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Evaluation of sesame (*Sesamum indicum* L.) germplasm based on agro morphological traits under soil salinity stress

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Abstract
The study was conducted at the research farm of School of Agriculture and Allied Sciences (SAAS), The Neotia University during 2021-2022 to evaluate performance of twenty-three sesame accessions obtained from Indian Institute of Oilseeds Research, Hyderabad in term of yield and yield attributing traits under mild soil salinity stress conditions. It revealed that the genotypes Rama, Usha, GT 10, YLM 16, VRI 3 and Savitri were found promising both in terms of their yield and yield attributing traits. These genotypes may be recommended to the farmers for large scale production in south 24 Parganas, West Bengal. Plant height, No. of branches plant^{-1}, No. of capsules plant^{-1} and 1000 seed weight were found to be positively correlated with seed yield. On the contrary, days to first flowering and 50% flowering, were found to be negatively correlated with seed yield. Thus, it was demonstrated that plant height, No. of capsules plant^{-1}, No. of branches plant^{-1} and 1000 seed weight were the most important characters having significant influence on sesame seed yield. Further, these characters are recommended to be considered in making selection or breeding new varieties of sesame for high seed yield under soil salinity stress situations.

Keywords: Yield, yield attributing traits, selection, salinity, sesame

Introduction
Sesame is the earliest oilseed plant to be used by humans (Mkamilo and Bedigian, 2007) [1]. It is an annual crop with an erect, pubescent, branching stem and up to 1.20 meter tall (Ujjainkar *et al*., 2022) [2]. Sesame grown all over the India, it possesses a wide range of variability and had number of distinct forms available all over the country. Sesame is better known as “Queen of oilseeds” by virtue of its quality edible oil and protein content. Rich in antioxidants, sesame oil is also notable for its resistance to oxidation, although the productivity of sesame stands alarmingly poor comparing other oil yielding crops. Adapted to tropical climates and with low water demand, sesame is a good cultivation option for semi-arid regions and can provide an alternative income source, especially for small and medium farmers (Antoniassi *et al*. 2013) [3]. Similarly, under irrigated conditions, linear increase in production was observed with the volume of water applied Uçan and Killi, 2010 [4]. Soil salinity and water stress are highly correlated. When saline soils are exposed to water stress, salinity has severe effects on the root zone that can inhibit overall plant growth. In South 24 Parganas, West Bengal there is a large track of land affected with different degree of salinity with water stress especially in pre-*kharif* season. Performance of different sesame germplasm varies based on the degrees of salinity. Therefore, there is urgent requirement of high yielding salinity tolerance sesame genotypes. sesame is sensitive to soil salinity that have been reported in the literature (Yousif *et al*. 1972 [5]; Cerda *et al*. 1997 [6]). It is considered to be moderately tolerant to salinity stress (Abbasdokht *et al*. 2012) [7]. Two genotypes tolerant to saline stress during stages of germination and initial seedling growth were earlier reported (Bahrami and Razmjoo 2017 [8] and Mahmood *et al*. 2003 [9]). In general, plants with high tolerance to saline stress during initial phases were shown to be more tolerant during adult phase of growth. There is, however, paucity of information on the effects of salinity on sesame germplasm in terms of different agro-morphological characters and seed yield. Therefore, the present study was conducted to evaluate the effects of salinity on different sesame genotypes and identify the types that are best adapted to salinity.

Materials and methods
The study was conducted at the research farm of School of Agriculture and Allied Sciences (SAAS), The Neotia University (22.261954°N latitude and 88.196574°E longitudes) in pre-*kharif* season 2022. The soil pH is 7.4 and EC of experimental area 4.2 ds m-1.

Plant materials
To evaluate various sesame germplasm in saline environment of South 24 Parganas, twenty-three different genotypes having distinct morphological features were collected from IIOR, Hyderabad. Although, all the genotypes under study having outstanding morphological features, however, limited has been done so far on whether they have salinity stress.

Field Experiment
The seeds of different genotypes were sown in Randomized Block Design (RBD) with 3 replications March, 2022. The plot size of each germplasm was 5 sq.mt and row distance and plant to plant distance were 50 and 10 cm, respectively. Data were taken on germination (%) along with yield and different traits *viz*. days to first flowering, days to 50% flowering, flower duration, plant height, no. of branches plant^{-1}, capsules plant^{-1}, days to maturity, capsule size, no. of seeds capsule^{-1}, 1000 seed weight and seed yield plant^{-1}. Regular agronomic cultivation package and practices including plant protection measures were followed towards crop maintenance. Data were analyzed using the statistical software IBM SPSS 20, XL-Stat, MS Excel 2008.

Result and Discussion
Assessment of genotypes based on means
The results of analysis of variance showed a highly significant difference (p<0.01) among genotypes for all studied traits under soil stress condition. The average morphological traits of twenty-three sesame genotypes were compared to measure the effect of salt stress (Table 1). Substantial genetic variability was observed for all agro-morphic characters under study. A perusal of the table revealed that there was no consistency in the behaviour of studied germplasm under soil salinity stress. Majority of the germplasm had combination of both positive and negative forms of important yield contributing traits.

Days to flowering and days to 50% flowering
Days to flower and days to 50% flowering ranged from 28.52 to 35.66 and 42.00 to 56.25, respectively. The grand mean value for these character was 32.23 and 56.25. The mean of genotypes *viz.*, GT 10, TMV 7, VRI 3, VRT 2 were significantly lower (5- 8 days) than others. The genotypes may be utilized directly or indirectly in the crossbreeding programme to reduce the duration under such stress condition. Arriel *et al*. (1998) [10] found 30 to 51 days to 1st flowering under soil salinity.

Plant height
It varied from 97.28 to 112.32 cm with a grand mean 81.29. Significant reduction in plant height was observed in Gowri (97.81cm) and Usha (97.28 cm). The shortest genotype was Usha. The genotypes may be used as dwarf type under salinity condition. Similar results were for sesame under salinity stress also obtained by Muhammad *et al.* (2013) [11], Iqbal *et al*. (2016) [12].

No. of branches plant^{-1} and No. of capsules plant^{-1}
Variability for these character ranged from 3.00 to 6.00 and 32.20 to 199.35 with grand mean of 3.95 and 69.40 respectively. The mean of genotypes Tillotama were significantly higher than (4.08 to 5.17) than others. Seed yield plant^{-1} also reflected in the same trend as observed for earlier parameter. This apparently suggest that no. of branches plant^{-1} would be indicative for increase in seed yield plant^{-1}. The genotypes Tillotama, GT 3, VRI 3 and YLM 66 showed significant increase in capsules^{-1} plant over others. Earlier evidences (Mukhekar *et al.* 2003 [13], Boranayaka *et al.* 2010 [14], Chowdhury *et al*. 2010 [15], Begum and Dasgupta 2011 [16], Birara *et al.* 2013 [17], Muhammad *et al.* 2013 [11]) obtained the enhancement of variability for capsules plant^{-1} in sesame under draught and salinity stress.

Capsule length and No. of seeds capsule^{-1}
Variability ranged from 1.13 cm to 2.74 cm and with grand mean 1.63 cm. This character did not showed sort of apparent variation among different genotypes. Maximum length of capsule was recorded in 2.74 cm. This range was supported by Iqbal *et al*. (2016) [12] who obtained 2.00 cm to 3.5 cm of capsule length under soil stress condition. Range for no. of seeds capsule^{-1} character was 60.35 to 96.60 with grand mean 68.60. Valarmathi *et al*. (2003) [18] reported from 50.00 to 116.00 seed capsule^{-1} in sesame capsule under soil salinity stress.

Days to maturity
Days to maturity ranged from 86.67 to 111.28 with grand mean 99.94. Significant reduction was observed in Tilitara (86.67). Duration is one of the most important agronomic traits of a crop including sesame were a reduction in maturity is very much beneficial for its suitability in rice-based cropping system in a state like West Bengal there had been reports on the induction of mutation for maturity in sesame (70 to 85 days). This genotype may be utilized directly or indirectly in cross breeding programme to reduce the duration of other long duration varieties in sesame in saline soil.

1000 seed weight and Seed yield plant^{-1}
1000 seed weight ranged from 2.91 gm. to 3.90 gm. Similarly, Seed yield ranged from 6.85 g to 18.04 gm with grand mean 10.96. Maximum yield was observed in the genotypes CUMS 17 (18.04 gm), Savitri (17.12 gm), followed by Usha (14.32 gm) and Rama (12.67 gm). Valarmathi *et al.* (2003) [18] and Sheeba *et al.* (2004) [19] reported moderate range (2.50 g – 5.00 g) of variability of this character in sesame.

Yield is a complex of various components; the contribution of components for yield are through component compensation mechanism (Adams, 1967) [20]. The yield as such, is a complex manifestation of large number of genes involved in physicochemical process of the plant system. The increased seed yield plant^{-1} in above genotypes seemed to be due to increase in other yield attributing traits mainly no. of branches plant-1, capsules plant^{-1} and no. of seeds capsule^{-1}. Coefficient of variation indicated that the variability was highest in no. of capsules plant^{-1} followed by plant height, days to maturity, no. of seeds capsule^{-1} and seed yield plant^{-1} in all the genotypes.

Considering the performance under soil salinity stress condition of twenty-three sesame genotypes for above agronomically important characters, Rama, Usha, GT 10, YLM 16, VRI 3 and Savitri were found promising. These genotypes may use directly at farmers' field for large scale production in south 24parganas, West Bengal. The other genotypess may be used in cross breeding programme of sesame for utilization of agronomically useful characters.

Study of correlation coefficient

In the present investigation correlation coefficients among eleven quantitative character were estimated to study how seed yield is influenced by component characters. The estimates of correlation coefficient are presented in (Table 2).

seed yield plant^{-1} was found to be positively and significantly correlated with plant height, no. of capsules plant^{-1}, no. of branches plant^{-1}, no. of seeds capsule^{-1}, capsule length and 1000 seed weight. The results are agreement with Singh *et al.* (2000) [21], Arulmozhi *et al.* (2001) [22], Sankar and Kumar (2003) [23], for no. of capsules plant^{-1}, no. of seeds capsule^{-1}, plant height, branches plant^{-1} with seed yield plant^{-1}; Babu *et al.* (2004) [24], Siddiqui *et al.* (2005) [25], Aristya and Taryono (2016) [26], Aristya *et al.* (2017) [27] for no. of capsules plant^{-1}, no. of seeds capsule^{-1}, 1000 seed weight, plant height, length of capsule with 1000 seed weight and seed yield plant^{-1}. However, Sarwar and Jafar (2010) [28] observed negative correlation between capsules plant^{-1} and seed yield plant^{-1}.

When characters having direct bearing on yield are selected, their associations with other characters are to be considered simultaneously as this will indirectly affect yield. Significant positive correlation in this experiment were observed days to maturity with no. of seeds capsule^{-1}; plant height with no. of branches plant^{-1}, no. of capsules plant^{-1} no. with of seeds capsule^{-1} and 1000 seed weight; no. of branches plant^{-1} with no. of capsules plant^{-1} with no. of capsules plant^{-1} with no. of seeds capsule^{-1}; days to maturity with no. of seeds capsule^{-1}. Aristya and Taryono (2016) [26] observed significant positive correlation between seed yield plant^{-1} with plant height, capsules plant^{-1} and 1000 seed weight. Similar trends were followed by Aristya *et al.* (2017) [27], Patil and Lokesha (2018) [29]. Significant negative correlation was observed for days to 50% flowering with no. of branches plant^{-1}, no. of capsules plant^{-1} and seed yield plant^{-1}, days to 50% flowering with no. of branches plant^{-1} and no. of capsules plant^{-1}; no. of branches and no. of capsules plant^{-1} with days to maturity and days to maturity with 1000 seed weight. The results are in agreement with Begum and Dasgupta (2003) [30] for 1000 seed weight with seed yield plant^{-1}. The developing structures of the plant compete for common factors, possibly limited nutrient supply and if one structure is more favoured than the other for any reason, a negative correlation may arise between them. Component composition of parents allows an opportunity to have reasonable compromise and balance between one or two components resulting in high yield. The optimal level for each component would differ depending on the type of environment encountered (Grafius 1965) [31]. Pleiotropy and /or linkage may also be the genetic reasons for this type of negative association. The pleiotropic genes that affect both characters in the desired direction will be strongly acted upon by selection and rapidly brought towards fixation. According to Newall and Eberhart (1961) [32] when two characters show negative correlation it would be difficult to exercise simultaneously for these characters in the development of variety. Hence, under such situations, judicious selection programme might be formulated for simultaneous improvement of such important developmental and component characters. The result of correlation coefficient implied that branches plant^{-1}, no. of capsules plant^{-1} and no. of seeds capsule^{-1} may be considered for selection for yield improvement.

Table 1: Mean performance of twenty –three sesame genotypes for eleven quantitative characters under soil salinity stress

	Days to flowering	Days to 50% flowering	Flower duration	Plant height (cm)	No. of branches plant^{-1}	No. of capsules plant^{-1}	No. of seeds capsule^{-1}	Capsule length (cm)	Days to maturity	1000 seed weight	Seed yield plant^{-1}
GT 4	33.66	55.00	61.00	98.94	3.13	48.20	62.40	1.88	87.67	3.23	14.11
Tillarani	31.33	51.33	67.00	101.43	3.40	111.20	60.70	1.51	102.40	3.06	14.20
TMV 7	29.55	50.43	67.67	105.43	4.67	97.02	59.82	1.50	97.78	3.04	9.55
Gowri	33.66	56.23	64.33	97.81	3.64	148.41	64.44	1.23	105.97	3.09	10.65
Tillotama	31.33	51.33	60.33	105.30	6.00	198.35	64.23	1.13	111.28	3.01	11.24
Amrit	33.66	53.33	61.00	101.43	3.13	33.20	66.75	1.45	88.67	3.15	10.78
Rama	31.33	42.23	67.00	100.53	3.73	115.91	63.02	1.30	104.40	3.05	12.67
Usha	35.66	55.21	67.67	97.28	4.00	99.02	71.02	1.34	100.78	2.97	14.32
GT 10	29.55	55.56	60.33	99.26	3.63	147.41	87.64	2.45	105.97	3.02	13.47
GT 3	33.33	53.66	61.33	101.43	5.33	199.35	64.44	2.39	111.28	3.06	10.85
Tilatara	31.33	50.23	67.00	100.88	3.13	36.20	60.35	2.22	86.67	3.21	13.69
Krishna	34.56	54.21	60.33	100.66	3.73	100.90	61.15	2.46	102.40	2.97	9.50
Prachi	30.33	42.21	61.00	99.26	4.00	95.02	64.27	2.27	97.78	3.71	11.97
Piyur	34.33	53.24	67.00	100.93	5.33	189.35	71.20	2.32	111.28	3.26	12.49
DSS 9	35.23	56.25	60.33	105.86	3.27	33.20	96.40	2.64	87.27	3.33	16.05
Savitri	31.33	52.45	61.00	107.76	3.73	105.90	67.15	2.70	101.40	3.26	17.12
Rajeshwari	30.12	42.23	67.00	112.32	4.00	92.02	95.60	2.20	97.83	3.90	14.08
CUMS 17	34.85	54.25	68.65	99.23	3.64	142.41	66.62	2.45	105.97	3.54	18.04
VRI 3	28.44	42.00	64.23	101.43	5.66	199.35	72.39	2.69	111.28	3.57	9.83
YLM 16	33.33	53.66	60.33	104.82	3.06	35.22	67.11	2.74	89.67	2.91	14.71
VRT 2	28.52	50.23	61.00	100.56	3.53	106.85	60.71	2.31	109.40	3.54	6.85
TKG 305	31.33	42.15	67.12	99.26	4.00	98.02	68.84	1.87	97.83	3.15	9.21
YLM 66	34.56	52.66	60.23	100.93	3.00	197.35	61.47	2.45	111.28	3.34	11.90
Range(min)	28.52	42.00	60.23	97.28	3.00	33.20	60.35	1.13	86.67	2.91	6.85
Range(max)	35.66	56.25	67.67	112.32	6.00	199.35	96.60	2.74	111.28	3.90	18.04
GM	32.23	50.87	64.04	81.29	3.95	69.40	68.60	1.63	99.94	2.39	10.96
CV (%)	5.60	5.83	2.77	4.12	10.49	18.48	7.52	8.74	11.96	14.13	21.02
SE	1.04	1.71	1.03	2.62	0.34	3.07	4.21	0.38	1.13	0.57	2.12
CD (%)	2.94	4.84	2.89	5.13	0.67	5.96	8.41	0.76	3.19	1.60	5.99

Table 2: Correlation coefficient for eleven quantitative characters for different germplasm of sesame under soil salinity stress

	Days to flowering	Days to 50% flowering	Flower duration	Plant height (cm)	No. of branches plant^{-1}	No. of capsules plant^{-1}	No. of seeds capsule^{-1}	Capsule length (cm)	Days to maturity	1000 seed weight	Seed yield plant^{-1}
Days to flowering	1.00	0.764**	-0.049	-0.491*	-0.685**	-0.556**	-0.027	-0.030	0.503*	-0.228	-0.139
Days to 50% flowering		1.00	0.442*	-0.735**	-0.769**	-0.855**	0.069	0.067	0.775**	-0.094	-0.295*
Flower duration			1.00	0.008	-0.168	-0.201	-0.030	0.084	-0.058	0.114	-0.079
Plant height (cm)				1.00	0.610**	0.798**	-0.267	-0.057	0.832**	0.226*	0.340**
No. of branches plant^{-1}					1.00	0.696**	-0.002	-0.184	0.322*	0.018	0.645**
No. of capsules plant^{-1}						1.00	-0.077	0.113	0.245**	0.374*	0.985**
No. of seeds capsule^{-1}							1.00	0.442**	-0.105	0.340*	0.533**
Capsule length (cm)								1.00	-0.109	0.585**	0.293*
Days to maturity									1.00	0.071	-0.245*
1000 seed weight										1.00	0.771**

Conclusion

It can be established that the genotypes Rama, Usha, GT 10, YLM 16, VRI 3 and Savitri were agronomically promising and may use directly at farmers' field for large scale production in the areas where soil salinity is a major abiotic stress. The correlation study concluded that branches plant^{-1}, no. of capsules plant^{-1} and no. of seeds capsule^{-1} can be selected for yield maximization in sesame germplasm evaluation.

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References

1. Mkamilo GS, Bedigian D. *Sesamum indicum* L. Plant Resources of Tropical Africa. 2007;14:153-158
2. Ujjainkar VV, Vaidya ER, Shinde SM, Kale GG. Characterization of Sesame (*Sesamum indicum* L.) Germplasm. International Journal of Innovative Science and Research Technology. 2022;7:7.
3. Antoniassi R, Arriel NH, Gonçalves EB, Freitas SC, Zanotto DL, Bizzo HR. Effect of Cultivation Conditions on the Composition of Sesame Seed and Oil. Revista Ceres. 2013;60:301-310. https://doi.org/10.1590/S0034-737X2013000300001.
4. Ucan K, Killi F. Effects of Different Irrigation Programs on Flower and Capsule Numbers and Shedding Percentage of Sesame. Agricultural Water Management. 2010;96:227-233. https://doi.org/10.1016/j.agwat.2010.08.005.
5. Yousif YH, Bingham FT, Yermanos DM. Growth, mineral composition and seed oil of sesame (*Sesamum indicum*, L) as affected by NaCl. Soil Science Society of American Journal. 1972;36:450-453.
6. Cerda A, Bingham FT, Hoffman GJ. Interactive effect of salinity and phosphorus in sesame. Soil Science Society of American Journal. 1997;41:915-918.
7. Abbasdokht H, Ashrafi E, Taheri S. Effects of Different Salt Levels on Germination and Seedling Growth of Sesame (*Sesamum indicum* L.) Cultivars. Technical Journal of engineering and applied sciences. 2012;2:309-313.
8. Bahrami H, Razmjoo J. Effect of Salinity Stress (NaCl) on Germination and Early Seedling Growth of Ten Sesame Cultivars (*Sesamum indicum* L.). International Journal of Agri Science. 2012;2:529-537.
9. Mahmood S, Iran S, Athar HR. Intra-Specific Variability in Sesame (*Sesamum indicum* L.) for Various Quantitative and Qualitative Attributes under Differential Salt Regimes. Journal of Research Science. 2003;14:177-186.
10. Arriel NHC, Moreira JDAN, Guedes AR, Costa ITD, Firmino PDT. Agronomic and botanical evaluation of the live collection of sesame germplasm at Embrapa Algodao. Peoquisaem Andamento.1998;91:9.
11. Muhammad LM, Falusi OA, Daudu OA, Gado AA, Lateef AA, Yahaya SA. Radiation induced polygenic mutation in two common Nigerian sesame (*Sesamum indicum* L.) cultivars. International Journal of Biotechnology and Food Science. 2013;1(2):23-28.
12. Iqbal A, Akhtar R, Begum T, Dasgupta. Genetic estimates and diversity study in Sesame (*Sesamum indicum* L.). IOSR Journal of Agriculture and Veterinary Science. 2016;9(8):01-05.
13. Mukhekar GD, Bangar ND, Bhor T, Mungse HB. Genetic variability and correlation studies in sesame (*Sesamum indicum* L.). Journal of Maharastra Agricultural University. 2003;27:284-285.
14. Boranayaka MB, Ibrahim SM, Ananda KCR, Rajavel DS, Shadakshari TV, Ragesha, G. Studies on heritability and genetic advance in mutant populations of sesame (*Sesamum indicum* L.). International Journal of Agricultural Sciences. 2010;6(2):508-512.
15. Chowdhury S, Datta AK, Saha A, Sengupta S, Paul R, Maity S, *et al*. Traits influencing yield in sesame (*Sesamum indicum*. L.) and multi locational trials of yield parameters in some desirable plant types. Indian Journal of Science and Technology. 2010;3(2):163-166.
16. Begum T and Dasgupta T. Effect of mutagens on character association in sesame (*Sesamum indicum* L.). Pakistan Journal of Botany. 2011; 43: 243-251.
17. Birara A, Muthuswamy M, Andargie M. Effect of chemical mutation by sodium azide on quantitative traits variations in *Sesamum indicum* L. Asian Journal of Biological Science. 2013;6(8):356-362.
18. Valarmathi G, Surendaran C, Vanniarajan C, Kumar M, Saravanan NA. Morphological and biochemical characterization of sesame (*Sesamum indicum* L. and *Sesamum mulayanum* L.). Sesame and Safflower Newsletter, 2003; 18: 42-46.
19. Sheeba A, Ibrahim SM, Yogameenakshi P, Babu S. Mutagen induced polygenic variability in sesame (*Sesamum indicum* L.). Madras Agricultural Journal. 2004;91(4-6):195-197.
20. Adams MV. Basic of yield compensation in crop plants with special reference to field bean (*Phaseolus vulgaris* L.). Crop Science. 1967;13:630-632.
21. Singh VP, Singh M, Lal JP. Gamma rays and EMS induced genetic variability for quantitative traits in urdbean (*Vigna mungo* (L.) Hepper). Indian Journal of Genetics and Plant Breeding. 2000;60(1):89-96.

22. Arulmozhi NS, Santha, Mohammed S. Correlation and path co-efficient analysis in sesame. Journal of Ecology and Environment. 2001;13(3):229-232.
23. Sankar PD, Kumar CRA. Character association and path coefficient analysis in sesame (*Sesamum indicum* L.). Agricultural Science Digest. 2003;23(1):17-19.
24. Babu DR, Kumar PVR, Rani CVD, Reddy AV. Studies on combining ability for yield and yield components in sesame, *Sesamum indicum* L. Journal of Oilseeds Research. 2004; 21:260-262.
25. Siddiqui S, Meghvansi MK, Khan SS, Aali NS. Mutagenic effect of herbicide (Maleic hydrazide) on seed germination and radical length on *Trigonella foenum-graecum* L. Indian Journal of Applied and Pure Biology. 2005;23:103-106
26. Aristya VE, Taryono. Factor wise contribution on sesame seed yield. AIP Conference Proceedings. 2016;1755:40001-40007.
27. Aristya VE, Taryono, Wulandari RA. Genetic variability, standardized multiple linear regression and principal component analysis to determine some important sesame yield components. AGRIVITA Journal of Agricultural Science. 2017;39(1):83-90.
28. Sarwar G, Jafar H. Selection criteria in M_3 and M_4 population of sesame (*Sesamum indicum* L.) Journal of Agricultural Research. 2010;48(1):39-51.
29. Patil MK, Lokesha R, Diwan JR. Genetic divergence of advanced mutant breeding lines, In Sesame (*Sesamum indicum* L.) assessed through D^2 Statistics. International Journal of Current Microbiology and Applied Science. 2017;6(9):3133-3139.
30. Begum T, Dasgupta T. Character association in sesame (*Sesamum indicum* L.). Indian Agriculturist. 2003;47(3/4):253-258.
31. Grafius JE. Short cuts in plant breeding. Crop Science. 1965;6:377.
32. NeWall EC, Eberhart SA. Clone and progeny evaluation in the improvement of switch grass (*Panicum virgatum* L.). Crop Science. 1961;1:117-121.