Biological Forum – An International Journal **15(2): 365-370(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Stability Analysis in Sesame (*Sesamum indicum* L.) under different Doses of Fertilizers

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(Received: 26 December 2022; Revised: 05 February 2023; Accepted: 08 February 2023; Published: 13 February 2023)
(Published by Research Trend)

ABSTRACT: A study of stability analysis using Eberhart & Russell model was conducted for seed yield and its component traits on 20 genotypes of sesame (*Sesamum indicum* L.). The experiment was conducted during *kharif*, 2018 at Research Farm of S.K.N. College of Agriculture, Jobner. The sesame genotypes were grown in randomized block design (RBD) with three replications over three artificially created environments by providing different doses of fertilizers. Fertility gradient and different soil type is a major concern in Indian soils especially in Rajasthan. Farmers of Rajasthan grow sesame as *kharif* crop and do not follow recommended dosage of fertilizers which is a major challenge. So, to identify most stable genotypes for seed yield and its component traits under different fertility levels present investigation has been planned. The mean sum of squares due to genotypes were significant for all the traits in all the environments, which shows the variability among genotypes. Significant genotype × environment interaction was found for all the traits excluding days to 50% flowering and days to maturity, which indicate the effect of fertility levels on the performance of genotypes. The pooled deviations were significant for biological yield per plant, capsules per plant, harvest index, seeds per capsule, and seed yield per plant, suggesting the unexplained variation in these traits. Genotypes RT-346 and RT-351 were found stable for seed yield. Genotypes RT-372, RT-384, RT-385, RMT-447, and RMT-450 had below-average stability for seed yield and were suited for better environments. On the other hand, genotypes RT-103 and RT-378 had above average stability for seed yield and were found appropriate for poor fertility conditions. Genotypes RT-346 and RT-351 were found stable for most of the traits. Hence, these genotypes can be grown in the soil with different fertility levels and recommended to the farmers of Rajasthan, where soil fertility varies tremendously. Further, this study will help farmers to choose a right variety of sesame to get maximum production.

Keywords: Eberhart & Russell model, Fertility level, G × E interaction, Sesame, Stability.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is anautogamous, diploid species (2n=2x= 26) that categorized under family Pedaliaceae. It is commonly called Beniseed, Gingelly, Til, and Nuvvulu in the different parts of the country (Priyadarshini *et al*., 2021a); it also considered as "queen of oilseeds" (Priyadarshini *et al*., 2021b) Ancient records suggest that sesame might have originated in Ethiopia (Africa) and was introduced to India and China. From then, it became a common food in Southern Asia and other parts of the continent.

Being an oilseed crop, sesame stands at third position next to groundnut and rapeseed-mustard. Sesame seeds are good source of energy which comprise 50-60% oil, 18-25% protein, 13.5% carbohydrate, and 5% ash (Prasad *et al.,* 2012). Since, sesame oil is cholesterol-free; hence it is commonly recommended for heart patients. Further, it also contains certain compounds which carry anti-pathogenic, and anti-oxidant properties (Jat *et al*., 2017; Alshahrani *et al*., 2020).

There are several uncontrollable factors such as soil type, location effect, fertility gradients, seasonal fluctuations and so on, which may affect the performance of a genotype especially in terms of yield potential. In addition, climatic factors like temperature, rainfall, day length and management practices affects yield of a genotype (Valiki *et al.,* 2015). So, to deal with such uncontrollable factors there is an urgent need to identify such genotypes which have good buffering capacity under different environmental conditions. In addition, seed yield, being a complex trait, is easily affected by the environmental factors due its quantitative nature, and irregular soil fertility is a major environmental factor which influence the seed yield of a genotype.

The sesame crop improvement programmes are lacked as compared to other oilseed crops in terms of organized research efforts. However, researchers have made significant efforts to improve economic traits of sesame (Solanki *et al.*, 2001; Ahmed *et al.,* 2022). Being a short-day plant and photoperiod sensitive, sesame grown as rainfed crop and as a result its yield is not stable (Velu and Shunmugavalli 2005). This instability is mainly due to location, environmental influence, fertility gradient and due to their interaction. So, to tackle this challenge, identification of stable varieties across the environment is the best solution (Verma and Mahto 1994). Several studies have been performed on sesame to identify stable varieties. Beniwal *et al.* (2003) performed stability analysis for yield traits on 79 genotypes of sesame and identified RT-54 and RT-103 as stable genotypes. Anuradha and Reddy (2005) carried out stability analysis for component traits of yield and identified eight stable genotypes out of 71 sesame genotypes for seed yield per plant. Suvarna *et al.* (2011) studied 51 sesame genotypes for yield stability in different environments of Karnataka and identified that genotypes ST-3 and ST-16 were stable for seed yield. Later, Abate (2015) performed a study to identify stable genotypes for yield and its component traits using AMMI and Joint regression model. At the same time, Chaudhari *et al.* (2015) studied 50 hybrids along with 15 parents to identify stable hybrid in different locations of Gujarat, and they identified that three crosses were stable across the environments. Patil *et al.* (2015) identified that genotypes IC-413189, IC-413201and IC-413205 were stable for days to 50% flowering, whereas genotypes IC-413214 and IC-413216 were stable for days to maturity. Raikwar (2016) identified six-genotypes *viz.,* TKG-478, TKG-501, TKG-503, TKG-506, TKG-306 and TKG-512 stable for grain yield. Beniwal *et al.* (2018) performed stability analysis for oil content and agronomic traits, and identified genotype RT-103 as stable for most of the traits.

However, various studies have been made on stability analysis, but till now as per our knowledge, no study have been performed on artificially created environment by providing different doses of fertilizers. Farmers of Rajasthan grow sesame as a *Kharif* crop in which they do not follow recommended doses of fertilizers, and the soil of Rajasthan is also highly variable regarding fertility. So, the prime motive of the present investigation is to recommend stable varieties of sesame to the farmers which perform well at different doses of fertilizers. Hence, considering the above aspects, the current research was planned, using twenty sesame genotypes in three artificially created environments, to estimate G × E interactions and stability parameters for seed yield and its component traits and identify the most stable genotype under the different fertility levels.

MATERIALS AND METHODS

Plant Materials. The plant materials comprise of twenty genotypes(RT-46, RT-125, RT-103, RT-127, RT-351, RT-346, RT-372, RT-378, RT-383, RT-384, RT-385, RMT-425, RMT-447, RMT-450, RMT-479, RMT- 486, RMT- 505, PRAGATI, TKG-22 and GT-10) of sesame which were obtained from Agriculture University, Mandore, Jodhpur.

Experimental method. During *kharif* 2018, a set of 20 sesame genotypes were phenotypically evaluated at Research Farm of S.K.N. College of Agriculture, Jobner. The genotypes were evaluated in randomized block design with three replications under three artificially created environments by applying different doses of fertilizers as 150% Recommended dose of fertilizer (E1) *i.e.,* N_2 @ 60 kg/ha, P_2O_5 @ 30 kg/ha and K_2O @ 30 kg/ha, 100% Recommended dose of fertilizer (E2) *i.e.,*N_2 @ 40 kg/ha, P_2O_5 @ 20 kg/ha and K_2O @ 20 kg/ha, and 50% Recommended dose of fertilizer (E3) *i.e.,*N_2 @ 20 kg/ha, P_2O_5 @ 10 kg/ha and K_2O @ 10 kg/ha. The plot size was 4.0 × 0.6 m^2 consisting two rows of each genotype in each replication in each environment. The row to row and plant to plant distances were kept 30 cm and 10 cm, respectively.

Record of observations. Observations were documented for ten characters. Further, Observations for branches per plant, biological yield per plant, capsules per plant, harvest index, plant height, seeds per capsules, test weight, and seed yield per plant were recorded on five randomly chosen plants from each plot. However, for days to 50% flowering and days to maturity data were recorded per plot basis.

Analysis. The stability analysis was done as per Eberhart and Russell (1966) model.

RESULTS AND DISCUSSION

Genotype-by-environment interaction. The significant difference among genotypes was observed for all the characters in all the environments, which indicated the existing variability among genotypes. The pooled analysis of variance (Table 1) showed significant G × E interaction for all the traits except days to 50% flowering and days to maturity, indicating the diverse effect of artificially created environments on the genotypes. Non-significant G × E interaction for days to 50% flowering and days to maturity, indicates that environments do not have specific influence on individual genotypes for those traits and, further stability analysis for those traits were not carried out. Similar results were observed by Mali *et al.* (2015) for days to 50% flowering, by Patil *et al.* (2015) for plant height, branches per plant, capsules per plant, seeds per capsule, and for test weight and Kumaresan and Nadarajan (2005); Suvarna *et al.* (2011), observed similar result for seed yield per plant. Above mentioned studies support that majority of the yield component traits are highly influenced by fertility difference and other environmental factors.

Table 1: Pooled analysis of variance for ten yield contributing traits in sesame under different doses of fertilizers.

source	d.f.	Days to 50% flowering	Days to maturity	Plant height (cm)	Branches per plant	Capsules per plant	Seeds per capsule	Test weight (g)	Biological yield per plant (g)	Harvest index (%)	Seed yield per plant (g)
Environment	2	138.01**	125.4**	26559.6**	31.95**	2768.75**	1697.56**	2.46**	1543.5**	111.95*	153.5**
Rep. in Env.	6	3.64	8.89*	41.14	0.26	2.02	59.07	0.03	2.66	16.61	0.47
Genotypes	19	40.32**	29.66**	316.32**	0.83*	288.32**	256.85**	0.08*	42.54**	67.45*	5.30**
G × E Interaction	38	1.97	3.40	110.5**	0.38**	11.32**	79.49**	0.04**	15.25**	34.0**	1.93**
Pooled error	114	3.56	4.11	44.01	0.14	5.24	25.75	0.02	3.77	12.36	0.48

*, ** = significant at 5% and 1% levels, respectively

Table 2: Joint regression analysis (Eberhart and Russell 1966) for eight yield contributing traits in sesame which have shown significant G × E interaction under different doses of fertilizers.

Source	d.f.	Plant height (cm)	Branches per plant	Capsules per plant	Seeds per capsule	Test weight (g)	Biological yield per plant (g)	Harvest index (%)	Seed yield per plant (g)
Genotype	19	105.440**	0.278**	96.109**	85.617**	0.028**	14.180*	22.482	1.765**
E+(G x E)	40	477.65**	0.653**	49.732**	53.466**	0.053**	30.552**	12.635	3.171**
Environment (Linear)	1	17706.4**	21.30**	1845.83**	1131.7**	1.643**	1028.98**	74.63*	102.3**
G×E (Linear)	19	57.176**	0.172**	3.845	36.768*	0.0137*	4.912	11.595	0.765
Pooled deviation	20	15.665	0.076	3.520*	15.416*	0.010	4.988**	10.52**	0.499**
Pooled error	114	44.015	0.140	5.243	25.746	0.0206	3.777	12.356	0.477

*, ** = significant at 5% and 1% levels, respectively

Joint Regression Analysis. Joint regression analysis (Table 2) showed significant linear component of G x E interaction for plant height, branches per plant, seeds per capsule, and test weight, denoting diverse linear response of the genotypes for these traits under changing fertility conditions. Similar findings were obtained by Raikwar (2016) for plant height, Kumaresan and Nadarajan (2005) for branches per plant, Chaudhari *et al.* (2015) for seeds per capsule, Patil *et al.* (2015) for the test weight. The G × E (linear) was non-significant for the remaining traits suggesting that considerable variation in regression coefficient (b_i) was not there.

The pooled deviations were significant for biological yield per plant, capsules per plant, harvest index, seeds per capsule, and seed yield per plant (Table 2), which indicate that deviations from linear regression also influencing the stability performance of genotypes for those traits. Significant pool deviations denote the unpredictable performance of genotypes across the environments that varies from genotype to genotype. Similar findings to present experiment have also been observed by several authors. Mali *et al.* (2015) observed similar results for plant height and test weight, Kumaresan and Nadarajan (2005); Chaudhari *et al.* (2015) for capsules per plant, seeds per capsule, and seed yield per plant, Patil *et al.* (2015) for branches per plant, Beniwal *et al.* (2018) seeds per capsule and seed yield per plant.

Stability Parameters. Eberhart and Russell model (1966) states that, a stable genotype has high mean (x), regression coefficient (b_i) equals to unity (b_i = 1.0) and deviation from regression is zero (S^2d_i = 0).

Table 3: Mean values and stability parameters (b_i and s^2_{di}) of the sesame genotypes for eight yield contributing traits which have shown significant G × E interaction under different doses of fertilizers.

Genotypes	Plant Height (cm)			Branches per plant			Capsules per plant			Seeds per capsule		
	$\bar{x}$	b_i	S^2d_i	$\bar{x}$	b_i	S^2d_i	$\bar{x}$	b_i	S^2d_i	$\bar{x}$	b_i	S^2d_i
RT-46	86.98	1.01**	-7.62	3.04	1.35**	-0.02	37.40	0.84*	9.64*	43.84	1.07**	-3.27
RT-103	94.40	0.74**	14.2	2.60	0.93**	0.07	32.64	1.48**	5.97*	52.12	2.97**	-8.01
RT 125	91.09	1.06**	50.17*	3.09	0.83**	-0.05	24.80	1.44**	-1.07	50.44	0.78	32.47*
RT127	88.49	1.07**	-10.01	2.93	0.95**	-0.02	25.47	1.04**	-0.52	50.11	0.96	15.97
RT 346	105.18	1.02**	-13.93	3.09	1.33**	0.18*	36.36	0.91**	4.65	47.47	1.26**	-7.52
RT 351	99.29	1.06**	2.41	2.96	0.86	0.35**	29.78	1.01**	3.13	55.87	0.42	42.05*
RT 372	84.93	1.16**	-8.09	3.11	1.70**	-0.05	38.16	0.80**	-1.62	50.49	0.96**	-8.37
RT 378	97.47	1.18**	-14.54	3.02	1.32**	-0.04	33.09	1.03**	0.46	57.42	1.04**	-7.77
RT 383	90.80	1.27**	31.08	2.44	0.62*	0.01	26.22	1.01**	1.89	62.51	1.13**	-4.87
RT 384	103.31	1.45**	18.77	2.71	1.49**	0.01	36.09	0.79**	1.57	55.49	1.8**	-8.53
RT 385	96.71	1.19**	11.63	2.84	1.01**	-0.05	35.67	0.91**	0.60	53.38	1.27*	12.82
RMT 425	98.42	1.47**	-6.01	2.93	0.95**	-0.02	33.33	0.77**	2.82	49.58	0.51	-1.12
RMT 447	85.80	0.79**	-14.0	2.31	1.31**	0.02	40.96	1.06**	-1.69	48.00	1.03**	-6.43
RMT 450	89.89	1.04**	-11.92	2.89	1.42**	0.17*	34.38	0.84**	-1.74	56.27	1.90*	36.99*
RMT 479	90.22	0.84**	-0.85	3.11	1.24**	-0.05	25.56	1.21**	-1.72	55.84	0.73	11.02
RMT 486	92.78	0.60**	19.92	2.44	0.67*	0.02	33.49	0.78**	-1.53	48.69	0.97**	-4.45
RMT 505	88.11	0.82**	-14.65	3.40	0.93*	0.07	22.64	1.08**	2.59	64.76	0.50	3.24
PRAGATI	91.73	0.49**	-13.85	2.47	0.03	0.06	26.20	0.91**	3.40	57.84	1.26	58.04**
TKG 22	86.78	0.81**	-5.67	2.36	0.63**	-0.03	28.29	0.89**	5.11*	47.36	0.85**	-8.15
GT 10	85.80	0.92**	-7.18	3.00	0.46**	-0.05	21.62	1.22**	3.49	56.82	-1.42	-7.42
S.Em±	2.80	0.13		0.20	0.27		1.33	0.20		2.78	0.52	
Pop. mean	92.41	1		2.84	1		31.11	1		53.21	1	

Genotypes	Test weight (g)			Biological yield per plant (g)			Harvest Index (%)			Seed yield per plant (g)		
	$\bar{x}$	b_i	S^2d_i	$\bar{x}$	b_i	S^2d_i	$\bar{x}$	b_i	S^2d_i	$\bar{x}$	b_i	S^2d_i
RT-46	3.19	0.98**	-0.001	18.08	0.83**	-0.78	27.63	0.93	62.8**	5.14	1.44**	0.007
RT-103	3.14	1.74**	-0.006	16.37	0.74	10.22**	31.94	1.95*	-1.71	5.22	0.72	1.67**
RT 125	3.28	0.67**	-0.007	16.06	0.85**	-0.75	25.34	1.75**	-4.12	4.07	0.73**	0.07
RT127	3.34	1.65**	-0.001	15.28	0.74	22.34**	31.84	2.71**	-3.63	4.78	0.75	0.59*
RT 346	3.14	0.98**	-0.002	18.97	1.13*	6.99*	29.36	3.71**	-0.88	5.42	0.97**	-0.14
RT 351	3.20	1.04**	-0.007	16.20	1.16**	0.21	33.33	1.38	7.75	5.27	0.99**	0.04
RT 372	3.15	1.43**	-0.001	17.67	1.17*	11.21**	33.87	-2.07	6.29	6.04	1.52**	-0.10
RT 378	3.27	1.27**	-0.004	19.55	1.00**	-0.83	31.97	2.99	11.24	6.12	0.77**	0.07
RT 383	3.19	1.36**	-0.005	15.97	1.01**	-0.6	32.18	-0.62	-1.42	5.19	1.14**	0.39
RT 384	3.09	0.89*	0.004	16.37	0.95	11.21**	37.02	1.32	27.2**	6.14	1.44**	1.0**
RT 385	3.16	0.79**	-0.005	17.93	1.36**	-0.05	33.18	-0.06	-2.01	5.98	1.55**	-0.16
RMT 425	2.95	0.29*	-0.005	15.13	0.26*	-0.52	32.31	0.59	4.40	4.82	0.07	-0.02
RMT 447	3.20	0.95**	-0.0002	19.50	1.12**	-0.52	31.80	-2.38	4.03	6.27	1.30**	0.52*
RMT 450	3.14	0.21	0.002	21.73	1.90**	-1.08	28.28	1.26	-1.71	6.07	1.61**	-0.16
RMT 479	2.99	0.63*	-0.001	16.10	0.97**	0.07	26.83	4.46**	4.37	4.18	0.73*	0.41
RMT 486	3.29	1.31	0.12**	16.73	0.91**	2.23	31.47	-0.69	-2.55	5.30	0.93	1.0**
RMT 505	3.14	1.29*	0.017	13.97	0.84**	-1.19	29.98	0.66**	-4.06	4.17	0.81**	-0.12
PRAGATI	3.11	0.64**	-0.006	15.33	1.08**	-1.14	30.80	-0.68	9.39	4.61	0.75*	0.43
TKG 22	3.27	1.12**	-0.007	15.70	1.06	14.94**	28.68	1.04	15.75*	4.38	0.71	0.94**
GT 10	3.21	0.76**	-0.006	11.97	0.91**	2.63	33.00	1.74**	-3.05	3.96	1.08**	0.38
S.Em±	0.07	0.36		1.58	0.31		2.29	1.68		0.50	0.31	
Pop. Mean	3.17	1		16.74	1		31.04	1		5.16	1	

*, ** = significant at 5% and 1% levels, respectively

Hence, the genotypes with higher (lower in case of negative traits) mean and S^2d_i close to zero have been classified based on the regression coefficient (b_i). Genotypes with b_i=1 have been considered average stable and suitable for all the environments. Genotypes with b_i>1 have been considered below-average stability in poor environments and suitable for better environments. Varieties with bi<1 have been considered above-average stability in poor environments and suitable for poor environments. Stability parameters for all the traits are shown in Table 3.

In this study, the plant height of all the genotypes had non-significant S^2divalues except RT-125, which is unstable for plant height. Similar results, *i.e.,* non-significant S^2d_i for most of the genotypes, were found by Patil *et al.* (2015); Raikwar (2016); Beniwal *et al.* (2018). Genotypes RT-346 and RT-351 were considered as most stable and desirable genotypes, whereas RT-378, RT-384, RT-385, RMT-425 were exhibiting below average stability, thus suitable for high fertile soils. Genotypes RT-103 and RMT-486 had displayed above-average stability and were suited for poor fertility conditions.

Most of the present study genotypes had non-significant S^2di estimates for branches per plant except RT-346, RT-351, and RMT-450. Similar outcomes for non-significant S^2d_i were obtained by Patil *et al.* (2015), Raikwar (2016). By observing stability parameter, it can be interpretated that RT-127, RT-385, RMT-425, and RMT-505 were the most stable genotypes, whereas RT-46, RT-372, RT-378, RMT-450, and RMT-479 were suitable for better fertilizer doses. Genotypes RT-125 and GT-10 had exhibited above-average stability and were found appropriate for less fertile conditions.

For capsules per plant, Genotypes RT-346, RT-378, RT-385, and RMT-447 were the most stable among all the genotypes, whereas RT-103 having below-average stability, was suited for better management, *i.e.,* high fertility. RT-46, RT-372, RT-384 and RMT-425, RMT-450, RMT-486 had exhibited above-average stability.

For Seeds per capsule RT-378 and RT-383 were considered the most stable genotypes, whereas RT-384 and RMT-450 revealed below average stability, signifying their adaptability to a good fertility condition. RT-351, RMT-479, RMT-505, and GT-10 had exhibited above-average stability. Contrasting results obtained by Beniwal *et al.* (2018) where RT-103 showed average stability for days to maturity, plant height, seeds per capsule.

For test weight, the S^2di values were non-significant for most of the genotypes except RMT-486. Genotypes RT-46, RT-351, RMT-447, and TKG-22 were stable for test weight, whereas genotypes RT-127, RT-378, RT-383, and RMT-486 were suitable for better performance environment conditions. Genotypes RT-125 and GT-10 had exhibited above-average stability and were found suitable for poor fertile soils. A similar result to present investigation was observed by Mali *et al.* (2015), where the genotype RT-46 was found stable for the test weight.

For biological yield per plant, RT-346, RT-372, RT-378, and RMT-447 were most desirable, whereas RT-385 and RMT-450 exhibited below average stability suitable for better fertility conditions. RT-46 had displayed above-average stability and was appropriate for poor fertility conditions.

Genotypes RT-351 and RT-384 were more stable for harvest index, whereas RT-103, RT-127, RT-378, and GT-10 had below-average stability and were suitable for better environmental conditions. RT-372, RT-383, RT-385, and RMT-425 had above-average stability and were ideal for poor environmental conditions. Contrasting results obtained by Kumar *et al.* (2013) where GT-10 had wider adaptability whereas in present investigation GT-10 had suitability for better environmental conditions for harvest index.

For seed yield per plant, the S^2d_i associated with most genotypes was non-significant. Similar results for non-significant S^2d_i were obtained by Raikwar (2016). Genotypes RT-346, RT-351, RT-383, and RMT-486 are considered the most desirable genotypes. Interestingly, all the genotypes with a high mean value were found appropriate for good fertility conditions, *i.e.,* RT-372, RT-384, RT-385, RMT-447, and RMT-450. Genotypes RT-103 and RT-378 were found suitable for low fertility conditions. Contradictory results were obtained by Beniwal *et al.* (2018) where RT-103 had average stability for seed yield per plant, whereas in the present investigation RT-103 has above average stability, Bhandarkar and Kumar (2010) found TKG-22 and RT-46 genotypes stable for seed yield per plant.

CONCLUSIONS

In the present investigation, pooled analysis of variance has shown significant G × E interaction for most of the traits indicating the remarkable impact of different artificial created environments on the genotypes. In joint regression analysis, significant linear G × E interaction of the trait denoted the linear response of the genotypes under changing fertility conditions and significant pooled deviations indicated the unpredictable variation across the environment, that varied from genotype to genotype. In stability parameter, high mean, unit regression and minimum deviation from the regression line is a typical characteristic of the stable genotypes. In the present study, genotype RT-346 and RT-351 were found stable for most of the characters, including yield. Hence, these genotypes can be grown in different fertility conditions in that region for better productivity. It would be helpful to recommend these varieties to the farmer under different fertilizer doses.

Acknowledgments. The authors are thankful to all the members involved in the present investigation, either directly or indirectly. The authors would also like to thank the Department of Plant Breeding & Genetics, Sri Karan Narendra Agriculture University, Jobner, for providing the necessary facilities during the study period.

Conflict of Interest. None.

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How to cite this article: Manoj Kumar Patel, Dhirendra Singh, Versha Sharma, Deepti Tiwari, Mahaveer Prasad Ola, Shahil Kumar and Ranjit Saroj (2023). Stability Analysis in Sesame (*Sesamum indicum* L.) under different Doses of Fertilizers. *Biological Forum – An International Journal, 15*(2): 365-370.