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Identification of stable genotypes under different environments in Taramira (*Eruca sativa* Mill.)

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Abstract

This study was designed to analyze the stability of thirty genotypes of Taramira (*Eruca sativa* Mill.) and was evaluated over four environments during *Rabi* 2022–23 at Experimental Farm, Sri Karan Narendra College of Agriculture, Jobner, Rajasthan for various yield and yield attributing traits. Yield stability was analysed employing Eberhart and Russell's model, which revealed significant differences among genotypes x environments (linear) for most of the characters except siliqua length and 1000-seed weight. Environment + (G x E) was significant for most of the characters except siliqua length and pooled deviation was also significant for all the traits except for maturity, primary branches per plant, siliqua length and seeds per siliqua. Stability parameters for seed yield revealed that the genotypes *viz*., RTM-1351, RTM-1591 and RTM-1829 were identified as the most acceptable and consistent performers for seed yield per plant. Whereas RTM-314, RTM-1613 and RTM-1822 were showed non-significant deviations coupled with b_i values higher than unity (b_i>1), indicating that they were specifically suited for a better environment with good management. The identified stable and superior genotypes may serve as valuable genetic resources for selection and hybridization. Further, these genotypes can be tested in multi-location trials for wider adaptability and potential varietal release.

Keywords: *Eruca sativa*, G x E interaction, Environment + (G x E), pooled deviation, yield stability

Taramira (*Eruca sativa* Mill.) is a low growing, annual oilseed crop with dull green, deeply cut and compound leaves. The plant known as taramira is typically cultivated in marginal soils in north and north-western India. Singh (1958) states that this is known as tara, tera, schwan, seoha, duanturra, tirwa, merha, merkai, chara and ushan in Uttar Pradesh; as sondha in Gwalior, Madhya Pradesh and as tara or simply as taramira in Punjab. The plant taramira, often known as rocket in Europe, belongs to the *Brassicaceae* family. It is a highly drought-tolerant crop that may be produced as a rain-fed crop even on soils with a little capacity to hold water. The crop's effective root structure allows it to draw water from deep soil horizons, making it particularly suited for regions with little or no irrigation system. The only other option for sowing of taramira on soils with a low moisture availability during periods of severe drought in *kharif* season and rains during September-October. Taramira main applications are confined to massage oil and the manufacturing of lubricants and blown oil in industries (Singh, 1958). The oil cake is used as a feed for cattle and cattle fed taramira cake don't have any ticks (Singh, 1958).

Till now, little effort has been done so far to enhance the productivity of taramira. Therefore, it is essential to develop high oil content and high yielding varieties. The variety should have yield potential as well as stability in its performance across a range of environments. In addition to having a high yield, an improved ideal variety must also perform consistently. However, it has been noted that the genotype levels of stability vary, some genotypes showing significantly greater stability than others. The stability of these component characters is crucial for stabilizing grain yield over the environments because yield is a polygenic character that is influenced by many genes.

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A set of 25 genotypes lines along with five check varieties, namely RTM-314, RTM-1351, RTM-1355, RTM-1624 and RTM-2002 were selected at random from the collection of taramira being maintained in All India Coordinated Research Project on Oilseeds (Taramira Unit) at S.K.N. College of Agriculture, Jobner and were evaluated over four environments created by sowing date and *Orobanche* infestation. The study was conducted during *Rabi,* 2022-23 at Experimental Farm, Sri Karan Narendra College of Agriculture, Jobner, Rajasthan. Envionment-1 (timely sown *Orobanche* free field), Envionment-2 (timely sown *Orobanche* infested field), Envionment-3 (late sown *Orobanche* free field), Envionment-4 (late sown *Orobanche* infested field). In each environment, all the genotype were evaluated in Randomised Block Design with three replications in the one rowed and each row 3 meter length. The row-to-row distance was kept at 80 cm and plant to plant distance were maintained at 15 cm by thinning after 15 days of sowing. The date of timely sown environment was 17th October, 2022 and date of late sown was 5th November, 2022.

All recommended package and practices were followed to raise a good crop. Observations were recorded on five randomly selected plants and tagged before flowering for plant height (cm), primary branches per plant, height of first branch emergence (cm), siliqua on main shoot, siliqua density, siliqua length (cm), seeds per siliqua, chlorophyll content 35 DAS (SPAD), chlorophyll content 70 DAS (SPAD) and 1000-seed weight (g) were recorded on tagged plant basis in each row while data relating to days to 50 per cent flowering and days to maturity was recorded on whole plot basis. Mean values of five plants were used for stability analysis. Statistical analysis was carried out as per Eberhart and Russell (1966) model. Data were computed by using OPSTAT for variance and stability analysis. The environmental index is calculated by estimating the difference between the mean of characters in the environment of interest and the grand mean, resulting in the identification of a suitable environment for each of the characters.

Analysis of variance was carried out as per the model given by Eberhart and Russell (1996) indicated that variance due to Environment + (G x E) was significant for most of the characters except siliqua length, environment + (genotype x environment) sum of squares was further partitioned into environment (linear) which highly significant for all the characters. This demonstrated that the effects of the environment on genotype were significant and can be categorised and predictable. The genotype x environment (linear) component was significant for all the characters except siliqua length and 1000-seed weight revealed that the genotype's linear responses to the environment were different. Supporting evidence for a significant G x E (linear) component as observed in the present study was also reported by Tanin *et al.* (2018) and Gupta *et al.* (2021) in Indian mustard. Variance due to environment was also significant for all the characters. Combined analysis of variance for different characters presented in (**Table 1**).

Pooled deviation was also significant for all the traits except for maturity, primary branches per plant, siliqua length and seeds per siliqua presented in **(Table 1)** suggesting that a substantial portion of G x E interaction was due to some factor other than the regression. Priyamedha and Haider (2017) observed significant pooled deviation for plant height, number of siliquae on main shoot, number of seeds per siliqua, total number of siliqua per plant, 1000-seed weight, days to maturity and seed yield per plant in Indian mustard and Nagrale *et al*. (2023) reported pooled deviation was highly significant for all five characters in sunflower. To categorise the genotypes according to their stability and suitability for particular environment, all 30 genotypes were tested for three stability parameters, *viz.,* mean, bi and S^{2}di. The genotypes were divided into three categories based on the values of bi: bi = 1, bi<1 and bi>1 indicated average, above and below average stability, respectively.

Early flowering in taramira is a highly desirable trait in areas where water stress, edaphic or atmospheric adversities predominate during the growing season, particularly in the later stages of crop growth, so that the genotypes can avoid the adversities such as drought, water deficit, insect and pest attack and mature before such stresses occur. About 67 per cent genotypes showed non-significant S^2d_i values exhibiting stability for this character. The genotypes *viz.,* RTM-314 and RTM-2107 showed lower mean than the general mean and regression coefficient close to unity, emerged as most desirable. Similar findings were postulated by *et al.* (2022) days to 50 per cent flowering in Indian mustard. Tallness is desirable, as tall plants are predicted to bear more siliqua. 42 per cent of genotypes demonstrated a non-significant deviation. As per stability parameters, RTM-1206, RTM-1475, RTM-1613 and RTM-1829 were the most stable genotypes, as these had a high mean and value of b_i near to 1. Similar investigations were reported by Kumari *et al.* (2019) in Trombay mustard genotypes. Early maturity is also a desirable character in taramira to escape the crop from adverse environmental conditions. About 70 per cent genotypes had non-significant S^2_{di} values exhibiting stability for this particular trait. Similar findings were postulated by Rahman *et al.* (2018) for earliness of flowering and maturity in *Brassica napus*. It was found that the genotypes *viz.,* RTM-715, RTM-754, RTM-1206, RTM-1616 and RTM-2002, were the most stable performers and desirable for the above traits. All the genotypes exhibited a non-significant deviation from regression indicating its general stability for primary branches per plant. The genotypes *viz.,* RTM-1613 and RTM-1624 were identified as the most stable for primary branches per plant due to high mean and bi close to 1. Similar to the results found by Srivastava and Srivastava (2020) who evaluated *Indian mustard* genotypes in different environments for four years. Seventy per cent of genotypes exhibited a significant deviation from regression indicated for height of first branch emergence per plant. After analyzing mean value and stability parameters it has been found that genotype *viz.*, RTM-1530 and RTM GP-35 were suitable for a better environment as these had a low mean and high regression coefficient and low and non-significant deviation from regression **(Table 2).**

Table 1. Joint regression analysis (Eberhart and Russell, 1966) showing mean sum of squares for different characters tested over four environments

Source	d.f.	DFF	PH	DM	PBPP	HFBE	SMS	SD	SL	SPS	CC-35	CC-70	TW	SY/P
Genotype	29	27.53**	113.29**	84.49**	1.16**	0.33**	5.98**	0.007**	0.100**	24.21**	12.62**	11.17**	0.27**	0.34**
Env. + (Germ. x Envr.)	90	29.80**	67.43**	21.32**	0.11**	0.09**	2.86**	0.002**	0.010	6.37**	5.85**	33.64**	0.24**	2.06**
Environment(Linear)	1	1654.23**	4456.26**	1091.88**	5.19**	0.15**	139.80**	0.120**	0.510**	457.05**	204.57**	2504.1**	19.38**	177.75**
Germ. x Env. (Linear)	29	15.76**	20.30**	18.84**	0.12**	0.16**	2.45**	0.002**	0.006	3.43**	4.31**	10.77**	0.01	0.11**
Pooleddeviation	60	9.51**	17.07**	4.68	0.02	0.06**	0.78**	0.001**	0.004	0.27	3.27**	3.52**	0.03**	0.07**
RTM-314	2	6.18	88.82	0.45**	0.020*	0.1000	6.56	0.0100	0.00120**	0.71	1.54	0.22	0.4308	0.01**
RTM-644	2	8.20	24.71*	1.56	0.020	0.0004**	0.77*	-0.0200	0.01580	0.22**	0.50	11.12	0.0804	0.01**
RTM-715	2	12.20	54.13	1.73	0.310	0.0100**	0.27**	-0.0200	0.00390	0.47	4.06	3.85**	0.0177	0.27
RTM-754	2	24.93	6.55	0.54	0.050	0.0600*	1.46**	0.0002	0.00230	0.46*	2.26	5.18*	0.0108	0.17
RTM-1119	2	13.17	11.78**	2.34	0.010*	0.3900	1.28*	0.0001**	0.00020**	-0.03**	16.52	3.24	0.0113	0.11
RTM-1120	2	46.48	7.11**	4.31	0.030	0.0900*	10.22	0.0006	0.00020**	0.23**	24.26	8.71	0.0099	0.15
RTM-1206	2	0.01**	32.64	2.21	0.020	0.2400	3.94	0.0017	0.00020**	0.33	7.58	23.94	0.0223	0.01
RTM-1351	2	48.58	4.49	1.43	0.040	0.1300	0.30*	0.0012	0.02500	0.51	2.33	9.95	0.2119	0.01**
RTM-1355	2	12.08	14.05	7.16	0.100	0.3600	0.03**	0.0006	0.00090*	0.32**	4.21	0.08**	0.0005**	0.20
RTM-1396	2	13.57	80.83	3.26**	0.010	0.0500	0.15	0.0024	0.00310	0.58	35.53	0.44**	0.0437	0.01
RTM-1475	2	1.16**	9.92	1.20**	0.040	0.0600	0.10**	0.0001	0.00270	0.01**	1.11	16.47	0.0080	0.95
RTM-1530	2	7.53	27.45	18.01**	0.020	0.0400	0.16	0.0003**	0.00010**	0.07**	0.06**	2.18*	0.0007**	0.03
RTM-1587	2	6.85	63.26	-0.03	0.010*	0.0300	4.61	0.0005	0.01160	0.42	0.42**	24.35	0.0049	0.55
RTM-1591	2	2.80**	12.09	-0.03	0.040	0.1100	0.07**	0.0001*	0.00280	0.84	2.64	0.70**	0.0482	0.04
RTM-1598	2	39.03	68.84	2.51	0.010**	0.0700	6.20	0.0013	0.00140	0.05**	4.86	12.23	0.0038*	0.53
RTM-1613	2	10.21	8.30	2.80	0.030	0.1100	0.60*	0.0001**	0.08460	0.53**	12.68	25.11	0.2794	0.01**
RTM-1616	2	10.41	3.25*	3.35	0.060	0.0700	1.11	0.0007	0.00200	0.19**	20.54	0.17**	0.0488	0.01
RTM-1624	2	34.94	0.30**	1.02**	0.020	0.0100	1.93	0.0001	0.01620	0.04**	6.46	1.95	0.0131	0.14
RTM-1626	2	7.78	1.04	1.12*	0.001**	0.1100	0.10*	0.0004*	0.00970	0.37	4.96	0.61	0.0405	0.12
RTM-1651	2	5.98**	-0.19**	10.44	0.120	0.1100	0.08	0.0007	0.00100**	2.58**	0.16**	3.39	0.0414	0.02**
RTM-1660	2	31.79	288.81	2.20*	0.010	0.2900	0.84	0.0002	0.00290	0.81	0.08**	1.48**	0.0093	0.31
RTM-1822	2	2.66**	6.07	43.25	0.070**	0.1500	0.30*	0.0013	0.00230	0.42	6.56	2.41	0.0281	0.02**
RTM-1826	2	57.61	5.08	17.92	0.120	0.1000	1.00	0.0011	0.00050**	2.62*	5.56	4.20	0.0653	0.18
RTM-1829	2	34.50	1.11	3.48*	0.040	0.2600	1.23	0.0020	0.00070	0.21**	0.59*	32.18	0.0081	0.02
RTM-2002	2	3.40**	129.13	5.73	0.020	0.0200**	1.76	0.0003	0.00210**	0.31**	2.16	0.32**	0.0030**	0.24
RTM-2107	2	3.89	16.00	45.64	0.006	0.1700	0.40	0.0006	0.00150**	0.24**	9.69	4.52	0.0307	0.13
RTM-2110	2	4.54	22.03	16.39	0.170	0.3600	0.78	0.0004	0.00430	2.06	6.04	0.04**	0.0367	0.03
RTM GP-35	2	5.63*	1.59**	25.60	0.020	0.0400*	0.35**	0.0020	0.01580	0.47	7.02	5.68	0.0140	-0.02
RTM GP-41	2	99.75	1.35**	48.94	0.010*	0.0700	0.11	0.0635	0.00630	0.30**	3.97	2.99	0.0319	0.14
RTM GP-47	2	14.93	33.38	6.37*	0.010	0.0200	0.24**	0.0004**	0.00005**	0.10**	2.02	3.39	0.0026*	0.08
Pooled error	232	1.87	6.63	6.40	0.05	0.01	0.30	0.001	0.01	0.36	1.63	1.66	0.01	0.01

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

DFF	Days to 50 per cent flowering	SL	Silqua length
PH	Plant height	SPS	Seeds per siliqua
DM	Days to maturity	CC-35	Chlorophyll content 35 DAS (SPAD meter)
PBPP	Primary branches per plant	CC-70	Chlorophyll content 70 DAS (SPAD meter)
HFBE	Height of first branch emergence	TW	1000 seed weight
SMS	Siliqua on main shoot	SY/P	Seed yield per plant
SD	Siliqua density		

Table 2. Mean values and stability parameters (bi and S^2_{di}) of the taramira genotypes for days to 50 per cent flowering, plant height, days to maturity, primary branches per plant and height of first branch emergence

Genotype	Days to 50 per cent flowering			Plant height (cm)			Days to maturity			Primary branches per plant			Height of first branch emergence (cm)		
	Mean	bi	S^2_{di}	Mean	bi	S^2_{di}	Mean	bi	S^2_{di}	Mean	bi	S^2_{di}	Mean	bi	S^2_{di}
RTM-314	48.99	1.22	1.22	72.85	1.26	37.77*	129.67	0.20**	-6.17	5.77	1.67*	-0.03	1.84	-2.00	0.044**
RTM-644	49.33	1.35	2.23	65.30	1.86*	5.72	127.08	0.61	-5.61	5.18	0.63	-0.03	1.44	-0.18**	-0.005
RTM-715	50.65	1.59	4.23	66.85	0.91	20.43*	122.00	1.15	-5.53	5.08	3.01	0.10	1.59	-4.00**	-0.001
RTM-754	52.82	1.15	10.59*	77.55	0.76	-3.35	119.42	0.87	-6.12	6.55	1.27	-0.02	1.95	8.00*	0.024*
RTM-1119	51.97	1.29	4.71	69.42	1.91**	-0.74	133.42	1.07	-5.22	5.22	0.52*	-0.04	1.96	2.00	0.189**
RTM-1120	54.45	0.59	21.37**	70.53	1.65**	-3.07	135.00	0.87	-4.24	5.30	0.29	-0.03	1.90	10.00*	0.039**
RTM-1206	54.39	0.39**	-1.86	70.57	1.01	9.68	124.67	1.07	-5.29	5.58	0.35	-0.03	2.10	-6.00	0.114**
RTM-1351	54.63	0.77	22.42**	75.77	0.74	-4.38	124.92	0.73	-5.68	6.30	0.06	-0.02	2.02	8.00	0.059**
RTM-1355	55.52	0.61	4.17	74.85	0.60	0.39	116.25	0.60	-2.81	6.55	1.73	0.00	2.24	-10.00	0.174**
RTM-1396	54.11	0.33	4.91	63.70	0.95	33.78*	127.75	2.01**	-4.76	5.63	0.69	-0.04	2.24	-2.00	0.019*
RTM-1475	51.01	1.40**	-1.29	77.33	0.88	-1.67	121.75	1.87**	-5.79	6.78	1.68	-0.02	1.52	4.00	0.024*
RTM-1530	50.99	1.48	1.89	61.97	0.65	7.09	123.17	3.20**	2.60	5.43	1.10	-0.03	1.54	2.00	0.014
RTM-1587	52.27	1.47	1.55	63.57	0.77	24.99*	125.42	0.95	-6.41	5.83	0.46*	-0.04	2.29	2.00	0.009
RTM-1591	52.58	1.70**	-0.47	77.62	0.84	-0.58	125.75	0.95	-6.41	6.70	1.85	-0.02	2.05	-4.00	0.049**
RTM-1598	49.93	1.33	17.64**	63.48	1.31	27.78*	117.00	0.73	-5.14	5.40	0.35**	-0.04	1.78	-2.00	0.029*
RTM-1613	51.45	1.47	3.23	76.93	1.00	-2.48	124.75	0.54	-4.99	6.68	1.16	-0.03	1.64	-2.00	0.049**
RTM-1616	51.25	0.79	3.33	64.32	0.69*	-5.00	117.67	1.09	-4.72	6.25	1.45	-0.01	1.58	0.00	0.029*
RTM-1624	53.14	1.03	15.60**	67.87	0.83**	-6.48	121.67	0.55**	-5.88	6.38	0.87	-0.03	1.59	-1.48	-0.001
RTM-1626	55.45	0.51	2.02	66.03	0.84	-6.11	128.67	0.61*	-5.83	5.17	0.57**	-0.04	1.70	2.00	0.049**
RTM-1651	56.30	-0.37**	1.12	65.98	1.21**	-6.72	129.00	1.55	-1.17	5.73	0.46	0.01	2.32	8.00	0.049**
RTM-1660	58.60	0.63	14.02**	67.32	0.67	137.77**	130.17	0.42*	-5.29	5.63	0.92	-0.04	2.18	6.00	0.139**
RTM-1822	58.14	0.17**	-0.54	76.78	0.82	-3.59	125.83	-0.55	15.22	6.35	3.47**	-0.01	2.04	4.00	0.069**
RTM-1826	54.39	1.18	26.93**	62.43	0.91	-4.09	134.25	1.04	2.56	5.67	0.69	0.01	1.94	4.00	0.044**
RTM-1829	56.61	0.47	15.38**	71.77	0.85	-6.07	125.74	1.79*	-4.65	5.58	0.64	-0.02	1.81	6.00	0.124**
RTM-2002	51.76	1.73**	-0.17	70.43	1.29	57.93**	125.25	1.08	-3.53	6.13	0.69	-0.03	2.36	-6.00**	0.004
RTM-2107	51.56	1.14	0.07	73.42	0.55	1.36	124.83	0.03	16.42	5.08	0.62	-0.04	2.36	-8.00	0.079**
RTM-2110	48.98	1.56	0.40	60.15	1.05	4.38	123.17	0.15	1.79	5.30	1.91	0.03	1.65	12.00	0.174**
RTM GP-35	49.49	1.77*	0.94	66.90	1.52**	-5.83	125.00	1.58	6.40	6.37	0.58	-0.03	1.69	8.00*	0.014
RTM GP-41	54.16	0.56	48.00**	64.43	0.46**	-5.95	125.50	1.28	18.07	5.77	-0.44**	-0.04	1.83	-6.00	0.029*
RTM GP-47	54.61	0.67	5.59*	66.60	1.22	10.05	123.25	1.95*	-3.21	5.47	0.64	-0.04	2.34	0.00	0.004
Mean	**52.98**	**0.99**	**7.60**	**69.09**	**1.00**	**10.43**	**125.27**	**1.00**	**-1.72**	**5.83**	**1.00**	**-0.03**	**1.92**	**1.08**	**0.05**
S.E	**0.79**	**0.50**		**1.49**	**0.37**		**1.46**	**0.40**		**0.13**	**0.45**		**0.04**	**4.41**	

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

Table 3. Mean values and stability parameters (bi and S^2_{di}) of the taramira genotypes for siliqua on main shoot, siliqua density, siliqua length, seeds per siliqua and chlorophyll content 35 DAS

Genotype	Siliqua on main shoot			Siliqua density			Siliqua length (cm)			Seeds per siliqua			Chlorophyll content 35 DAS (SPAD meter)		
	Mean	bi	S^2_{di}	Mean	bi	S^2_{di}	Mean	bi	S^2_{di}	Mean	bi	S^2_{di}	Mean	bi	S^2_{di}
RTM-314	15.22	1.10	2.97**	0.59	0.00	0.0050**	2.62	2.02**	-0.0079	18.43	1.18	-0.00	43.61	1.84	-0.85
RTM-644	13.25	1.86*	0.08	0.50	2.50	-0.0100**	2.56	0.26	-0.0006	12.13	0.46**	-0.24	39.47	0.82	-1.37
RTM-715	15.15	2.02**	-0.16	0.60	2.50	-0.0100**	2.33	1.83	-0.0065	13.98	0.88	-0.12	39.76	0.40	0.40
RTM-754	15.32	-0.69**	0.42	0.66	0.77	-0.0004	2.80	0.71	-0.0073	19.95	1.42*	-0.12	40.43	0.40	-0.49
RTM-1119	14.65	2.18*	0.33	0.55	0.55**	-0.0004	2.62	0.51**	-0.0084	14.63	0.81**	-0.37	42.83	0.82	6.63*
RTM-1120	15.28	1.16	4.80**	0.52	0.70	-0.0002	2.62	0.47**	-0.0084	13.88	0.60**	-0.24	41.73	1.02	10.50**
RTM-1206	13.12	0.76	1.66*	0.57	1.27	0.0004	2.35	0.24**	-0.0084	14.49	1.27	-0.19	43.04	0.60	2.16
RTM-1351	17.07	1.54*	-0.15	0.57	1.90	0.0001	2.67	1.29	0.004	18.55	1.18	-0.10	45.78	0.95	-0.46
RTM-1355	15.03	0.68**	-0.28	0.62	0.50	-0.0002	2.65	1.55*	-0.008	18.50	1.42**	-0.19	39.90	0.88	0.47
RTM-1396	15.72	1.34	-0.22	0.58	1.15	0.0007	2.37	0.66	-0.0069	13.57	0.68	-0.06	43.57	0.52	16.13**
RTM-1475	15.41	-0.08**	-0.25	0.67	1.17	-0.0004	2.80	1.10	-0.0071	19.28	1.14**	-0.35	39.84	0.80	-1.07
RTM-1530	15.98	0.80	-0.22	0.60	1.75**	-0.0003	2.54	0.31**	-0.0084	16.37	1.73**	-0.32	41.14	1.57**	-1.59
RTM-1587	13.92	0.95	2.00**	0.55	0.75	-0.0002	2.67	2.14	-0.0027	17.93	1.22	-0.14	41.57	1.99**	-1.41
RTM-1591	16.57	0.36**	-0.26	0.63	0.67*	-0.0004	2.63	1.62	-0.0071	19.43	1.10	0.06	44.32	1.24	-0.30
RTM-1598	13.45	1.37	2.79**	0.57	1.72	0.0002	2.50	0.92	-0.0078	12.68	0.76**	-0.33	44.85	1.60	0.80
RTM-1613	15.53	0.11*	-0.00	0.63	0.35**	-0.0004	2.66	1.30	0.0338*	20.17	1.56**	-0.09	43.63	-1.08	4.71*
RTM-1616	13.38	1.15	0.25	0.57	1.17	-0.0001	2.43	0.93	-0.0075	13.95	0.65**	-0.26	41.57	0.90	8.64*
RTM-1624	13.85	0.94	0.66	0.61	1.02	-0.0004	2.53	1.57	-0.0004	17.55	0.86**	-0.33	40.70	0.06	1.60
RTM-1626	12.64	0.70*	-0.25	0.61	0.32*	-0.0003	2.50	1.56	-0.0036	16.03	1.16	-0.17	40.06	2.18	0.85
RTM-1651	12.85	1.22	-0.26	0.61	0.27	-0.0001	2.41	0.32**	-0.008	14.38	-0.36**	0.93	40.33	0.55**	-1.54
RTM-1660	13.77	0.59	0.11	0.60	0.67	-0.0004	2.47	0.79	-0.007	14.30	0.78	0.04	42.71	1.59**	-1.58
RTM-1822	15.93	0.39*	-0.15	0.67	0.52	0.0002	2.76	1.48	-0.0073	19.60	1.25	-0.14	42.77	2.06	1.65
RTM-1826	14.70	1.56	0.19	0.58	0.15	0.0001	2.22	0.45**	-0.0082	16.42	2.02*	0.95	43.87	-0.76	1.15
RTM-1829	14.08	0.61	0.31	0.55	1.25	0.0005	2.31	0.82	-0.0081	16.63	1.51**	-0.25	43.93	1.67*	-1.33
RTM-2002	15.67	1.06	0.57	0.60	0.62	-0.0003	2.64	2.02**	-0.0074	18.98	1.51**	-0.20	40.60	0.29	-0.54
RTM-2107	13.18	1.48	-0.10	0.54	1.40	-0.0002	2.27	0.21**	-0.0077	13.38	0.54**	-0.23	43.61	0.86	3.21
RTM-2110	13.48	1.12	0.08	0.57	1.10	-0.0003	2.43	1.13	-0.0063	13.00	0.73	0.67	40.62	1.98	1.39
RTM GP-35	16.78	2.85**	-0.12	0.56	1.37	0.0005	2.71	0.15	-0.0006	16.40	0.87	-0.12	42.14	1.70	1.88
RTM GP-41	15.28	0.96	-0.24	0.51	0.45	0.0313**	2.59	0.97	-0.0053	14.67	0.42**	-0.20	42.69	1.89	0.35
RTM GP-47	14.60	-0.10**	-0.18	0.55	1.92**	-0.0003	2.39	0.32**	-0.0084	14.90	0.63**	-0.30	44.78	0.65	-0.61
Mean	**14.70**	**1.00**	**0.47**	**0.58**	**1.02**	**0.0004**	**2.53**	**0.99**	**0.0047**	**16.14**	**1.00**	**-0.08**	**42.19**	**1.00**	**1.64**
S.E	**0.32**	**0.46**		**0.01**	**0.67**		**0.05**	**0.49**		**0.35**	**0.17**		**0.74**	**0.83**	

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

Table 4. Mean values and stability parameters (bi and S^2_{di}) of the taramira genotypes chlorophyll content 70 DAS, 1000-seed weight and seed yield per plant

Genotype	Chlorophyll content 70 DAS (SPAD meter)			1000-seed weight (g)			Seed yield per plant (g)		
	Mean	bi	S²di	Mean	bi	S²di	Mean	bi	S²di
RTM-314	38.34	0.97	-1.54	2.77	0.93	0.2102**	2.91	1.21**	-0.006
RTM-644	35.60	0.94	3.90	2.32	0.93	0.0350**	2.08	0.86**	-0.006
RTM-715	33.79	1.58**	0.26	2.70	1.16	0.0036	2.15	0.91	0.124**
RTM-754	40.12	1.62*	0.93	2.96	1.16	0.0002	2.66	1.08	0.074**
RTM-1119	37.24	1.27	-0.03	2.63	1.05	0.0004	2.78	1.15	0.044*
RTM-1120	34.64	1.59	2.69	2.43	0.92	-0.0002	2.33	0.93	0.064*
RTM-1206	35.51	1.25	10.31**	2.67	1.07	0.0060	2.29	0.93	-0.006
RTM-1351	38.98	1.14	3.31	2.72	0.75	0.1007**	2.71	1.13**	-0.006
RTM-1355	35.41	0.51**	-1.61	2.85	1.31**	-0.0049	2.51	1.02	0.089**
RTM-1396	35.61	0.59**	-1.43	2.53	0.77	0.0166*	2.40	0.98	-0.006
RTM-1475	33.66	1.19	6.57*	2.77	1.16	-0.0011	2.38	0.90	0.464**
RTM-1530	37.00	0.65*	-0.56	2.46	1.09**	-0.0048	2.26	0.91	0.004
RTM-1587	37.63	0.61	10.51**	2.33	1.04	-0.0027	2.13	0.88	0.264**
RTM-1591	37.34	1.65**	-1.30	2.69	1.05	0.0189*	2.68	1.08	0.009
RTM-1598	34.53	1.17	4.45	2.49	1.16*	-0.0032	2.54	1.10	0.254**
RTM-1613	35.45	1.04	10.89**	2.78	1.04	0.1345**	2.98	1.24**	-0.006
RTM-1616	35.68	0.6**	-1.57	2.38	0.91	0.0192*	2.41	0.98	-0.006
RTM-1624	35.41	0.71	-0.68	2.86	1.16	0.0013	2.69	1.12	0.059*
RTM-1626	38.94	0.84	-1.35	2.42	0.95	0.0150*	2.25	0.86	0.049*
RTM-1651	38.24	0.87	0.03	2.29	0.89	0.0155*	2.13	0.80**	-0.001
RTM-1660	34.76	1.74**	-0.91	2.11	0.94	-0.0005	2.06	0.76	0.144**
RTM-1822	36.98	1.02	-0.45	2.63	0.90	0.0088	2.87	1.16**	-0.001
RTM-1826	39.22	1.08	0.44	2.47	0.93	0.0274*	2.58	1.07	0.079**
RTM-1829	38.24	0.61	14.43**	2.37	0.97	-0.0011	2.50	1.05	-0.001
RTM-2002	35.68	0.72**	-1.49	2.88	1.20**	-0.0036	3.14	1.31	0.109**
RTM-2107	35.94	0.74	0.60	2.08	0.81	0.0102	2.12	0.84	0.054*
RTM-2110	36.12	0.62**	-1.63	2.13	0.81	0.0132	2.18	0.87	0.004
RTM GP-35	36.24	0.81	1.18	2.30	0.92	0.0018	2.29	0.95	-0.021
RTM GP-41	37.91	0.87	-0.16	2.20	1.00	0.0107	2.39	0.99	0.059*
RTM GP-47	37.17	0.99	0.03	2.07	0.86*	-0.0038	2.24	0.91	0.029
Mean	**36.58**	**1.00**	**1.86**	**2.51**	**1.00**	**0.02**	**2.45**	**1.00**	**0.06**
S.E	**0.74**	**0.24**		**0.04**	**0.22**		**0.06**	**0.13**	

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

Seed yield is positively associated with the number of siliqua on main shoot, primary branches per plant, siliqua per main raceme and silique length by Shinwari *et al.* (2013) in taramira and Kamdi *et al.* (2022) in Indian mustard. About 84 per cent genotypes had non-significant S^2di values exhibiting stability for this particular trait. RTM-2002 and RTM GP-41 exhibited average stability thus, suitable for all environmental conditions for this trait. S^2di estimates of 87 per cent genotypes were non-significant exhibiting stability for siliqua density. Siliqua density is positively correlated with yield in taramira. RTM-1475 and RTM-1624 were found to be suitable for all the environments. The information generated by Nanjundan *et al*. (2014) will help in developing breeding strategies for utilizing this trait to redesign the Indian mustard ideotype for high siliqua density. S^2_{di} estimates of 97 per cent genotypes were non-significant exhibiting stability for length of siliqua. RTM-1475 was found to be most desirable. Sagolsem *et al.* (2013) in Indian mustard and Ola *et al*. (2022) also specified similar results in taramira. S^2di was non-significant in all the genotypes, indicating stability for seeds per siliqua. The genotypes RTM-1475

Table 5. Environment indices for different characters of taramira genotypes

Environments	DFF	PH	DM	PBPP	HFBE	SMS	SD	SL	SPS	CC-35	CC-70	TW	SY/P
Environments-1 (Timely sown & *Orobanche* free)	4.24	6.91	3.48	0.26	-0.054	1.02	0.043	0.09	2.55	1.92	4.54	0.49	1.16
Environments-2 (Timely sown & *Orobanche* infested)	3.11	-5.15	2.25	-0.07	0.007	-0.83	-0.013	-0.02	-1.64	-0.63	-0.43	-0.20	-0.18
Environments-3 (Late sown & *Orobanche* free)	-3.32	5.14	-1.72	0.10	0.043	1.11	0.012	0.01	1.22	0.32	3.15	0.25	0.94
Environments-4 (Late sown & *Orobanche* infested)	-4.03	-6.90	-4.02	-0.29	0.004	-1.30	-0.042	-0.08	-2.13	-1.62	-7.26	-0.55	-1.92

DFF	Days to 50 per cent flowering	SL	Silqua length
PH	Plant height	SPS	Seeds per siliqua
DM	Days to maturity	CC-35	Chlorophyll content 35 DAS (SPAD meter)
PBPP	Primary branches per plant	CC-70	Chlorophyll content 70 DAS (SPAD meter)
HFBE	Height of first branch emergence	TW	1000 seed weight
SMS	Siliqua on main shoot	SY/P	Seed yield per plant
SD	Siliqua density		

and RTM-1591 were classified as most desirable for seeds per siliqua. Similar results were obtained by many workers, like Jakhar and Yadav (2010) in taramira and Gazal *et al.* (2013) in brown sarson. For chlorophyll content 35 days after sowing S^2_{di} estimates of 84 per cent genotypes were non-significant exhibiting stability for chlorophyll content 35 DAS. Since more chlorophyll content is positively correlated with yield in taramira, it was found that the genotypes *viz.*, RTM-1351, RTM-1591 and RTM-2107 were identified as most stable **(Table 3).**

The genotypes *viz.,* RTM-314, RTM-1351, RTM-1822, RTM-1826 and RTM GP-47 were found to be most stable for chlorophyll for 70 DAS. Similar investigation on effect of date of sowing on chlorophyll content was done by Godara *et al.* (2016) in Indian mustard and Nefzi *et al.* (2016) in chickpea where chlorophyll content reduced significantly under infestation in all genotypes. In 67 per cent genotypes, S^2_{di} estimates were non-significant exhibiting stability for 1000-seed weight. The genotypes RTM-1119, RTM-1206 and RTM-1822 were recognized as the most desirable and reliable performing for the character 1000- seed weight. Supporting evidence for test weight was reported by Srivastava and Srivastava (2020) in Indian mustard. For seed yield, RTM-1351, RTM-1591 and RTM-1829 were recognized as the most acceptable and consistent performing genotypes. RTM-314, RTM-1613 and RTM-1822 were suitable for better environments and exhibited below average stability. These are in accordance with the findings of Henry and Daulay (1990) in Indian mustard. Deviation from regression coefficient estimates (S^2_{di}) for 50 per cent genotypes was non-significant **(Table 4)**. Similar results were obtained by Tahira and Muhammad (2013) in rapeseed and Sadhu *et al.* (2024) in Indian mustard.

The environment can be graded based upon the overall mean performance of the genotypes. According to environmental indices, environment-1 *Orobanche* free (early sown) was most favorable for seed yield and yield-contributing traits like plant height, primary branches per plant, siliqua on main shoot, siliqua density, siliqua length, seeds per siliqua, chlorophyll content at 35 DAS, chlorophyll content at 70 DAS and 1000-seed weight and least favourable in environment-4 **(Table 5)**. Such results were also reported by Acharya *et al.* (2002) in toria.

Three genotypes *viz*., RTM-1351, RTM-1591 and RTM-1829 were most stable performer for seed yield per plant along with most of the yield determining traits which could be recommended for general cultivation over a wide range of environmental conditions. The other three genotypes *viz*., RTM-314, RTM-1613 and RTM-1822 indicated below average performance and could be recommended for cultivation under suitable soil conditions and high input management. In the present study, the effect of *Orobanche* on taramira genotypes was found to be low at 60 DAS and was high at 110 DAS in both the environment (timely and late sown *Orobanche* infested field). The incidence of *Orobanche* in late sown conditions was found to be high at 60 DAS and 110 DAS in comparison to timely sowing. The findings of the present study can be effectively utilized in future breeding programmes for the development of high-yielding and *Orobanche*-tolerant taramira varieties suitable for diverse environments.

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