICAR, Project Coordinating Unit (Sesame & Niger), J.N.K.V.V., Jabalpur (M.P). The experiment was sown on 27th, July, 2018. Each treatment was grown in 3m X 4m plot spaced 30cm apart. The plant to plant distance was maintained 10cm by thinning. Recommended agronomic practices and

plant protection measures were adopted to raise a good crop. Five plants of each genotype were selected randomly from each replication at maturity to record the data on following pre and post-harvest of 10 quantitative and qualitative traits.

## Result and Discussion

**Table 1:** Analysis of Variance for twelve quantitative and qualitative characters in Sesame

| S. No. | Characters | Mean Sum of Square | | |
|---|---|---|---|---|
| | | Replication | Treatments | Error |
| | d.f. | 2 | 9 | 18 |
| 1 | Days to 50% Flowering | 4.31 | 58.29*** | 2.73 |
| 2 | Capsule length(mm) | 17.87 | 15.07 | 11.12 |
| 3 | No. of capsule/plant | 96.2 | 51.57 | 28.66 |
| 4 | No. of seeds/capsule | 5.59 | 14.69*** | 4.02 |
| 5 | Plant height (cm) | 28.73 | 277.21*** | 51.8 |
| 6 | Days to 80% Maturity | 88.53 | 100.53 | 30.41 |
| 7 | 1000 seed weight(g) | 0.14 | 0.17* | 0.04 |
| 8 | Oil (%) | 4.07 | 15.92*** | 1.86 |
| 9 | Moisture content (%) | 1.01 | 8.23*** | 1.52 |
| 10 | Seed Yield (kg/ha) | 346.04 | 3943.97*** | 193.44 |

*Significant at 5% probability level; **Significant at 1% probability level

**Table 2:** Genetic parameters for 10 quantitative and qualitative characters in Sesame seed

| S. No. | Characters | Grand mean (X)+SE(m) | Range | | Coefficient of Variation | | C.V (%) | Heritability Broad sense($h^2b$) | GA | GA % of mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | GCV | PCV | | | | |
| 1 | Days to 50% Flowering | 38.39±1.26 | 33.33 | 47.67 | 11.21 | 12.01 | 4.23 | 87.18 | 21.56 | 8.28 |
| 2 | Capsule length(mm) | 27.16±1.59 | 22.87 | 30.44 | 4.22 | 12.98 | 2.48 | 10.58 | 2.83 | 0.77 |
| 3 | No. of capsule/plant | 13.56±0.16 | 9.07 | 20.07 | 20.39 | 44.45 | 0.49 | 21.04 | 19.26 | 2.61 |
| 4 | No. of seeds/capsule | 49.72±0.49 | 46.43 | 54.13 | 3.79 | 5.54 | 3.46 | 46.93 | 5.35 | 2.66 |
| 5 | Plant height (cm) | 102.90±0.47 | 86.87 | 114 | 8.42 | 10.95 | 3.15 | 59.19 | 13.35 | 13.74 |
| 6 | Days to 80% Maturity | 85.15±7.46 | 79.33 | 99.13 | 5.68 | 8.61 | 7.19 | 43.46 | 7.71 | 6.57 |
| 7 | 1000 seed weight(g) | 3.21±0.24 | 2.85 | 3.45 | 6.59 | 9.00 | 2.46 | 53.60 | 9.94 | 0.32 |
| 8 | Oil (%) | 44.43±0.16 | 41.62 | 49.45 | 4.87 | 5.76 | 3.16 | 71.66 | 8.50 | 3.78 |
| 9 | Moisture content (%) | 11.29±2.16 | 7.4 | 12.52 | 13.25 | 17.16 | 2.15 | 59.63 | 21.08 | 2.38 |
| 10 | Seed Yield (kg/ha) | 577.76±1.26 | 461.1 | 761.45 | 19.35 | 20.80 | 2.19 | 86.60 | 37.10 | 214.35 |

**Table 3:** Estimates of genotypic Correlations for different 10 characters in Sesame Large seed

| S. No | Characters | Days to 50% flowering | Capsule length (mm) | No. of capsule/plant | No. of seeds/capsule | Plant height (cm) | Days to 80% Maturity | 1000 seed weight(g) | Oil (%) | Moisture content (%) | Seed Yield (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Days to 50% flowering | 1.000 | | | | | | | | | |
| 2 | Capsule length (mm) | 0.841** | 1.000 | | | | | | | | |
| 3 | No. of capsule/plant | -0.014NS | -0.739** | 1.000 | | | | | | | |
| 4 | No. of seeds/capsule | 0.254NS | 0.402* | 0.430* | 1.000 | | | | | | |
| 5 | Plant height (cm) | -0.170NS | 0.637** | 0.988** | 0.779** | 1.000 | | | | | |
| 6 | Days to 80% Maturity | 1.158** | 0.765** | 0.055NS | 0.436* | -0.073NS | 1.000 | | | | |
| 7 | 1000 seed weight(g) | 0.151NS- | -0.778** | 0.651** | 0.829** | 0.568** | 0.239NS | 1.000 | | | |
| 8 | Oil (%) | -0.854** | -1.543** | 0.686** | -0.315NS | 0.389* | -0.903** | -0.023NS | 1.000 | | |
| 9 | Moisture content (%) | 0.448 | 1.490** | 0.136NS | 0.539** | 0.692** | 0.375* | -0.138NS | -0.422* | 1.000 | |
| 10 | Seed Yield (kg/ha) | -0.129NS | -0.240NS | 1.096** | 0.904** | 0.853** | 0.149NS | 0.829** | 0.209NS | 0.398* | 1.000 |

**Table 4:** Estimates of phenotypic Correlations for different 10 characters in Sesame Large seed

| S. No | Characters | Days to 50% flowering | Capsule length (mm) | No. of capsule/plant | No. of seeds/capsule | Plant height (cm) | Days to 80% Maturity | 1000 seed weight(g) | Oil (%) | Moisture content (%) | Seed Yield (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Days to 50% flowering | 1.000 | | | | | | | | | |
| 2 | Capsule length (mm) | 0.215NS | 1.000 | | | | | | | | |
| 3 | No. of capsule/plant | -0.021NS | -0.140NS | 1.000 | | | | | | | |
| 4 | No. of seeds/capsule | 0.132NS | 0.171NS | 0.351NS | 1.000 | | | | | | |
| 5 | Plant height (cm) | -0.128NS | -0.092NS | 0.186NS | 0.470** | 1.000 | | | | | |
| 6 | Days to 80% Maturity | 0.679** | -0.080NS | 0.170NS | 0.356NS | -0.012NS | 1.000 | | | | |
| 7 | 1000 seed weight(g) | 0.028NS | -0.099NS | 0.265NS | 0.585** | 0.403* | 0.365* | 1.000 | | | |
| 8 | Oil (%) | -0.706** | -0.236NS | 0.266NS | -0.173NS | 0.169NS | -0.611** | 0.122NS | 1.000 | | |
| 9 | Moisture content (%) | 0.285NS | 0.518** | 0.103NS | 0.285NS | 0.387* | 0.383* | 0.116NS | -0.430* | 1.000 | |
| 10 | Seed yield (kg/ha) | -0.080NS | -0.085NS | 0.505** | 0.656** | 0.610** | 0.197NS | 0.624** | 0.214NS | 0.258NS | 1.000 |

**Table 5:** Direct and Indirect effects for different characters on seed yield per plant at genotypic and phenotypic level in Sesame large seed

| S. No | Characters | | Days to 50% flowering | Capsule length(mm) | No. of capsule/plant | No. of seeds/capsule | Plant height(cm) | Days to 80 %maturity | 1000 seed weight(g) | Oil content (%) | Moisture content (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Days to 50% flowering | G | 0.453 | 0.060 | 0.003 | 0.149 | -0.152 | -0.007 | 0.009 | -0.353 | -0.291 |
| | | P | 0.047 | -0.036 | -0.003 | 0.057 | -0.020 | 0.042 | 0.005 | -0.240 | 0.067 |
| 2 | Capsule length(mm) | G | 0.381 | 0.071 | 0.161 | 0.236 | 0.570 | -0.005 | -0.048 | -0.638 | -0.969 |
| | | P | 0.010 | -0.166 | -0.019 | 0.074 | -0.015 | 0.005 | -0.016 | -0.080 | 0.123 |
| 3 | No. of capsule/plant | G | -0.006 | -0.052 | -0.218 | 0.253 | 0.884 | 0.000 | 0.040 | 0.283 | -0.088 |
| | | P | -0.001 | 0.023 | 0.134 | 0.151 | 0.030 | 0.011 | 0.043 | 0.090 | 0.024 |
| 4 | No. of seeds/capsule | G | 0.115 | 0.028 | -0.094 | 0.588 | 0.698 | -0.003 | 0.052 | -0.130 | -0.350 |
| | | P | 0.006 | -0.028 | 0.047 | 0.430 | 0.075 | 0.022 | 0.095 | -0.059 | 0.067 |
| 5 | Plant height(cm) | G | -0.077 | 0.045 | -0.216 | 0.458 | 0.895 | 0.000 | 0.035 | 0.161 | -0.450 |
| | | P | -0.006 | 0.015 | 0.025 | 0.202 | 0.159 | -0.001 | 0.066 | 0.057 | 0.092 |
| 6 | Days to 80 %maturity | G | 0.524 | 0.054 | -0.012 | 0.257 | -0.066 | -0.006 | 0.015 | -0.373 | -0.244 |
| | | P | 0.032 | -0.013 | 0.023 | 0.153 | -0.002 | 0.062 | 0.060 | -0.207 | 0.090 |
| 7 | 1000 seed weight(g) | G | 0.068 | -0.055 | -0.142 | 0.488 | 0.509 | -0.001 | 0.062 | -0.010 | -0.090 |
| | | P | 0.001 | 0.017 | 0.036 | 0.251 | 0.064 | 0.023 | 0.163 | 0.041 | 0.027 |
| 8 | Oil content (%) | G | -0.386 | -0.109 | -0.150 | -0.185 | 0.348 | 0.005 | -0.001 | 0.413 | 0.274 |
| | | P | -0.033 | 0.039 | 0.036 | -0.074 | 0.027 | -0.038 | 0.020 | 0.340 | -0.102 |
| 9 | Moisture content (%) | G | 0.203 | 0.106 | -0.030 | 0.317 | 0.620 | -0.002 | 0.009 | -0.174 | -0.650 |
| | | P | 0.014 | -0.086 | 0.14 | 0.122 | 0.062 | 0.024 | 0.019 | -0.146 | 0.237 |

**Genetic variability along with biochemical traits**

The Analysis of variance for design of the experiment indicated highly significant differences among the genotypes for all the ten Characters under study which indicated the presence of considerable amount of variability in the materials. The results on range and coefficient of variation are presented Character wise (Days to 50%flowering:, Capsule length (cm), Number of capsules per plant, No. of Seeds Per Capsule, Plant height (PH), Days to 80%Maturity (DM), 1000-Seed weight (g), Oil content (%)) in Table 1. Heritability estimates are used to predict expected advance under selection so that breeders are able to anticipate improvement from different of selection intensity. Johnson *et al*. (1955) [5] have suggested heritability estimates in association with genetic advance are much useful for selection than heritability alone. In the present study, estimates of the heritability values ranged from 25.62 per cent for oil content to 97.40 per cent for seeds/ capsule. High heritability estimates were found for seeds/ capsule followed by days to 80% maturity and primary branches / plant while moderate heritability was expressed by no. of capsule per plant, 1000-seed weight, soluble protein and capsule length whereas low heritability were expressed by seed yield kg/ha, moisture%, plant height and days to 50% flowering, respectively. The expected genetic advance in per cent of mean ranged from 1.45 % for oil content to 40.15 for days to 80% maturity. High estimates of expected genetic advance were found for days to 80% maturity, number of capsules per plant, soluble protein, primary branches/ plant, No. of seeds per capsule, 1000-seed weight, seed yield per plant, plant height, moisture% and capsules length in decreasing order and low estimates of expected genetic advance were found for, days to 50% flowering and oil content in decreasing order. These results in consonance with the result reported by Sarwar *et al*. (2005) [12] and Bharathi *et al*. (2014) [2] for seed yield per plant followed by capsule number and branches per plant while days to flower, days to maturity and plant height showed a very negligible genetic advance. High heritability coupled with high genetic advance was observed for seed yield kg/ha, days to 80% maturity, number of capsule per plant, seeds /plant and plant height. High heritability coupled with low genetic advance was observed for capsule length, oil content and 1000-seed weight suggesting the presence of additive gene action in the expression of these characters. Phenotypic selection for these characters would be highly effective as also reported earlier by Padmavathi (1997) [7] for branches per plant, capsule per plant and seed yield per plant, Laurentin and Montilla (2002) [6] observed a high heritability along with a high genetic advance for seed yield per plant, capsule number and plant height, Solanki and Gupta (2003) [15] for the capsules per plant and seed yield per plant, Ved Narain *et al*. (2004) [15] for capsules per plant, seed yield per plant and harvest index, Rao (2005) [10] for plant height, number of capsules per plant and 1000-seed weight, Sarwar *et al*. (2005) [12] for branches per plant and capsule number showed high heritability along with higher values of genetic advance, Singh *et al*. (2008) [13] for seed yield, capsules on primary branches, plant height, capsules on main stem and on secondary branches. Bharathi *et al*. (2014) [2] for seed yield per plant and number of capsule per plant and Saxena and Bisen (2017) [14]. Seeds per capsule followed by oil content, yield per plant, harvest index, days to 50% flowering, number of primary branches per plant. The phenotypic and genotypic correlations were estimated. The direction of phenotypic and genotypic correlations was similar for almost all the characters. In general, genotypic correlations were higher than phenotypic ones in magnitude for many characters. The character which showed negative association at genotypic level also showed negative association at phenotypic level. The seed yield kg/ha showed highly significant and positive correlation with seeds/capsule while significant and negative correlation was exhibited with oil content, 1000-seed weight and days to 80% maturity at genotypic level, respectively. The seed yield kg/ha showed highly significant and positive correlation with plant height, days to 50% flowering, capsules / plant and seeds/capsule while significant and negative correlation was exhibited with oil content and soluble protein at phenotypic level, respectively. Soluble protein exhibited significant and positive correlation with 1000-seed weight; oil content exhibited positive correlation with 1000-seed weight; days to 80% maturity with seeds / capsule; plant height with capsule / plant, primary branches/ plant and days to 50% flowering; seeds / capsule with capsule length and days to 50% flowering; capsule length with primary branches; capsules / plant with primary branches/ plant and days to 50% flowering and primary branches with days to 50% flowering

while showed highly significant and negative correlation soluble protein with primary branches; moisture % with plant height, capsule / plant(-0.650), days to 50% flowering and primary branches/ plant; oil content with capsule / plant, days to 50% flowering and primary branches/ plant; 1000-seed weight with capsule / plant, capsule length and primary branches and days to 80% maturity with days to 50% flowering at genotypic level, respectively. Soluble protein exhibited significant and positive correlation with 1000-seed weight and oil content; days to 80% maturity with seeds / capsule; plant height with capsule / plant, days to 50% flowering and primary branches/ plant; seeds / capsule with capsule length; capsules / plant with primary branches/ plant and days to 50% flowering and primary branches with days to 50% flowering while showed highly significant and negative correlation soluble protein with primary branches; moisture % with plant height and capsule / plant; oil content with capsule / plant, plant height, primary branches/ plant and days to 50% flowering; 1000-seed weight with capsule length at phenotypic level, respectively. Path coefficient analysis showed that plant height, moisture %, seeds per capsule, Oil content and primary branches had exerted maximum positive direct effect while 100-seed weight, capsule length, days to 50% flowering, days to 80% maturity, soluble protein and number of capsules per plant had exerted maximum substantial negative direct effect by the characters on seed yield at genotypic level. Path coefficient analysis exhibited that seeds per capsule, days to 50% flowering, number of capsules per plant, plant height and Oil content had exerted maximum positive direct effect while soluble protein, primary branches, days to 80% maturity, capsule length, moisture % and 100-seed weight had exerted maximum substantial negative direct effect by the characters on seed yield at phenotypic level. The plant height, capsule length *via* soluble protein; moisture% and days to 50% flowering *via* oil content; capsule length and oil content *via* 1000-seed weight; seeds / capsule and 1000-seed weight *via* capsule length; plant height and 1000-seed weight *via* capsule / plant; plant height and 1000-seed weight *via* primary branches; plant height, seeds / capsule and primary branches *via* days to 50% flowering had exerted maximum positive indirect effect while moisture % and 1000- seeds weight *via* soluble protein; plant height and seeds / capsule *via* moisture %; plant height, 1000-seed weight and seeds / capsule *via* Oil content; plant height *via* days to 80% maturity; moisture % *via* plant height; capsule length and moisture % *via* seeds / capsule; plant height *via* capsule length; moisture % and oil content *via* capsule / plant; moisture %, oil content and capsule length *via* primary branches; moisture % and oil content *via* days to 50% flowering had exerted maximum substantial negative indirect effect by the characters on seed yield at genotypic level.

Primary branches (0.149) *via* soluble protein; primary branches *via* oil content; seeds / capsule *via* days to 80% maturity; soluble protein *via* capsule length had exerted maximum positive indirect effect while soluble protein *via* oil content; soluble protein *via* 1000-seed weight and primary branches *via* capsules / plant had exerted maximum substantial negative indirect effect by the characters on seed yield phenotypic level. The similar findings were reported by Ved Narain *et al*. (2004) [15] that the capsules per plant recorded highest positive direct effect on seed yield per plant followed by 1000-seed weight and harvest index. Raghuwanshi *et al*. (2007) [9] observed highest positive direct effect observed for number of capsules per plant while negative direct effect for oil content, 1000-seed weight and plant height on seed yield. Bharathi *et al*. (2015) [3] reported that seed yield was significant positively correlated with number of capsules per plant, number of seeds per capsule, test weight and plant height. Fazal *et al*. (2015) [4] for path analysis revealed that capsules per plant had highest direct effect on seed yield per plant and Seeds per capsules had highest indirect effect via capsules per plant on seed yield per plant and Patil and Lokesha, (2018) [8] for number of capsules per plant, number of branches per plant, capsule length, number of seeds per capsule, capsule weight and test weight. The other characters values are found too low to be not taken in to consideration. The residual effect at genotypic level was (0.14018) and at phenotypic level (0.29540) was found high indicating that some of characters affecting seed yield has to be included in the future study. Based on per se performances RT-375,RT-372,RAMA (SC),AT-338 and GT-10(NC) are high yielding varieties and possess good percent of oil content.

## Conclusion

There are sample of variation found in genotypes of sesame and the high PCV and GCV recorded for the trait no. of capsules / plant. High heritability and genetic advance was observed for the character Days to 50 % flowering. The traits with high heritability and high genetic advance as percent of mean are governed by the additive gene action where simple selection is effective for breeding programmes. capsules per plant had highest direct effect on seed yield per plant and Seeds per capsules had highest indirect effect via capsules per plant on seed yield per plant for number of capsules per plant, number of branches per plant, capsule length, number of seeds per capsule, capsule weight and test weight these traits should be given top priority during selection breeding and high indicating that some of characters affecting seed yield has to be included in the future study..

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## References

1. Abate, Mohammed, Mekbib, Firew. Assessment of Genetic Variability and Character Association in Ethiopian Low-Altitude Sesame (*Sesamum Indicum* L.) Genotypes. Journal of Advanced Studies in Agricultural, Biological and Environmental Sciences (JABE) 2015;2(3):55-66.
2. Bharathi D, Rao Thirumala V, Mohan Chandra Y, Bhadru D, Venkanna V. Genetic Variability Studies in Sesame (*Sesamum indicum* L.). International Journal of Applied Biology and Pharmaceutical Technology 2014;5(4):31-33.
3. Bharathi D, Rao Thirumala V, Venkanna V, Bhadru D. Association Analysis in Sesame (*Sesamum indicum* L.). International Journal of Applied Biology and Pharmaceutical Technology 2015;6(1):210-212.
4. Fazal Ammara, Mustafa Hafiz Saad Bin, Hasan Ejaz-ul, Anwar Muhammad, Tahir, Muhammad Hammad Nadeem *et al*. Interrelationship and Path Coefficient Analysis among Yield and Yield Related Traits in

Sesame (*Sesamum indicum* L.) Nature and Science 2015;13(5):27-32.
5. Johnson HW, Robinson HF, Comstock RE. Estimates of genetic and environmental variability in soybeans. Agron. J 1955;47:314-318.
6. Laurentin H, Montilla D. Variability studies for yield and yield components in white grain Sesame. Sesame and Safflower Newsletter 2002;17:26-28.
7. Padmavathi N. Genetic variability for seed yield and its components in sesame. Sesame and Safflower Newsletter 1997;12:64-65.
8. Patil M, Lokesha R. Estimation of Genetic Variability, Heritability, Genetic Advance, Correlations and Path Analysis in Advanced Mutant Breeding Lines of Sesame (*Sesamum indicum* L.). J Pharmacogn Nat Prod 2018;4:151. Doi:10.4172/2472-0992.1000151
9. Raghuwanshi KMS, Sandhu SS, Duhoon SS. Direct and indirect effects of different yield attributes on seed yield in sesame (*Sesamum indicum* L.). ISOR National Seminar 2007, 29-31, 103-105.
10. Rao Gangadhar SVS. Genetic variability in sesame (*Sesamum indicum* L.). Sesame and Safflower Newsl 2005;20:26-27.
11. Ranganatha ARG, Lokesha R, Tripathi A, Tabassum Aasfa, Paroha S, Shrivastava MK. Sesame improvement-Present status and future strategies. Journal of Oilseeds Research 2012;29(1):1-26.
12. Sarwar G, Haq MA, Mughal MS. Genetic parameters and correlation study in diverse types of sesame germplasm. Sesame and Safflower Newsletter 2005;20:29-33.
13. Singh PK, Vajpeyi Madhu, Mohd Akram, Ram Naresh. Analysis of genetic variability and character association in summer sesame (*Sesamum indicum* L.). J Oilseeds Res 2008;25(2):183-185.
14. Singh A, Bisen R, Tiwari A. Genetic Variability and Character Association in Sesame (*Sesamum indicum* L.) Genotypes Int. J Curr. Microbiol. App. Sci 2018;7(11):2407-2415.
15. Ved Narain, Gupta RR, Singh PK. Variability and character association in sesame. Farm Sci. J 2004;13(2):130-132.
16. Yogranjan, Satpute GK, Mishra SP. Genetic and genomics intervention to upsurge nutritive values of sesame (*Sesamum indicum* L.) Asian Journal of Science and Technology 2015;6(04):1296-1303.