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Evaluation of Drought Tolerance Indices for Selection of High Yielding Fenugreek Genotypes under Moisture Regimes

Bhuri Singh and Vivechana Rajpoot[1]

Department of Basic Science, Agriculture University, Kota, Jhalawar-326 023, India
[1]Department of Botany, University of Kota, Kota-324 001, India
E-mail: bhurisingh.gpb@gmail.com

***Abstract*:** Drought is the most severe production constraint for fenugreek worldwide. Identification and screening of drought tolerant genotype is necessary for mitigation the problem. This study aimed to find out the repeatability of drought tolerance indices for selection of high yielding fenugreek genotypes. Thirty genotypes of fenugreek were sown in RBD with three replications under two moisture regimes for two year during *Rabi* season. Rank correlation between seed yield and drought tolerant indices was highly correlated. PCA indicated that first and second PCA accounted for 97.10 and 93.70% of variations for proline content and seed yield. Consequently, GGE biplot showed that the genotypes RMt-305, GM-1, RMt-303, RMt-143, RMt-351 and GM-2 were ideal for un-predictable environments.

***Keywords*:** Environment, Fenugreek, Moisture regimes, PCA

Fenugreek (*Trigonella foenum-graecum* L.) is a self pollinated crop which is used as leafy as well as seed spice purposes. The seeds and leaves are aromatic, carminative, tonic and anti-inflammatory in nature (Rathore et al 2013) and also possess numerous health properties. Drought is an emerging and serious concern globally. Thus, there is need of efficient use of water by the development of resilience crop cultivars which really sustain under moisture regimes. In India, Rajasthan is a dry state where annual average rainfall is around 550mm and often faces stress like situation. In the absence of an understanding of the special mechanisms of tolerance the quantification of drought tolerance should be based on the yield under moisture regimes. Several selection criteria have been proposed to select cultivar based on their performance in moisture regimes. Thus, drought tolerances indices which provide a measure of drought based on yield loss under drought conditions in comparison to normal conditions. However, the optimal selection criterion should distinguish genotypes that express uniform superiority in moisture regimes. Therefore, the present study aimed to identify drought tolerance cultivar of fenugreek.

MATERIAL AND METHODS

Thirty genotype of fenugreek were sown in a RBD with three replications in two moisture regimes, namely, (1) no water stress (E_1) and (2) water stress (E_2) for two cropping years (2018–2020) in the experimental field of the College of Horticulture and Forestry, Jhalawar during *Rabi* season (Table 1). Each genotype was sown in a double row plot of 4m length with row to row and plant to plant distance at 30 cm and 10 cm, respectively. Each year all recommended agronomic practices were adopted uniformly in order to ensure a healthy crop stand except irrigation in water stress condition (E_2). Irrigation was given at the time of seed sowing for establishing the crop in both the conditions every year. No water stress (E_1) condition was created by providing required irrigations sowing to maturity of the crop as per recommendation and water stress (E_2) condition was created by withholding irrigation at the time of pre flowering stage which commensurate with 40-45 days after sowing (DAS) and post flowering stage which commensurate with 70-80 days after sowing (DAS). Mean weekly meteorological data for the period of experiment are presented in Figure 1. Every year observation were recorded on five randomly selected plants in each genotype, each replication and each environment after eliminating border and unhealthy plants for proline content in leaves at maturity (mg/g) and seed yield per plant (g). Eighteen drought tolerance indices(DSI) were calculated based on pooled mean data of experiment for seed yield per plant under no water stress (Yp) and water stress (Ys) conditions and $\bar{Y}p$ and $\bar{Y}s$ are mean seed yield per plant (g) in Yp and Ys, respectively (for all genotypes).

1. Mean relative performance (MRP) = $(Ys / \bar{Y}s) + (Yp / \bar{Y}p)$ (Hossain et al 1999).
2. Stress susceptibility index (SSI) = $[1 - (Ys / Yp)] / [1 - (\bar{Y}s / \bar{Y}p)]$ (Clarke et al 1992).
3. Stress tolerance index (TOL) = Yp -Ys (Rosielle and Hamblin 1981).
4. Geometric mean productivity (GMP) = $\sqrt{Yp \times Ys}$ (Ramirez and Kelly 1998).

5. Harmonic mean (HM) = 2 × (Yp×Ys)/(Yp+Ys) (Dadbakhsh et al 2011).
6. Relative efficiency index (REI) = (Ys / $\bar{Y}s$) × (Yp / $\bar{Y}p$) (Hossain et al 1999).
7. Modified stress tolerance index (K1STI) = ($Y^{p2}/\bar{Y}^{p2}$) × [(Yp+Ys)/$\bar{Y}^{p2}$)] (Farshadfar and Sutka 2002).
8. Modified stress tolerance index (K2STI) = ($Ys^2/\bar{Y}s^2$) × [(Yp+Ys)/$\bar{Y}p^2$)] (Farshadfar and Sutka 2002).
9. Yield index (YI) = (Ys) / ($\bar{Y}s$) (Gavuzzi et al 1997).
10. Sensitivity drought index (SDI) = (Yp -Ys)/ Yp (Farshadfar and Javadinia 2011).
11. Relative drought index (RDI) = (Ys/Yp)/ ($\bar{Y}s$ / $\bar{Y}p$) (Fisher and Wood 1979).
12. Drought resistance index (DI) = [Ys × (Ys /Yp)] / $\bar{Y}s$ (Lan 1988).
13. Golden mean (GM) = (Yp + Ys) / (Yp - Ys) (Moradi et al 2012).
14. Abiotic tolerance index (ATI) = [(Yp–Ys)/ ($\bar{Y}p$ / $\bar{Y}s$)] × [√Yp×Ys] (Moosavi et al 2008).
15. Stress susceptibility percentage index (SSPI) = [Yp– Ys / 2($\bar{Y}p$)] ×100 (Moosavi et al 2008).
16. Stress non-stress production index (SNPI) = 3√(Yp+Ys)/(Yp–Ys) × 3√Yp×Ys×Ys (Moosavi et al 2008).
17. Relative decrease in yield (RDY) = 100 – ((Ys / 100) ×Yp) (Farshadfar and Elyasi 2012).
18. Drought tolerance efficiency (DTE) = (Ys/ Yp) ×100 (Fischer and Wood 1981).

Statistical analysis: The spearman's rank correlation coefficients were calculated among indices, seed yield and proline content under moisture regimes using SPSS 2011. Finally, to identify ideal genotype, principal component analysis (PCA) and GGE biplot were performed for proline content and seed yield using PB Tools, IRRI (Yan et al 2000).

RESULTS AND DISCUSSION

Seed yield and proline content: The pooled mean data of seed yield of genotype under E_2 revealed a greater variation than E_1. Seed yield ranged from 6.61g (Nagour local-2) to 13.33g (RMt-143) and 9.46g (GM-2) to 17.60g (RMt-143) with mean values of 8.72 and 13.87 under E_2 and E_1, respectively (Table 2).The highest ranks were assigned in ascending order for RMt-143, RMt-305, RMt-303, GM-1 and RMt-351 and lowest ranks in descending order Nagour local-2, MP local-1, Jhalawar local and Karnataka local under E_2 and RMt-143, RMt-303, Rajendra Kranti, AFG-3 and GM-1 were assigned highest ranks in ascending order and lower ranks in descending order GM-2, Jaipur local, Nagour local and Sikar local under E_1. Mean seed yield of genotypes reduced by 73.68 percent under E_2 and similar result was confirmed by Choudhary et al (2017). Proline content in E_2 and E_1 ranged from 182.47 (AGF-2) to 364.54(GM-1) and

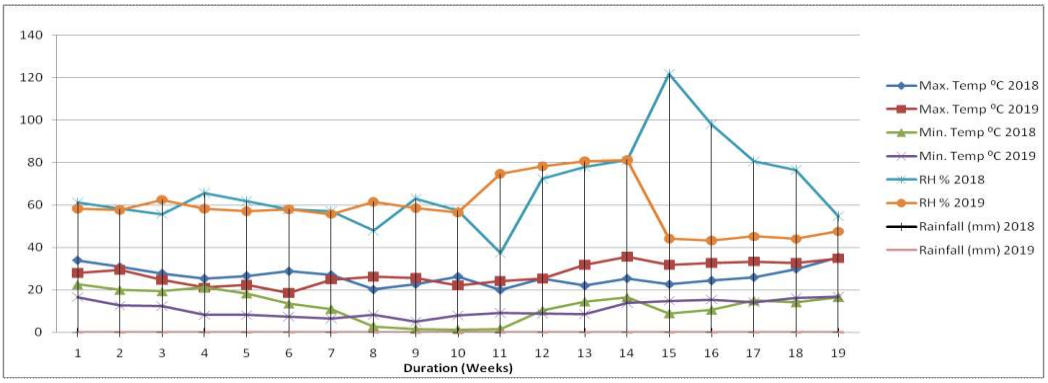

Fig. 1. Mean weekly meteorological data for the period of experiment

Table 1. Fenugreek genotype used under study

Notation	Genotype	Notation	Genotype	Notation	Genotype	Notation	Genotype	Notation	Genotype	Notation	Genotype
G1	RMt-305	G6	Karnataka local	G11	RMt-143	G16	Jhunjhunu local	G21	Hisar Sonali	G26	AFG-2
G2	GM-1	G7	Chittorgarh local	G12	Rajendra Kranti	G17	Azad Methi	G22	RMt-351	G27	Lam selection
G3	MP local-1	G8	Jhalawar local	G13	Hisar Suvarna	G18	Nagour local-1	G23	GM-2	G28	Sikar local
G4	MP local-2	G9	Nagour local-2	G14	AFG-1	G19	Hisar Mukta	G24	AFG-3	G29	AFG-4
G5	Jaipur local	G10	RMt-303	G15	Pant Ragini	G20	CO-2	G25	RMt-1	G30	Hisar Madhavi

150.94 (Lam selection) to 306.95(GM-1) (Table 2). The higher ranks were assigned for proline content in ascending order in GM-1, RMt-305, RMt-143, GM-2 and RMt-303 and lower ranks in descending order in AFG-2, Karnataka local, Lam selection and Azad methi under E_2. The highest rank were assigned in ascending order of GM-1, RMt-305, Rmt-143, GM-2 and AFG-3 and lowest ranks were assigned in descending order of Lam selection, AFG-2, Azad methi and Karnataka local under E_1, respectively. Proline content of genotypes was increase to 20.80% under water stress conditions and similar result was reported by Meena et al (2016).

Ranking of genotypes in response to drought tolerance indices: The significant differences were found in ranking of genotypes in each drought tolerance index (Table 3 and 4), indicating that the drought tolerance of genotypes is influenced by the moisture regimes. The higher ranks of MRP, GMP, HM, REI, MSTIK1, MSTIK2, YI, RDI, DI, GM,

Table 2. Pooled mean data of seed yield and proline content of the genotypes under moisture regimes

Genotype	Seed yield per plant						Proline content in leaves at maturity					
	Yp	Rank	Ys	Rank	Reduction (%)	Rank	PCMI	Rank	PCMS	Rank	Increase (%)	Rank
RMt-305	15.59	6	12.65	2	23.24	1	227.04	2	306.69	2	35.08	4
GM-1	15.62	5	12.13	4	28.81	3	306.95	1	364.54	1	18.76	17
MP local-1	13.65	16	6.7	29	103.71	29	184.31	16	209.11	21	13.46	28
MP local-2	13.4	17	7.49	23	79	24	183.29	18	209	23	14.03	27
Jaipur local	11.85	29	7.36	25	60.93	18	191.45	9	220.54	15	15.19	24
Karnataka local	14.5	11	7.21	27	101.06	28	159.28	27	183.06	29	14.93	26
Chittorgarh local	13.1	19	7.94	16	65.05	20	187.79	14	227.98	10	21.40	11
Jhalawar local	13.08	20	7.04	28	85.75	26	181.28	19	209.06	22	15.32	23
Nagour local-2	12	28	6.61	30	81.61	25	168.63	26	209.79	20	24.41	7
RMt-303	16.45	2	12.23	3	34.46	5	189.37	10	262.12	5	38.42	2
RMt-143	17.6	1	13.33	1	32	4	204.67	3	296	3	44.62	1
Rajendra Kranti	16.25	3	7.95	15	104.4	30	188.64	12	221.36	13	17.35	21
Hisar Suvarna	13.66	15	7.88	17	73.3	23	176.94	23	213.78	19	20.82	12
AFG-1	15.08	10	9.42	8	60.12	16	193.34	7	240.36	7	24.32	8
Pant Ragini	15.21	9	7.79	18	95.27	27	172.07	25	199.61	24	16.01	22
Jhunjhunu local	12.37	24	7.73	19	60	15	188.25	13	222.3	12	18.09	19
Azad Methi	12.64	22	7.43	24	70.04	22	158.36	28	188.44	27	18.99	16
Nagour local-1	12.23	25	7.22	26	69.53	21	180.65	20	196.48	26	8.76	30
Hisar Mukta	15.47	8	9.74	7	58.86	14	180.65	20	215.8	18	19.46	14
CO-2	14.45	12	9.27	9	55.88	12	183.4	17	224.5	11	22.41	10
Hisar Sonali	12.61	23	8.31	14	51.71	7	176.69	24	221.11	14	25.14	6
RMt-351	15.59	6	10.51	5	48.34	6	195.16	6	250.5	6	28.36	5
GM-2	9.46	30	7.64	21	23.9	2	203.26	4	279.8	4	37.66	3
AFG-3	15.71	4	10.08	6	55.77	11	200.36	5	238.73	8	19.15	15
RMt-1	12.83	21	8.33	13	54.15	8	179.83	22	198.24	25	10.24	29
AFG-2	12.09	26	7.73	19	56.41	13	154.81	29	182.47	30	17.87	20
Lam Selection	13.22	18	8.54	12	54.79	9	150.94	30	186.15	28	23.33	9
Sikar local	12.09	26	7.53	22	60.46	17	185.03	15	219.68	16	18.73	18
AFG-4	14.32	13	9.2	10	55.62	10	192.48	8	230.83	9	19.92	13
Hisar Madhavi	14.09	14	8.67	11	62.65	19	189.34	11	218.03	17	15.15	25
Mean	13.87		8.72		62.23		187.81		228.20		21.25	
Minimum	9.46		6.61		23.24		150.94		182.47		8.76	
Maximum	17.60		13.33		104.40		306.95		364.54		44.62	

Table 3. Drought tolerance indices of fenugreek genotype

Genotype	Drought tolerance indices																	
	MRP	SSI	TOL	GMP	HM	REI	MSTIK1	MSTIK2	YI	SDI	RDI	DI	GM	ATI	SSPI	SNPI	RDY	DTE
RMt-305	2.6	0.5	2.9	14.0	14.0	1.6	1.3	2.2	1.5	0.2	1.3	1.2	9.6	26.0	10.6	28.8	98.0	81.1
GM-1	2.5	0.6	3.5	13.8	13.7	1.6	1.2	1.9	1.4	0.2	1.2	1.1	7.9	30.2	12.6	26.3	98.1	77.6
MP local-1	1.8	1.4	7.0	9.6	9.0	0.8	0.5	0.3	0.8	0.5	0.8	0.4	2.9	41.8	25.0	12.2	99.1	49.1
MP local-2	1.8	1.2	5.9	10.0	9.6	0.8	0.5	0.4	0.9	0.4	0.9	0.5	3.5	37.2	21.3	13.8	99.0	55.9
Jaipur local	1.7	1.0	4.5	9.3	9.1	0.7	0.3	0.3	0.8	0.4	1.0	0.5	4.3	26.3	16.2	14.0	99.1	62.1
Karnataka local	1.9	1.4	7.3	10.2	9.6	0.9	0.6	0.4	0.8	0.5	0.8	0.4	3.0	46.9	26.3	13.1	99.0	49.7
Chittorgarh local	1.9	1.1	5.2	10.2	9.9	0.9	0.5	0.4	0.9	0.4	1.0	0.6	4.1	33.1	18.6	15.0	99.0	60.6
Jhalawar local	1.8	1.2	6.0	9.6	9.2	0.8	0.4	0.3	0.8	0.5	0.9	0.4	3.3	36.4	21.8	12.9	99.1	53.8
Nagour local-2	1.6	1.2	5.4	8.9	8.5	0.7	0.3	0.2	0.8	0.4	0.9	0.4	3.5	30.2	19.4	12.2	99.2	55.1
RMt-303	2.6	0.7	4.2	14.2	14.0	1.7	1.5	2.1	1.4	0.3	1.2	1.0	6.8	37.6	15.2	25.6	98.0	74.4
RMt-143	2.8	0.7	4.3	15.3	15.2	1.9	2.0	2.8	1.5	0.2	1.2	1.2	7.3	41.1	15.4	28.3	97.7	75.8
Rajendra Kranti	2.1	1.4	8.3	11.4	10.7	1.1	0.9	0.6	0.9	0.5	0.8	0.4	2.9	59.3	29.9	14.4	98.7	48.9
Hisar Suvarna	1.9	1.1	5.8	10.4	10.0	0.9	0.5	0.5	0.9	0.4	0.9	0.5	3.7	37.7	20.8	14.7	98.9	57.7
AFG-1	2.2	1.0	5.7	11.9	11.6	1.2	0.9	0.9	1.1	0.4	1.0	0.7	4.3	42.4	20.4	18.0	98.6	62.5
Pant Ragini	2.0	1.3	7.4	10.9	10.3	1.0	0.7	0.5	0.9	0.5	0.8	0.5	3.1	50.8	26.7	14.2	98.8	51.2
Jhunjhunu local	1.8	1.0	4.6	9.8	9.5	0.8	0.4	0.4	0.9	0.4	1.0	0.6	4.3	28.5	16.7	14.7	99.0	62.5
Azad Methi	1.8	1.1	5.2	9.7	9.4	0.8	0.4	0.4	0.9	0.4	0.9	0.5	3.9	31.7	18.8	13.9	99.1	58.8
Nagour local-1	1.7	1.1	5.0	9.4	9.1	0.7	0.4	0.3	0.8	0.4	0.9	0.5	3.9	29.6	18.1	13.5	99.1	59.0
Hisar Mukta	2.2	1.0	5.7	12.3	11.9	1.2	1.0	1.0	1.1	0.4	1.0	0.7	4.4	44.2	20.7	18.6	98.5	62.9
CO-2	2.1	1.0	5.2	11.6	11.3	1.1	0.8	0.8	1.1	0.4	1.0	0.7	4.6	37.7	18.7	17.8	98.7	64.2
Hisar Sonali	1.9	0.9	4.3	10.2	10.0	0.9	0.4	0.5	1.0	0.3	1.0	0.6	4.9	27.7	15.5	16.2	99.0	65.9
RMt-351	2.3	0.9	5.1	12.8	12.6	1.4	1.1	1.2	1.2	0.3	1.1	0.8	5.1	40.9	18.3	20.7	98.4	67.4
GM-2	1.6	0.5	1.8	8.5	8.5	0.6	0.2	0.3	0.9	0.2	1.3	0.7	9.4	9.8	6.6	17.3	99.3	80.7
AFG-3	2.3	1.0	5.6	12.6	12.3	1.3	1.1	1.1	1.2	0.4	1.0	0.7	4.6	44.5	20.3	19.4	98.4	64.2
RMt-1	1.9	0.9	4.5	10.3	10.1	0.9	0.5	0.5	1.0	0.4	1.0	0.6	4.7	29.3	16.2	16.1	98.9	64.9
AFG-2	1.8	1.0	4.4	9.7	9.4	0.8	0.4	0.4	0.9	0.4	1.0	0.6	4.5	26.5	15.7	14.9	99.1	63.9
Lam selection	1.9	1.0	4.7	10.6	10.4	0.9	0.5	0.6	1.0	0.4	1.0	0.6	4.7	31.2	16.9	16.5	98.9	64.6
Sikar local	1.7	1.0	4.6	9.5	9.3	0.8	0.4	0.4	0.9	0.4	1.0	0.5	4.3	27.3	16.4	14.3	99.1	62.3
AFG-4	2.1	1.0	5.1	11.5	11.2	1.1	0.7	0.8	1.1	0.4	1.0	0.7	4.6	36.9	18.4	17.7	98.7	64.3
Hisar Madhavi	2.0	1.0	5.4	11.1	10.7	1.0	0.7	0.6	1.0	0.4	1.0	0.6	4.2	37.7	19.6	16.4	98.8	61.5

DTE and SNPI in descending order of RMt-143, RMt-303, RMt-305, GM-1 and RMt-351 and lowest ranks observed in Nagour local-2, MP local-1, Jhalawar local and Karnataka local. According to SSI and TOL index, the greater value of SSI and TOL, means the higher yield reduction under E_2. The lowest rank of SSI, TOL, SDI, ATI, SSPI and RDY in RMt-305, GM-2, GM-1, RMt-143 and RMt-303 and highest ranks observed in Rajendra Kranti, MP local-1, Karnataka local and Pant Ragni. The genotypes RMt-305, GM-1, RMt-143, RMt-303 and RMt-351 determined lower and genotypes Nagour local-2, MP local-1, Jhalawar local, Karnataka local and Nagour local-1 were observed higher total ranks (Table 4). The results showed a great deal of inconsistency in ranking of genotypes as tolerant based on each one of the indices. The similar findings were reported by Pour-Siahbidi and Pour-Aboughadareh (2014) in chickpea, Sahar et al (2016) in bread wheat and Choudhary et al (2017) in fenugreek.

Drought tolerance indices: Spearman's rank correlation

Table 4. Rank of drought tolerance indices of fenugreek genotype

Genotype	Drought tolerance indices																		
	MRP	SSI	TOL	GMP	HM	REI	MSTIK1	MSTIK2	YI	SDI	RDI	DI	GM	ATI	SSPI	SNPI	RDY	DTE	Total
RMt-305	3	1	2	3	3	3	3	2	2	1	1	1	1	2	2	1	3	1	35
GM-1	4	3	3	4	4	4	4	4	4	3	3	3	3	11	3	3	4	3	70
MP local-1	24	29	27	25	28	25	20	29	29	29	29	30	29	24	27	30	25	29	488
MP local-2	20	24	25	20	20	20	17	20	23	24	24	24	24	17	25	25	20	24	396
Jaipur local	28	18	8	28	26	28	28	25	25	18	18	20	18	3	8	23	28	18	368
Karnataka local	17	28	28	18	19	18	14	22	27	28	28	29	28	28	28	27	18	28	433
Chittorgarh local	19	20	16	19	18	19	18	18	16	20	20	18	20	14	16	16	19	20	326
Jhalawar local	25	26	26	24	25	24	22	27	28	26	26	27	26	15	26	28	24	26	451
Nagour local-2	29	25	19	29	29	29	29	30	30	25	25	28	25	10	19	29	29	25	464
RMt-303	2	5	4	2	2	2	2	3	3	5	5	4	5	18	4	4	2	5	77
RMt-143	1	4	5	1	1	1	1	1	1	4	4	2	4	23	5	2	1	4	65
Rajendra Kranti	11	30	30	11	12	11	8	13	15	30	30	26	30	30	30	20	11	30	378
Hisar Suvarna	15	23	24	15	17	15	15	17	17	23	23	21	23	20	24	19	15	23	349
AFG-1	8	16	22	8	8	8	9	8	8	16	16	11	16	25	22	8	8	16	233
Pant Ragini	13	27	29	13	14	13	11	16	18	27	27	25	27	29	29	22	13	27	380
Jhunjhunu local	21	15	11	21	21	21	24	19	19	15	15	17	15	7	11	18	21	15	306
Azad Methi	22	22	18	22	23	22	23	23	24	22	22	22	22	13	18	24	22	22	386
Nagour local-1	27	21	13	27	27	27	27	26	26	21	21	23	21	9	13	26	27	21	403
Hisar Mukta	7	14	23	7	7	7	7	7	7	14	14	8	14	26	23	7	7	14	213
CO-2	9	12	17	9	9	9	10	9	9	12	12	9	12	19	17	9	9	12	204
Hisar Sonali	18	7	6	17	16	17	21	15	14	7	7	13	7	6	6	14	17	7	215
RMt-351	5	6	14	5	5	5	5	5	5	6	6	5	6	22	14	5	5	6	130
GM-2	30	2	1	30	30	30	30	28	21	2	2	7	2	1	1	11	30	2	260
AFG-3	6	11	21	6	6	6	6	6	6	11	11	6	11	27	21	6	6	11	184
RMt-1	16	8	9	16	15	16	19	14	13	8	8	14	8	8	9	15	16	8	220
AFG-2	23	13	7	23	22	23	25	21	20	13	13	16	13	4	7	17	23	13	296
Lam Selection	14	9	12	14	13	14	16	12	12	9	9	12	9	12	12	12	14	9	214
Sikar local	26	17	10	26	24	26	26	24	22	17	17	19	17	5	10	21	26	17	350
AFG-4	10	10	15	10	10	10	12	10	10	10	10	10	10	16	15	10	10	10	198
Hisar Madhavi	12	19	20	12	11	12	13	11	11	19	19	15	19	21	20	13	12	19	278

coefficients among the drought tolerance indices, proline content and seed yield were calculated (Table 5). The relationship between seed yield under moisture regimes was significant positively, indicating that relationship between genotype seed yield is moisture regimes and year effect. Yp was positive and significant with Ys, GMP, REI, RDY, HM, MSTIK1, MSTIK2, YI and SNPI indicating that selecting genotypes for these indices will not always improve seed yield under E_2. Ys indicated positive significant correlation with the indices MRP, SSI, SDI, RDI, GM, DTE, GMP, REI, RDY, HM, MSTIK1 MSTIK2, YI, DI and SNPI indicating that selecting genotypes for these indices will improve the seed yield under E_2water stress condition. These results can be supported by other works (Farshadfar and Sutka, 2002 and Mohammadi et al 2011). The indices MRP, GMP, HM, REI, MSTIK1, MSTIK2, YI, SNPI and RDY had a significantly positive correlation with seed yield under E_1 and E_2, indicating that these indices are able to discriminate group a genotype (genotypes with high yield in E_1 and E_2). Proline content was found positive and significant with SSI, SDI, RDI, GM and

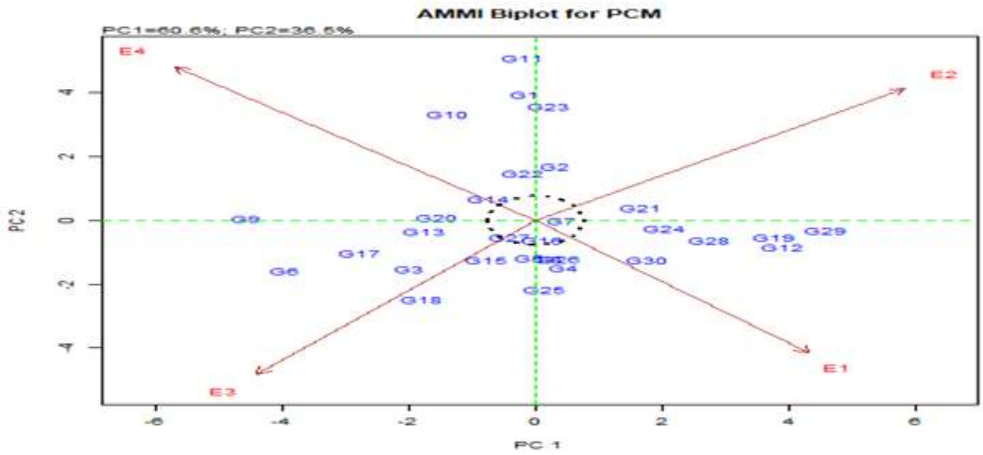

Fig. 2. GGE Biplotwith the first two principal axes of the interaction (PC1 and PC2) for proline content

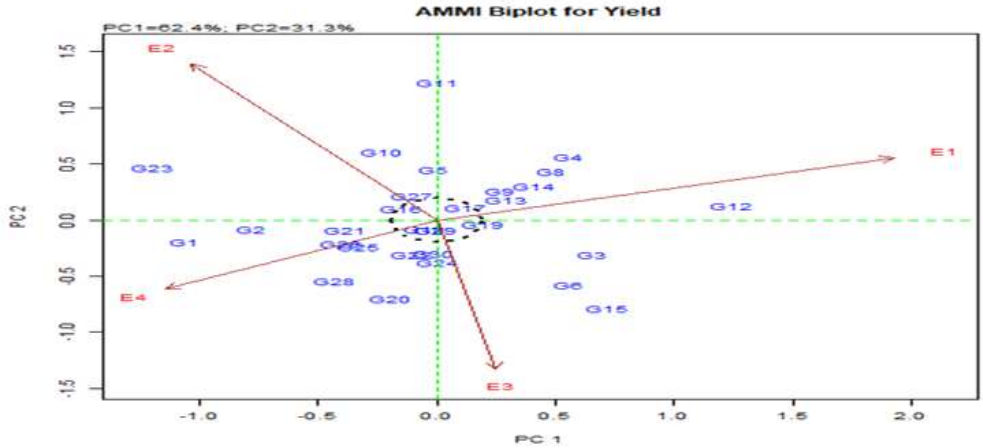

Fig. 3. GGE Biplotwith the first two principal axes of the interaction(PC1 and PC2) for the seed yield

Table 5. Spearman's rank correlation coefficient among seed yield, proline content and drought tolerance indices

Characters	Drought tolerance indices																					
	Yp	Ys	PCMI	PCMS	MRP	SSI	TOL	GMP	HM	REI	MSTIK1	MSTIK2	YI	SDI	RDI	DI	GM	ATI	SSPI	SNPI	RDY	DTE
Yp	-	.734**	.436*	.459*	.922**	.187	-.191	.914**	.875**	.914**	.976**	.823**	.734**	.187	.187	.440*	.187	-.711	-.191	.590**	.914**	.187
Ys		-	.567**	.677**	.921**	.727**	.371*	.927**	.951**	.927**	.844**	.977**	1000*	.727**	.727**	.890**	.727**	-.209	.371*	.960**	.927**	.727**
PCMI			-	.906**	.461*	.509**	.367*	.461*	.473**	.461*	.469**	.500**	.567**	.509**	.509**	.624**	.509**	-.010	.367*	.627**	.461*	.509**
PCMS				-	.544**	.622**	.454*	.551**	.564**	.551**	.520**	.593**	.677**	.622**	.622**	.728**	.622**	.022	.454*	.742**	.551**	.622**

DTE indicating that selecting genotypes for these indices will improve the seed yield under E_2. Repeatable relationships were observed between seed yield with MRP, GMP, HM, REI, MSTIK1, MSTIK2, YI, SNPI and RDY suggesting that one of them can be used as alternative to others for the evaluation of drought tolerant genotypes. These results are in agreement with the previous studied by Sahar et al (2016) and Choudhary et al (2017).

Ideal genotypes: The analysis revealed that the first two PCA of proline content in leave at maturity and seed yield per plant explained 97.10 and 93.70% of the total variation. An ideal genotype should have invariably high average proline content and seed yield in the entire environment. This ideal genotype is graphically defined by the longest vector in PC1 and without projections in PC2 (Costa De Mattos et al 2013). G1(RMt-305), G2(GM-1), G10(RMt-303), G11(RMt-143), G22(RMt-351) and G23(GM-2) genotypes were located between E_2 and E_4 concentric circles away from centre (Figure 2 and 3). These genotypes are closest to the ideal and can be considered desirable in terms of yield and stability of the seed yield. The similar findings were reported by Pour-Siahbidi and Pour- Aboughadareh (2014) in chickpea and Meena et al (2016) in fenugreek..

CONCLUSION

The seed yields were influenced by the year effect under moisture regimes and differences in ranking of genotypes based on each drought tolerant index. MRP, GMP, HM, REI, MSTIK1, MSTIK2, YI, SNPI and RDY indices highly correlated with seed yield in moisture regimes are introduced as the best indices. Consequently, genotypes RMt-305, GM-1, RMt-303, RMt-143, RMt-351 and GM-2 were more droughts tolerant and can be used as parents for developing the drought tolerance varieties in fenugreek.

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