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Stability analysis of yield and its components in safflower (*Carthamus tinctorious* L.)

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Abstract
Twenty five promising genotypes including four checks were evaluated during *rabi* 2020-21, 2021-22 and 2022-23 for the assessment of stability in seed yield and yield contributing traits of safflower were subjects of field experiments carried out at IGKV in a RBD design with three replications. Eleven morphological characters were used as the subjects of the observations and stability and character association analysis were conducted in accordance with the model of Eberhart and Russell (1966). The analysis of variance resulting from genotype was highly significant for all the characters under investigation while environment was significant for days to maturity and plant height but highly significant for seed yield per plant, 100 seed weight and harvest index (%). On the basis of performance and stability parameters, it was concluded that the genotype SSF-18-72 and PBNS-12 was the most ideal, as this showed higher seed yield, number of capitulum/plant along with number of seeds/capitulum and adaptability to wide range of climatic conditions. The genotype PBNS-202 was other promising and suited to favorable environment while genotype PBNS-198 was also another most desirable and suited to poor or unfavorable environment.

Keywords: Safflower, G x E interaction, stability

Introduction

Safflower (*Carthamus tinctorius* L.) is an oilseed crop member of the *Compositae* or *Asteraceae* family and native of Afghanistan and Ethiopia (middle east). Safflower is a diploid (2n=24) annual herbaceous crop which grows well in hot and dry climate and is only cultivated species among the 25 species under the genus *Carthamus.* The safflower genome is 1.4 GB in size (Badiger *et al*., 2009) [2]. Safflower (*Carthamus tinctorious* L.) is one of the major oilseed crops in the world. The seed contains 24-36% oil. Safflower cakes contain about 40-45% protein. Traditionally, it is grown for its seeds, flowers, fabric dyes, food colouring and for medicinal reasons. The natural dyes called carthamin is extracted from brilliantly coloured flowers. The seeds are used for extraction of vegetable oil for consumption as well as industrial uses. The oil is one of the best cooking oils due to its high level of unsaturated fatty acid content (>75% linoleic or oleic acid).

Location, planting date, air temperature, soil, water availability and light intensity, particularly in the seedling and flowering periods, all have an impact on safflower yield. Genotype x environment (GE) interaction is of major importance to the plant breeders for produce superior cultivars. Estimation of stability performance has become an important tool to identify consistently high-yielding genotypes (Kang, 1998) [5]. When varieties are compared, under different environmental conditions their relative performances usually differ. To overcome this constraint, stability analyses should be carried out (Eberhart and Russell, 1966) [3].

Materials and Methods

The present experiment on safflower was conducted during *rabi* 2020-21, *rabi* 2021-22 and *rabi* 2022-23 at the research cum instructional farm of IGKV, Raipur with three in a randomized complete block design using 25 elite genotypes of safflower including four check varieties PBNS-12, JSI-99, DSH-185 and A-1 were assessed for their stability of seed yield and its components in accordance with a method outlined by Eberhart and Russell (1966) [3], where the years were treated as random factors while the genotypes were treated as fixed variables. Each plot size was 1.80 m x 5 m contains 4 rows. In every replication the row to row spacing was 45 cm and plant to plant was 20cm. Five plants were selected randomly from each treatment for recording observations. Observations were recorded on eleven characters including Oil content (%) and Seed yield per plant (g). The data recorded for different characters were subjected to statistical analysis. The mean data collected on five competitive selected plants in each replication on each line were subjected stability analysis by using model of Eberhart & Russell (1966) [3].

Table 1: List of genotypes of safflower used in experiment

S. No.	Entry	S. No.	Entry
1	PBNS-198	14	SSF-18-02
2	SSF-18-72	15	PBNS-201
3	PBNS-12	16	ISH-419
4	ISF-300	17	TSF-89
5	JSI-99	18	DSH-185
6	AKS-351	19	RVS-120
7	ISF-351	20	SSF-18-37
8	RVS-119	21	A-1
9	SSF-16-30	22	PBNS-200
10	ISH-417	23	ISF-867
11	PBNS-201	24	PBNS-194
12	TSF-91	25	RVS-118
13	ISH-413		

Result and Discussion

The combined analysis of variance resulting from genotype was highly significant for all the characters under investigation at 1% level and it indicated the presence of substantial genetic variation among the genotypes (Table 1). The mean sum of square due to environment was significant for days to maturity and plant height, while highly significant for seed yield per plant, 100 seed weight and harvest index (%). It is suggested that the environment played a major role in developing genetic variation among the genotypes for yield and its contributing characters. Day to maturity, harvest index (%) and 100 seed weight all had significant variance due to environment + (genotype x environment). Whereas the environment linear was significant for day to 50% flowering, days to maturity, plant height, number of effective capitulum per plant, seed yield per plant, 100 seed weight, oil content % and harvest index (%). The fact of that the mean sum of square due to pooled deviation was significant for number of effective capitulum per plant, number of primary branches per plant, biological yield per plant and harvest index (%). The present findings are close agreement with findings of Badiger *et al.*, (2009) [2] and Golkar *et al*., (2020) [4].

Stability parameters for yield and its contributing traits in safflower a genotype with unit regression coefficient (bi=1) and deviation from regression not significantly different from (S^2di =0) is said to be stable genotypes. Accession with bi values significant higher than 1 and non - significant deviation from regression are expected to perform better in the favorable environments, whereas accessions with bi values significant lower than 1 and non significant deviations from regression are more suitable for low yielding environments. Those which have both regression coefficient (bi) and deviation from regression (S^2di =0) significant are unstable.

Days to 50% flowering indicated that A-1 was stable genotype had higher mean value than the population mean along with regression coefficient (bi), bi=1 or close to 1 but non-significant with deviation from regression (S^2di) is nearly zero, while ISF-351, TSF-91, SSF-18-02, ISH-419, TSF-89, PBNS-202 genotypes were stable for favorable environment.

Table 2: Combined analysis of variance for stability in safflower under three different environments (year's 2020-21, 2021-22 and 2022-23) (Eberhart and Russell model, 1966) [3]

	DF	DFF	DM	PH(cm)	NPB	NCP	NSC	SYPP(g)	BYPP (g)	100SW(g)	OC%	HI%
Rep within Env.	6	3.46	3.513 *	3.17	0.08	1.10	4.57	2.11	4.41	0.06	0.15	3.74
Varieties	24	9.56 **	12.05**	262.07**	0.97**	11.69**	92.54**	14.40**	391.78**	0.59**	19.54**	234.02**
Env.+ (Var.* Env.)	50	4.20	4.67**	13.74	0.27	2.00	8.56	2.25	9.65	0.15*	0.57	11.74*
Environments	2	6.19	5.61*	57.11*	0.57	6.54	4.25	18.94**	12.54	0.49**	1.75	77.11**
Var.* Env.	48	4.12	4.63**	11.94	0.26	1.81	8.74	1.56	9.53	0.14	0.52	9.02
Environments (Lin.)	1	12.37 *	11.23**	114.23**	1.14	13.08*	8.49	37.89**	25.07	0.98**	3.50*	154.22**
Var.* Env. (Lin.)	24	5.50*	8.11**	12.52	0.16	0.93	11.88*	1.49	4.79	0.20**	0.34	11.53
Pooled Deviation	25	2.63	1.10	10.90	0.34**	2.59**	5.37*	1.55	13.69**	0.08	0.67	6.24**
Pooled Error	144	2.70	3.42	9.92	0.08	1.27	2.91	1.19	6.88	0.05	1.16	2.59
Total	74	5.94	7.06	94.28	0.50	5.15	35.80	6.19	133.59	0.30	6.72	83.83

*,** Significance at 5% and 1% levels, respectively

DFF= Days to 50% flowering, DM= Days to maturity, PH (cm)= Plant height (cm), NPB= No. of primary branches/plant, NECP= No. of effective capitulum/plant, NSC = Number of seeds /capitulum, BYPP (g)= Biological yield /plant (g), 100SW (g)= 100 seed weight(g), OC (%)=Oil content (%), HI (%)=Harvest index (%), SYPP (g)= Seed yield /plant (g).

with high mean, bi>1 and significant and S2di non-significant. Genotypes ISF-351 (103.56), TSF-91 (104.89), SSF-18-02 (102.22), ISH-419 (102.33), TSF-89 (102.11), PBNS-202 (102.67) were exhibiting above in stability with bi>1 and they were highly sensitive to environmental situation. Some genotypes exhibiting below average in stability with bi <1 value in SSF-18-72, RVS-119, ISH-413 and PBNS-200 were indicating that these genotypes were least sensitive to environmental conditions. Therefore, it revealed that the genotypes adapted to poor environment condition while the genotypes had observed that higher or lower mean than population mean and exhibiting above, unity or below stability with bi>1, bi <1, or bi=1, but deviation from regression (S^2di) was significant value in PBNS-12 and RVS-120. These genotypes indicated that they are unstable and unpredictable response in all environments. Whereas, for days to maturity genotypes JSI-99, TSF-91, ISH-417, ISH-413, TSF-89, SSF-18-72, SSF-18-02, PBNS-200 were identified as stable variety in favorable environment as well as genotypes PBNS-198, ISF-351, ISH-417, PBNS-202 (147.11), DSH-185 having bi <1 were least sensitive to environmental conditions. Therefore, it revealed that these genotypes can be adapted to poor environment condition. Similar results were also reported by Naik *et al.*, (2005) [8], Badiger *et al.*, (2009) [2] and Shivani and Sreelakshmi, (2013) [9], and Oliveira *et al.*, (2022) [6].

However, for Plant height (cm) ISH-419 and SSF-16-30 were more stable across the genotype. Whereas genotypes ISH-417, TSF-91, TSF-89, PBNS-202, RVS-119, DSH-185 exhibited bi>1, significant and S2di non-significant were recommended to favorable environment. Whereas genotypes exhibiting below average in stability with bi <1 value in genotypes SSF-18-72, ISH-413, PBNS-194 and PBNS-200 with non-significant deviation from regression (S^2di) were Suitable for poor or unfavorable environment. For number of primary branches per plant AKS-351 and SSF-18-02 were identified as stable across genotypes having high mean value with regression coefficient in unity (bi =1), while, ISF-867, ISF-300, SSF-16-30, TSF-91, PBNS-202, SSF-18-37, PBNS-194, RVS-118 were recommended for favorable environment. Genotype RVS-19 was suitable for poor or unfavorable environment but significant bi<1 and S2di non-significant. Whereas, for number of capitulum per plant PBNS-202, SSF-18-02 genotypes were observed that these were highly sensitive to environmental situation and stable for favorable environment. While, genotypes PBNS-198, PBNS-12, TSF-91, ISF-867, RVS-118, RVS-120, ISH-419 were exhibiting below average in stability with bi <1 value and recommended for poor environment. The results are in accordance with the finding of earlier workers *viz*. Rao and Ramachandra, (1979) [7], Badiger *et al.*, (2009) [2] and Shivani and Sreelakshmi, (2013) [9]. For number of seeds per capitulum the genotype ISF-869 was stable genotypes having high mean with regression coefficient near to unity (bi ≈ 1) were recommended for all environments while genotypes SSF-18-72, RVS-120, ISF-300, ISH-413, SSF-18-02, TSF-89, DSH-185, PBNS-194 and RVS- 118 with High mean, bi>1 but significant and S^2di non-significant were recommended for favorable environmental conditions. The results are in accordance with the finding of earlier workers *viz*., Golkar *et al.*, (2020) [4] and Afzal *et al.*, (2021) [1].

Seed yield per plant varied from 12.26 (PBNS-194) to 22.57 (A-1) along with overall mean of 19.33. Genotypes SSF-18-72 and PBNS-201 had higher mean value bi=1 or near to one but non-significant and S^2di non-significant were stable for all environments whereas genotypes ISF-351, SSF-16-30, PBNS-200 and ISH-417 were showed high mean value than population mean were exhibiting above in stability with bi>1values. These were high responsive and adaptable to rich environment. High mean, bi<1 and significant and S^2di non-significant value were observed in PBNS-198, ISF-300, ISH-419, DSH-185, A-1 and RVS-118 recommended for poor or unfavorable environments. JSI-99 had significant, bi>1, bi <1, or bi=1 and higher or lower mean were unstable and unpredictable response in all environments. These findings are confirming the earlier studies of Afzal *et al.*, (2021) [1] and Oliveira *et al.*, (2022) [6]. For biological yield per plant the genotypes ISF-300 and PBNS-202 were exhibiting above in stability with bi>1 while PBNS-198, SSF-16-30 and RVS-118 were recommended for poor environment with non-significant S^2di with bi<1 value. For 100 seed weight, higher mean value, bi>1 and S^2di non-significant were observed in genotypes PBNS-12, RVS-170, SSF-16-30, TSF-91 and RVS-120 and these were found stable for favorable environment and PBNS-200, PBNS-198, A-1, PBNS-202, JSI-99, ISH-419, TSF-89 with high mean, bi<1 and and S2di non-significant genotypes were least sensitive to environmental conditions. Therefore, it revealed that the genotype adapted to poor or unstable environment condition. These findings are confirming the earlier studies of Badiger *et al.*, (2009) [2] and Shivani and Sreelakshmi, (2013) [9]. For oil content (%), ISH-413 had higher oil content % with bi=1 but non-significant and S^2di non-significant for all environment conditions while ISF-300, SSF-16-30, ISH-417, ISH-419, DSH-185 and SSF-18-02 were stable for favorable condition with high oil content % and bi>1 but significant and S^2di non-significant. For harvest index % the genotype ISF-351, ISH-413 and PBNS-201 had high mean with regression coefficient greater then unity (bi>1) indicates suitability for favorable environment

Table 3: Estimation of stability parameters for different observation included in the present studies-

Sl. No.	Genotypes	Days to 50% flowering			Days to maturity			Plant height (cm)			Number of Primary branches		
		m Mean	bi	σ^2di	m Mean	bi	σ^2di	m Mean	bi	σ^2di	m Mean	bi	σ^2di
1	PBNS-198	100.78	-1.94	2.60	145.22	-0.66	-3.10	90.37	-0.76	-9.56	5.61	0.38	0.5018 **
2	SSF-18-72	102.11	-0.03	-1.77	146.11	1.74	-3.38	94.37	-0.09	-6.13	5.51	1.63	-0.06
3	PBNS-12	101.56	2.24	6.86	144.44	9.53	-3.32	85.93	0.82	-9.31	5.97	-0.74	0.05
4	ISF-300	100.44	1.87	-2.61	144.67	-1.33	-2.67	89.68	1.73	-6.26	6.44	1.92	0.2724 *
5	JSI-99	100.22	-4.93	-2.70	147.22	-8.45	-3.42	54.06	0.93	9.73	4.69	0.20	0.06
6	AKS-351	100.78	1.91	-0.90	143.78	-3.35	0.72	84.69	1.55	2.57	6.39	0.96	0.17
7	ISF-351	103.56	-3.13	0.50	145.78	-0.43	-2.54	88.23	0.96	-9.42	5.70	2.51	0.18
8	RVS-119	102.33	0.13	-1.18	143.44	-4.01	-0.80	99.17	1.46	-4.24	6.47	-0.09	-0.02
9	SSF-16-30	96.33	2.85	1.24	141.00	2.95	-1.10	95.41	-0.99	-7.69	7.03	3.79	1.1351 **
10	ISH-417	102.44	0.78	-0.29	145.44	-0.43	-2.54	96.10	1.92	-9.01	5.89	3.15	0.04
11	PBNS-201	99.67	-4.62	1.58	142.67	-7.72	-3.34	88.11	-3.64	36.3275 *	5.60	-1.49	-0.07
12	TSF-91	104.89	4.05	-0.54	147.78	2.76	-3.00	94.49	3.15	-2.69	6.16	-2.95	-0.06
13	ISH-413	102.22	-0.27	-2.69	145.44	2.51	-3.08	97.00	0.74	-9.55	5.71	0.42	0.15
14	SSF-18-02	102.22	-1.83	1.46	147.00	1.40	-3.42	95.78	0.56	5.86	6.18	1.22	0.3546 *
15	PBNS-201	102.67	-1.43	-1.74	147.11	0.48	-1.23	95.81	-1.27	-5.49	6.29	3.55	0.11
16	ISH-419	102.33	3.33	2.67	147.78	4.17	-2.93	96.01	0.97	-7.41	5.63	0.14	0.06
17	TSF-89	102.11	1.43	0.11	145.22	5.28	-3.42	97.38	2.12	-8.77	5.61	-0.06	0.4861 **
18	DSH-185	101.44	-0.37	-2.72	147.00	0.25	-1.90	93.74	2.74	1.74	5.13	0.36	-0.05
19	RVS-120	100.89	9.49	6.13	141.33	6.32	-3.37	76.61	1.56	-5.53	6.96	3.50	2.5300 **
20	SSF-18-37	99.33	6.39	1.93	143.89	8.15	-3.01	86.48	3.13	-8.56	6.76	3.44	0.3192 *
21	A-1	102.56	0.85	-2.57	143.22	2.85	-3.23	87.71	1.19	-6.18	5.51	-0.13	0.2877 *
22	PBNS-200	104.56	-0.61	-1.51	147.00	1.90	2.96	99.86	-0.10	-9.29	6.00	3.06	0.04
23	ISF-867	99.56	4.90	-2.09	146.00	3.05	-1.62	85.48	4.68	116.82 **	6.19	1.30	-0.06

24	PBNS-194	101.22	-0.58	-2.38	144.11	-2.40	-2.83	92.51	0.76	-7.40	6.24	1.80	0.15
25	RVS-118	100.00	4.52	-1.98	141.56	0.43	-2.54	85.34	0.86	-9.43	6.86	-2.87	-0.02
	Population Mean	101.45			144.97			90.01			6.02		

* and ** indicates significance at 5 and 1 percent level respectively

Sl. No.	Genotypes	No. of effective capitula/plant			No. of seeds/capitulum			Seed yield per plant (g)			Biological yield (g/plant)		
		m Mean	bi	σ^2di	m Mean	bi	σ^2di	m Mean	bi	σ^2di	m Mean	bi	σ^2di
1	PBNS-198	28.07	0.08	1.16	32.56	4.38	-2.10	21.54	0.50	-1.23	74.84	-0.34	-1.77
2	SSF-18-72	22.29	-1.05	-0.09	40.22	8.69	-1.65	21.28	0.80	-0.53	38.04	5.27	-6.78
3	PBNS-12	25.00	-0.11	0.28	30.79	-1.68	14.03 *	19.97	-1.06	-0.36	75.36	5.36	8.33
4	ISF-300	28.40	3.89	7.21 *	44.34	-7.77	-0.42	20.54	-0.67	-1.21	61.82	-3.89	3.75
5	JSI-99	18.17	0.92	-0.98	20.44	5.42	-1.77	21.93	1.98	17.11 **	45.72	0.65	-4.73
6	AKS-351	25.49	-0.27	5.68 *	33.32	0.75	-1.68	17.36	2.07	-0.97	54.28	-1.37	30.01 *
7	ISF-351	23.91	-0.26	-0.05	29.78	4.34	-2.65	21.16	1.90	-1.01	45.17	2.29	-4.19
8	RVS-119	24.39	0.04	5.19 *	25.46	2.20	-2.73	17.23	0.84	-1.23	73.62	2.04	16.81
9	SSF-16-30	23.72	1.91	-0.93	26.78	-2.87	-1.03	20.37	1.80	-1.22	60.07	-0.70	-3.42
10	ISH-417	23.76	2.99	1.53	33.11	3.83	-2.10	20.82	1.73	-0.57	43.63	0.88	-5.87
11	PBNS-201	24.29	2.87	-0.89	34.11	0.56	0.54	19.33	1.07	2.28	38.27	-1.36	-0.48
12	TSF-91	25.29	-0.47	1.13	37.67	-2.79	16.60 *	17.19	-0.02	0.51	39.10	1.11	-4.58
13	ISH-413	23.94	3.30	-0.27	39.33	-3.95	-2.27	17.98	2.90	-0.91	55.73	2.01	12.97
14	SSF-18-02	25.27	1.25	-1.12	40.56	6.78	-2.50	18.21	0.47	2.12	50.51	2.62	56.62 **
15	PBNS-201	23.61	0.70	-0.58	32.99	-0.81	-2.98	16.53	2.28	-0.88	60.89	2.04	-0.35
16	ISH-419	24.20	0.56	-0.39	34.00	0.48	-0.39	20.71	0.28	1.44	77.39	0.11	47.12 **
17	TSF-89	23.69	1.91	2.17	38.32	-2.63	-2.50	19.04	1.19	0.08	57.04	0.55	-6.76
18	DSH-185	22.72	2.95	-0.47	43.99	-6.62	-2.95	20.09	-0.06	-1.22	58.41	4.00	-5.91
19	RVS-120	24.38	0.59	5.38 *	34.89	1.83	1.51	18.77	-0.01	-1.17	65.94	1.36	-5.34
20	SSF-18-37	23.88	0.27	0.58	32.88	21.40	64.70 **	17.93	0.82	-0.50	54.98	-0.90	0.73
21	A-1	22.77	0.71	-0.24	27.77	-0.21	-2.51	22.57	0.06	-0.68	66.99	0.73	-6.75
22	PBNS-200	22.42	-0.06	5.35 *	34.11	1.95	-2.87	20.28	1.54	-0.37	58.44	-2.01	53.88 **
23	ISF-867	25.61	0.00	0.43	34.89	0.96	-2.77	19.68	1.77	-0.06	56.08	3.43	3.90
24	PBNS-194	22.60	1.54	2.73	36.12	-4.51	-0.59	12.26	2.04	-0.14	52.92	1.22	-5.30
25	RVS-118	25.93	0.75	0.29	36.11	-4.74	1.01	20.37	0.76	-1.22	59.47	-0.08	0.93
	Population Mean	24.15			34.18			19.33			56.99		

* and ** indicates significance at 5 and 1 percent level respectively

SL. No.	Genotypes	100 Seed Weight(g)			Oil Content%			Harvest Index (%)		
		m Mean	bi	σ^2di	m Mean	bi	σ^2di	m Mean	bi	σ^2di
1	PBNS-198	5.34	0.76	0.09	34.37	-0.01	-0.84	28.96	-0.11	-2.61
2	SSF-18-72	4.82	-2.56	0.14	35.17	-0.50	1.36	56.00	1.27	15.27*
3	PBNS-12	5.19	4.93	0.09	34.52	1.30	0.63	26.61	-1.38	1.80
4	ISF-300	3.96	-2.03	0.01	41.93	2.53	-1.12	33.50	-1.23	-1.70
5	JSI-99	5.33	0.08	-0.05	26.79	-1.31	-0.80	48.41	3.16	47.47 **
6	AKS-351	4.89	7.42	0.06	34.82	3.77	0.86	31.92	0.06	5.34
7	ISF-351	4.72	0.28	-0.05	33.09	3.00	-1.12	47.34	2.69	-1.25
8	RVS-119	5.22	1.70	-0.04	36.26	-0.25	-1.00	23.41	1.02	-2.60
9	SSF-16-30	5.41	4.12	0.13	35.39	1.59	-0.54	34.04	0.91	-0.24
10	ISH-417	4.66	-0.11	-0.05	35.84	1.51	-1.12	47.71	2.62	-2.53
11	PBNS-201	4.72	1.81	0.11	34.58	0.67	-0.96	51.85	3.26	2.34
12	TSF-91	5.27	1.96	-0.04	33.77	-1.99	-0.93	43.92	0.25	2.75
13	ISH-413	4.50	3.03	-0.03	37.46	-1.34	-0.82	32.27	1.33	0.72
14	SSF-18-02	4.63	-1.60	0.14	37.96	2.57	-1.12	36.55	3.68	7.15
15	PBNS-201	5.27	0.02	0.01	36.28	-0.15	-0.07	27.23	1.33	0.46
16	ISH-419	5.37	0.07	-0.05	36.84	1.65	1.16	26.79	0.81	4.03
17	TSF-89	5.59	-0.57	-0.05	34.71	3.17	-1.04	33.50	0.55	3.53
18	DSH-185	4.39	1.89	0.08	35.41	1.49	-1.12	34.73	0.23	3.83
19	RVS-120	5.23	3.25	0.02	33.40	1.61	-0.67	28.67	0.16	-2.50
20	SSF-18-37	5.63	1.46	0.03	34.16	-0.09	-1.07	32.87	-0.09	2.69
21	A-1	5.79	0.75	-0.05	32.42	2.72	-0.62	33.81	-0.07	-2.18
22	PBNS-200	5.03	0.23	-0.05	36.34	-0.49	-0.78	35.02	-0.59	-2.55
23	ISF-867	4.44	-0.72	0.11	34.62	2.57	0.31	35.81	2.41	4.78
24	PBNS-194	5.00	-1.45	0.11	35.61	0.23	0.75	23.14	1.57	7.9655 *
25	RVS-118	4.72	0.28	-0.05	34.66	0.76	-0.74	34.44	1.17	-1.71
	Population Mean	5.01			35.06			35.54		

* and ** indicates significance at 5 and 1 percent level respectively

Table 4: Classification of genotypes according to stability parameters for yield and yield contributing characters in safflower:

Name of group	Criteria	Name of genotypes			Suitable for cultivation
		Days to 50% flowering	Days to maturity	Plant height (cm)	
Average stable	High mean, bi=1 but non significant and S2di non-significant	A-1,		ISH-419, SSF-16-30	Suitable for general cultivation
Above average response	High mean, bi>1 and significant and S2di non-significant	ISF-351, TSF-91, SSF-18-02, ISH-419, TSF-89, PBNS-202	JSI-99, TSF-91, ISH-417, ISH-413, TSF-89, SSF-18-72, SSF-18-02, PBNS-200	ISH-417, TSF-91, TSF-89, PBNS-202, RVS-119, DSH-185	Suitable for favourable environment
Below average response	High mean, bi<1 and significant and S2di non-significant	SSF-18-72, RVS-119, ISH-413, PBNS-200	PBNS-198, ISF-351, ISH-417, PBNS-202 (147.11), DSH-185	SSF-18-72, ISH-413, PBNS-194, PBNS-200	Suitable for poor or unfavourable environment
Unstable	High or low mean, bi=1, bi>1 or bi<1 and S2di non-significant	PBNS-12, RVS-120		PBNS-198, PBNS-201, SSF-18-02, ISF-867	Unpredictable responce in all environment

Name of group	Criteria	Name of genotypes			Suitable for cultivation
		Number of primary branches	Number of effective capitulum per plant	Number of seeds per capitulum	
Average stable	High mean, bi=1 but non significant and S2di non-significant	AKS-351, SSF-18-02		ISF-869	Suitable for general cultivation
Above average response	High mean, bi>1 and significant and S2di non-significant	ISF-867, ISF-300, SSF-16-30, TSF-91, PBNS-202, SSF-18-37, PBNS-194, RVS-118	PBNS-202, SSF-18-02	SSF-18-72, RVS-120, ISF-300, ISH-413, SSF-18-02, TSF-89, DSH-185, PBNS-194, RVS- 118	Suitable for favourable environment
Below average response	High mean, bi<1 and significant and S2di non-significant	RVS-19	PBNS-198, PBNS-12, TSF-91, ISF-867, RVS-118, RVS-120, ISH-419	-	Suitable for poor or unfavourable environment
Unstable	High or low mean, bi=1, bi>1 or bi<1 and S2di non-significant	-	ISF-300, AKS-351, RVS-119, RVS-120, PBNS-200	PBNS-12, TSF-91, SSF-18-37	Unpredictable responce in all environment

Name of group	Criteria	Name of genotypes			Suitable for cultivation
		Seed yield per plant (g)	Biological yield per plant (g)	100 seed weight	
Average stable	High mean, bi=1 but non significant and S2di non-significant	SSF-18-72, PBNS-201			Suitable for general cultivation
Above average response	High mean, bi>1 and significant and S2di non-significant	ISF-351, SSF-16-30, PBNS-200, ISH-417	ISF-300, PBNS-202	PBNS-12, RVS-170, SSF-16-30, TSF-91, RVS-120	Suitable for favourable environment
Below average response	High mean, bi<1 and significant and S2di non-significant	PBNS-198, ISF-300, ISH-419, DSH-185, A-1, RVS-118	PBNS-198, SSF-16-30, RVS-118	PBNS-200, PBNS-198, A-1, PBNS-202, JSI-99, ISH-419, TSF-89	Suitable for poor or unfavourable environment
Unstable	High or low mean, bi=1, bi>1 or bi<1 and S2di non-significant	JSI-99	SSF-18-72, PBNS-12, JSI-99, AKS-351, ISF-351, RVS-199, ISH-417, TSF-91, ISH-413, SSF-18-02, ISH-419, TSF-89, DSH-185, RVS-120, A-1, PBNS-200, PBNS-194		Unpredictable responce in all environment

Name of group	Criteria	Name of genotypes		Suitable for cultivation
		Oil content (%)	Harvest index (%)	
Average stable	High mean, bi=1 but non significant and S^2di non-significant	ISH-413		Suitable for general cultivation
Above average response	High mean, bi>1 and significant and S^2di non-significant	ISF-300, SSF-16-30, ISH-417, ISH-419, DSH-185, SSF-18-02	ISF-351, ISH-413, PBNS-201	Suitable for favourable environment
Belove average response	High mean, bi<1 and significant and S^2di non-significant	SSF-18-72, RVS-119, PBNS-202, PBNS-200, PBNS-194	TSF-91	Suitable for poor or unfavourable environment
Unstable	High or low mean, bi=1, bi>1 or bi<1 and S^2di non-significant		SSF-18-72, JSI-99, AKS-351, SSF-18-02, ISF-867, PBNS-194	Unpredictable responce in all environment

while TSF-91 was recommended for poor environment. These findings are confirming the earlier studies of Badiger *et al.*, (2009) [2], Golkar *et al.*, (2020) [4], Afzal *et al.*, (2021) [1] and Oliveira *et al.*, (2022) [6].

Conclusion
On the basis of performance and stability parameters, it was concluded that the genotype SSF-18-72 and PBNS-12 was the most ideal, as this showed higher seed yield, number of

capitulum/plant along with number of seeds/capitulum and adaptability to wide range of climatic conditions. The genotype PBNS-202 was other promising and suited to favorable environment while genotype PBNS-198 was also another most desirable and suited to poor or unfavorable environment. Multilocation experiments may be utilized to analyze these genotypes, and their high mean values for other yield components and average yield stability could be responsible for this.

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