RESEARCH ARTICLE

SABRAO Journal
of Breeding and Genetics
47 (4) 413-423, 2015

TRAIT VARIATION IN FENUGREEK

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SUMMARY

Trigonella foenum-graecum is an annual flowering species largely cultivated in the Mediterranean basin countries, Central Asia and especially in India. The grain is rarely grown outside its native habitat. A study on trait variation was undertaken on 102 diverse genotypes of fenugreek along with 3 superior varieties as check at the of Department of Horticulture, JNKVV Jabalpur, Madhya Pradesh during the *Rabi* seasons of 2009-2010 and 2011-2012. The results obtained in this investigation revealed presence of considerable amount of genetic variability and mean values for all the characters showed wide range of variability for all the traits studied. Genotype UM-117 recorded the maximum primary branches (8) as well as secondary branches (6) plant^{-1}. Number of seeds per pod^{-1} in different fenugreek germplasm lines ranged between 7.3 and 22.2 with its average being 15.3 seeds. The maximum (22.2) seeds pod^{-1} was observed in genotype HM-279 while, the maximum seed yield plot^{-1} was recorded in genotype UM-116 (439.5 g). With regard to the vegetative yield plant^{-1}, genotypes UM-122 and ACC-006 recorded the maximum (2.44 kg) value.

Key words: Fenugreek, variability, seed yield, vegetative yield

Key findings: Number of pods axis^{-1} varied from 0.00 to 4.00 with an average of 0.58. The maximum (4.0) pods axis^{-1} exhibited in the genotype UM-138.

Manuscript received: March 25, 2015; Decision on manuscript: July 29, 2015; Manuscript accepted: September 15, 2015.

Communicating Editor: Bertrand Collard

INTRODUCTION

Fenugreek (*Trigonella foenum-graecum* L.) is an annual diploid species, popularly known by its vernacular name "methi", belonging to the sub-family "Papilionaceae" of the family "Fabaceae". It is native to the countries bordering the Eastern shores of Mediterranean region, extending to Central Asia. It is widely cultivated in India, Iran, Nepal, Bangladesh, Pakistan, North Africa, East Africa, Ukraine, South East Asia, Russia, Greece, Argentina, Egypt, France, Spain, Turkey, Morocco and China. It is a self-pollinated crop with chromosome number 2n = 16 (Frayer, 1930). It is an important condiment crop grown for both seeds as well as leafy purpose, largely in North India during *Rabi* season. India is the only country producing majority of the world's total fenugreek (Petropoulos, 2002). Fenugreek is an old medicinal plant and has been commonly used as a traditional spice and medicine.

Table 1. Analysis of variance (mean squares) for different characters in fenugreek.

Source of variance	D.F.	Plant height (cm) 30 DAS	Plant height (cm) 45 DAS	Plant height (cm) 60 DAS	Plant height (cm) At maturity	Chlorophyll content 30 DAS	Chlorophyll content 45 DAS	Chlorophyll content 60 DAS	Leaf size (cm)	Diameter of stem (mm)	Petiole length (cm)
Replica-tions	2	51.509	116.562	95.730	77.562	8.036	2.401	10.806	1.266	0.170	0.135
Geno-types	101	9.207 **	39.771 **	153.990**	273.780**	45.403**	189.330**	215.775**	0.315**	0.578**	0.0784**
Error	202	0.610	1.461	0.259	0.405	6.395	1.457	0.591	0.035	0.008	0.025

Source of variance	D.F.	Nodulation at 60 DAS	No. of primary branches	No. of secondary branches	No of pod/axis	No of pod/plant	Pod length (cm)	No of seeds/ pod	1000 seed weight
Replications	2	2.635	26.694	6.954	13.739	53.069	3.280	51.346	0.362
Genotypes	101	53.396**	6.928**	2.383**	1.461**	163.598**	4.082**	25.771**	0.679**
Error	202	11.988	0.808	0.464	0.392	27.281	0.686	3.769	0.043

Source of variance	D.F.	Flowering time	Days to 75% maturity	Seed yield /plant (g)	Seed size (mm)	Vegetative yield (kg)	Seed yield/plot (g)
Replications	2	63.820	8.147	2.932	0.019	0.017	19.231
Genotypes	101	15.887**	18.995**	4.609**	0.935**	0.242**	19410.617**
Error	202	0.627	0.591	0.022	0.023	0.009	24.347

** Significant at 1% level

It is known to have hypoglycemic and hypocholesterolaemic effects. The several phytochemicals found in fenugreek viz. steroids, alkaloids and flavonoids form the basis of its widespread medical use and the crop is bloat-free (Acharya *et al.*, 2008). The leaves and seeds of fenugreek are consumed in different countries around the world for different purposes such as medicinal uses (anti-diabetic, lowering blood sugar and cholesterol level, anti-cancerous, anti-microbial etc.), making food (stew with rice in Iran, flavor cheese in Switzerland, syrup and bitter run in Germany, mixed seed powder with flour for making flat bread in Egypt, curries, dyes, young seedlings eaten as vegetables etc.), roasted grain as coffee-substitute (in Africa), controlling insects in grain storages, perfume industries etc. It is also utilized as a source for preparing raw materials of pharmaceutical industry, especially steroidal hormones.

The knowledge of genetic variation is important for selection in crop improvement program. McCormick *et al.* (2009) found significant variation for flowering time and duration, growth habit and seed yield. Yield is a complex character governed by several other yield attributing characters. Since, most of the yield attributing characters are quantitatively inherited and highly affected by environment, it is difficult to judge whether the observed variability is heritable or not. The genetic gain expected from selection depends on the amount of variability available in the quantitative traits in the germplasms of a crop. A successful selection program depends upon the information on genetic variability and association of yield components with seed yield. Information on variability in a population owing to genetic and non-genetic causes is a prerequisite for initiating a crop improvement program.

Table 2. Mean performance of different yield and its attributing traits in fenugreek (pooled).

No.	Genotype	Plant height				Chlorophyll content			Leaf size (cm)	Dia. of stem (mm)	Petiole length (cm)	Nodulation at 60 DAS	No of pri. branches/ plant	No of sec. branches/ plant	No of pods/ axis
		30 DAS	45 DAS	60 DAS	At maturity	30 DAS	45 DAS	60 DAS							
1	UM-117	12.1	26.2	48.0	72.6	22.0	30.9	41.8	3.3	2.8	1.3	19.8	8.5	6.7	0.0
2	UM-122	10.0	27.5	48.7	71.6	35.7	39.7	44.0	3.2	3.6	1.1	17.3	4.7	2.0	0.7
3	UM-131	10.3	22.5	52.6	81.2	26.3	36.2	37.9	3.2	3.8	1.5	19.3	3.7	0.2	0.3
4	UM-143	11.4	27.8	54.4	81.9	31.1	48.7	43.2	3.2	3.2	1.8	27.7	5.0	0.5	1.3
5	UM-118	10.5	19.6	45.3	69.8	19.7	43.7	42.0	3.5	3.3	1.2	20.0	2.7	0.2	0.0
6	UM-114	13.2	18.1	58.9	87.7	33.2	43.8	22.0	3.9	3.3	1.4	23.2	3.7	0.0	0.0
7	UM-116	9.6	19.4	71.8	102.9	19.9	38.6	34.8	3.4	4.1	1.1	13.0	3.8	0.0	1.7
8	UM-121	14.4	29.3	55.4	86.1	26.2	32.7	50.8	3.2	4.5	0.9	21.3	3.2	0.7	2.0
9	UM-123	13.4	23.6	62.5	93.1	24.6	38.9	37.1	3.4	4.3	1.4	15.2	3.7	0.2	0.3
10	UM-120	13.2	25.0	55.3	85.6	27.0	26.7	32.2	2.9	5.5	1.1	14.7	3.7	0.0	0.0
11	UM-128	9.6	22.8	72.7	103.2	24.8	50.9	46.5	3.4	4.2	1.2	15.2	6.2	0.0	0.0
12	UM-133	10.3	27.8	55.0	82.8	19.3	29.6	35.9	2.9	4.3	1.0	13.5	6.0	2.3	0.3
13	UM-132	12.3	22.2	57.1	83.8	25.2	36.1	39.1	3.6	3.2	1.0	12.3	4.2	1.0	0.3
14	UM-125	13.2	29.1	58.1	86.3	18.2	36.5	38.9	3.7	4.2	0.9	19.8	6.8	0.3	0.0
15	UM-130	13.6	27.9	66.6	95.8	25.1	33.1	33.4	3.3	4.3	1.0	19.0	5.3	0.2	1.0
16	UM-138	13.6	19.2	52.3	80.7	25.0	44.6	52.3	3.1	3.5	1.1	17.7	6.7	0.0	4.0
17	UM-129	10.4	23.5	44.5	68.9	30.1	43.2	39.5	3.5	3.6	1.3	22.5	5.2	1.0	1.7
18	UM-135	11.5	21.7	48.9	71.7	18.6	37.9	34.5	3.1	3.1	1.2	13.3	4.0	0.2	2.3
19	UM-113	11.2	24.3	54.8	84.5	24.2	40.7	36.4	3.2	3.4	1.2	19.3	7.5	1.3	0.0
20	RMT-361	13.1	19.4	54.5	82.3	18.6	53.5	34.4	3.3	3.5	1.1	17.7	3.8	0.5	0.3
21	UM-144	9.2	17.6	62.3	91.5	26.0	36.6	26.2	3.6	4.1	1.2	18.0	5.2	0.2	0.0
22	HM-267	12.5	21.5	48.7	74.7	16.7	34.7	28.1	3.0	4.3	1.0	13.0	3.0	0.2	0.0
23	HM-281	10.5	24.4	50.0	75.5	27.2	23.1	44.8	3.6	4.4	0.8	16.8	1.5	0.2	0.0
24	HM-279	11.4	26.8	51.6	80.0	25.0	43.8	35.5	3.2	3.5	1.0	15.7	6.7	2.5	0.7
25	HM-282	8.4	19.8	52.0	79.8	22.7	49.5	32.1	3.3	3.2	1.2	21.7	3.7	0.3	0.3
26	HM-278	12.5	26.6	51.6	80.6	24.1	30.9	43.8	2.5	3.3	1.0	16.2	3.2	0.3	1.3
27	HM-271	8.8	20.3	48.1	75.5	20.2	32.9	35.6	2.8	3.3	1.1	16.5	1.7	0.0	0.0
28	HM-258-1	9.6	22.6	47.9	74.0	20.7	25.0	28.7	3.0	3.3	1.0	17.0	4.7	0.2	0.3
29	HM-280	10.4	18.0	49.0	74.5	22.9	20.5	35.2	2.8	3.5	1.0	9.8	2.8	0.2	0.7
30	HM-258	9.8	18.1	47.8	70.4	25.8	47.3	55.7	2.8	4.5	1.2	16.0	3.8	0.2	0.0
31	HM-280-1	9.7	15.3	48.1	70.9	21.6	24.2	31.5	3.2	4.4	1.1	13.0	1.8	0.0	0.3
32	HM-259	8.7	25.5	54.2	82.3	24.5	23.1	31.7	2.5	3.8	1.2	15.8	2.8	0.7	0.3
33	HM-277	7.7	17.4	48.6	73.3	19.0	46.6	29.3	3.4	3.7	1.1	12.0	3.5	0.5	0.0
34	HM-277-1	18.0	17.6	43.6	70.1	23.1	42.7	36.7	3.2	3.3	1.2	21.2	2.0	0.3	0.3
35	HM-273	10.4	26.9	58.6	89.5	22.2	20.0	51.7	2.9	3.4	1.2	10.0	2.3	0.5	0.0
36	HM-260	11.6	28.0	50.6	78.0	24.2	49.6	37.8	3.4	4.3	1.1	14.7	2.0	0.3	0.3
37	NDM-8	12.2	24.0	50.0	76.7	19.6	50.6	31.5	3.4	3.2	1.3	14.3	3.7	0.2	0.0

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No.	Genotype	Plant height				Chlorophyll content			Leaf size (cm)	Dia. of stem (mm)	Petiole length (cm)	Nodulation at 60 DAS	No of pri. branches/ plant	No of sec. branches/ plant	No of pods/ axis
		30 DAS	45 DAS	60 DAS	At maturity	30 DAS	45 DAS	60 DAS							
38	NDM-7	14.4	25.4	51.2	80.3	21.7	48.5	44.5	3.4	3.6	1.1	18.3	3.0	0.3	0.0
39	NDM-6	11.7	24.9	58.3	85.6	18.5	29.3	35.3	3.5	3.8	1.4	20.3	3.5	0.0	0.0
40	NDM-5	12.2	20.9	54.2	83.4	25.9	31.4	43.5	3.5	4.2	0.9	24.8	7.5	0.2	0.0
41	NDM-4	14.6	19.5	52.1	80.6	24.4	38.5	42.5	3.5	4.5	1.5	12.2	2.8	0.2	0.0
42	NDM-10	9.6	20.9	55.7	84.4	21.6	18.4	42.9	2.8	3.8	1.1	12.8	4.7	0.3	1.3
43	NDM-3	9.9	21.7	58.7	89.7	18.9	34.6	44.3	3.0	3.4	1.4	16.2	4.7	0.2	0.0
44	NDM-2	13.5	22.0	77.7	109.0	24.0	36.6	37.7	3.0	4.1	1.0	16.8	5.7	1.7	0.0
45	NDM-1	10.6	23.9	50.2	78.7	28.1	42.6	36.8	3.5	4.2	1.1	20.2	2.2	0.2	0.0
46	NDM-25	13.0	22.0	60.7	91.2	16.5	23.7	44.9	3.4	3.5	0.9	22.3	3.5	0.3	2.3
47	NDM-18	9.7	29.3	57.9	88.8	20.9	44.5	30.4	3.5	3.6	1.0	18.3	2.8	0.2	0.0
48	NDM-19	11.5	23.1	48.5	72.6	34.5	35.5	41.5	3.4	3.8	1.1	21.7	4.0	0.3	0.7
49	NDM-20	11.5	19.6	53.3	82.1	24.6	34.0	45.2	3.4	4.3	1.3	18.0	8.0	0.0	0.0
50	NDM-26	10.3	17.8	41.6	68.4	29.2	45.1	20.8	3.4	4.0	1.2	13.5	4.7	1.0	0.3
51	NDM-15	10.4	16.8	50.7	77.5	23.6	54.8	26.4	3.0	3.5	1.0	22.8	8.0	0.8	2.7
52	NDM-14	10.7	23.1	63.0	92.2	21.0	38.7	31.8	2.5	4.3	1.3	12.3	2.7	0.3	0.3
53	NDM-13	11.6	19.8	46.6	70.8	20.1	35.5	36.7	2.3	4.0	1.3	19.5	3.8	1.5	0.0
54	NDM-21	7.6	17.0	47.5	76.0	21.4	40.8	36.7	2.7	3.1	1.1	16.7	4.0	0.8	0.0
55	NDM-11	9.6	21.3	50.5	79.2	25.4	41.8	28.0	2.8	3.5	1.4	10.7	6.7	0.5	0.7
56	NDM-12	11.5	19.3	63.9	96.4	16.4	35.7	57.8	3.1	3.1	1.4	10.5	4.5	0.5	0.0
57	NDM-33	10.2	22.3	77.3	108.6	17.9	36.3	32.9	3.0	3.5	1.4	13.7	4.2	1.3	2.0
58	NDM-24	12.8	21.1	53.3	81.5	22.7	31.7	19.2	3.3	4.1	1.2	13.2	4.0	1.0	1.3
59	NDM-23	12.6	21.6	51.9	81.0	25.0	41.9	60.0	3.8	3.8	1.0	15.8	4.7	1.7	1.0
60	NDM-22	9.6	23.3	62.0	91.6	25.3	31.8	34.9	3.1	4.1	1.0	20.0	3.2	1.7	0.3
61	NDM-27	11.3	24.5	64.2	95.1	23.3	41.1	33.1	3.2	3.4	1.1	20.8	2.7	3.5	2.0
62	NDM-32	12.5	21.4	64.2	96.1	26.9	42.1	52.1	3.2	3.5	1.3	15.2	4.2	2.3	0.0
63	NDM-31	12.7	24.1	61.1	91.3	21.1	44.6	42.1	3.3	4.2	1.2	17.3	2.8	1.3	0.0
64	NDM-28	13.4	22.4	59.6	90.3	14.4	33.5	42.9	3.7	4.1	1.2	23.2	3.5	0.3	0.0
65	NDM-30	11.8	28.7	57.2	86.4	21.0	36.3	54.4	3.7	3.7	1.1	8.2	3.5	0.7	2.0
66	NDM-29	11.4	25.5	63.3	93.3	24.8	32.3	51.8	3.8	4.0	1.4	17.8	2.8	0.0	0.7
67	RM-33	12.1	27.0	38.7	60.6	28.9	37.7	19.1	2.8	4.1	1.4	22.5	3.8	1.0	1.3
68	RM-27	10.4	20.7	47.7	75.6	25.4	39.6	26.3	2.5	3.8	1.3	15.5	1.7	0.5	0.3
69	RM-195	12.4	26.3	54.3	82.8	28.2	35.8	36.0	3.2	3.6	1.2	10.8	2.8	0.7	0.0
70	RM-187	11.5	22.4	56.3	83.4	27.7	27.1	11.4	2.9	4.1	1.4	11.7	3.7	0.7	0.0
71	RM-185	13.1	23.4	56.4	84.7	23.7	37.4	34.9	3.1	4.3	1.3	14.8	4.8	0.5	0.7
72	RM-16	11.1	26.2	58.3	88.6	26.7	38.4	23.7	3.2	3.5	1.2	17.7	5.0	0.2	2.0
73	RM-190	9.4	20.7	51.7	80.5	19.9	22.9	27.0	3.2	4.2	1.0	10.3	4.2	0.8	0.3
74	RM-14	7.7	18.7	53.2	81.5	27.7	29.9	34.9	2.7	3.9	1.2	16.0	3.2	0.3	1.0

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No.	Genotype	Plant height				Chlorophyll content			Leaf size (cm)	Dia. of stem (mm)	Petiole length (cm)	Nodulation at 60 DAS	No of pri. branches/ plant	No of sec. branches/ plant	No of pods/ axis
		30 DAS	45 DAS	60 DAS	At maturity	30 DAS	45 DAS	60 DAS							
75	RM-15	8.5	25.2	55.0	84.2	25.7	43.1	31.6	2.7	3.8	1.2	11.0	2.8	0.2	0.3
76	RM-18	10.3	15.1	47.5	72.3	25.1	28.8	51.2	3.5	4.0	1.2	10.2	2.7	0.3	0.3
77	RM-13	10.8	19.4	45.6	73.0	26.0	50.0	28.4	2.8	3.6	1.0	14.3	3.2	1.0	0.3
78	RM-186	13.6	17.1	36.8	59.4	23.4	33.8	48.1	3.0	3.7	1.3	13.5	4.7	1.7	0.3
79	RM-199	10.4	24.3	50.8	80.5	17.5	29.9	43.1	3.0	4.5	0.9	11.0	2.8	0.8	0.7
80	RM-189	12.1	18.9	47.6	71.4	21.0	30.5	34.4	2.6	3.5	1.0	24.7	2.3	0.0	0.3
81	RM-70	13.1	17.8	45.6	65.1	22.0	33.4	31.0	3.1	3.5	1.3	12.3	5.5	2.0	0.3
82	RM-28	11.9	17.6	46.8	70.5	24.7	31.3	31.6	3.0	3.6	1.1	15.5	3.5	1.2	0.3
83	RM-424	11.6	21.1	64.6	96.7	20.2	26.2	34.3	3.2	3.8	1.0	9.7	2.7	0.7	0.7
84	RM-198	14.0	20.9	63.4	95.1	19.4	30.0	41.8	3.1	3.6	0.9	12.5	4.8	1.7	0.3
85	RM-10	12.7	17.9	52.5	82.4	22.8	34.3	42.4	3.0	4.1	0.9	12.3	2.5	0.7	0.3
86	ACC-002	9.3	18.5	50.1	77.6	23.5	30.7	54.5	2.8	4.0	1.1	16.5	2.7	0.5	1.0
87	ACC-001	9.2	20.8	60.1	91.8	25.1	44.7	32.7	3.0	3.8	0.9	9.5	1.8	1.0	0.3
88	ACC-003	11.4	24.3	50.6	79.2	12.4	28.8	30.9	2.6	4.1	1.0	17.2	3.2	1.0	1.3
89	ACC-017	13.1	18.3	60.8	93.2	21.4	35.0	36.0	2.8	4.2	1.1	15.5	2.2	0.3	0.3
90	ACC-010	11.6	16.8	66.9	99.3	22.0	30.5	37.4	3.1	4.8	1.2	18.8	2.5	0.2	0.3
91	ACC-009	11.1	28.5	51.7	82.2	24.9	33.9	40.3	3.2	3.1	1.1	15.0	2.5	0.3	0.3
92	ACC-006	11.8	23.7	61.7	94.5	25.6	43.6	37.4	3.1	4.1	1.1	18.3	6.3	3.7	0.3
93	ACC-004	13.2	24.8	57.5	86.1	24.1	41.6	37.0	3.3	3.5	1.0	15.5	3.2	0.7	0.3
94	ACC-012	12.8	26.3	51.7	82.0	27.3	36.2	37.7	3.2	3.6	1.0	17.3	2.8	0.7	0.3
95	ACC-007	15.2	28.1	52.5	83.8	24.0	37.1	31.3	3.0	3.6	1.0	18.0	2.7	0.3	0.3
96	ACC-013	14.5	25.5	55.8	85.1	22.5	51.6	46.3	2.8	3.9	1.1	20.7	2.5	0.7	0.3
97	ACC-021	10.3	23.5	51.2	79.1	20.7	56.6	39.2	2.8	3.4	0.9	11.2	2.2	0.0	0.7
98	ACC-020	11.2	24.6	51.8	79.9	21.7	35.5	40.5	3.0	3.5	1.3	12.7	2.8	0.5	0.3
99	ACC-019	11.6	24.1	59.6	90.2	28.3	44.0	52.1	2.7	3.7	1.1	12.5	3.3	1.0	1.7
100	RMT-1 (C)	10.4	25.5	49.0	74.9	24.5	30.2	34.0	3.6	4.1	1.3	24.3	4.8	0.7	0.7
101	GM-2 (C)	10.3	29.2	58.4	86.6	27.8	35.1	34.2	3.4	3.5	1.1	20.8	5.7	0.2	1.0
102	PEB (C)	9.3	20.6	48.6	71.4	28.4	36.9	41.9	3.2	4.2	1.1	16.0	5.7	0.7	0.7
Mean		11.3	22.7	54.1	82.2	23.7	36.4	37.4	3.2	3.8	1.2	16.7	4.0	0.7	0.6
S.E.		0.5	0.7	0.3	0.4	1.5	0.7	0.4	0.1	0.1	0.1	2.0	0.5	0.4	0.4
C.D. 5%		1.3	1.9	0.8	1.0	4.1	1.9	1.2	0.3	0.2	0.3	5.6	1.4	1.1	1.0

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No.	Genotypes	No of pods/plant	Pod length (cm)	No of seeds/pod	1000 seed weight (g)	Days to 50% flowering	Days to 75% maturity	Seed yield /plant (g)	Seed size (mm)	Vegetative yield (kg)	Seed yield /plot (g)
1	UM-117	29.2	11.2	17.2	14.8	66.7	120.9	3.4	4.6	1.2	205.5
2	UM-122	11.3	11.9	11.7	13.8	67.2	118.0	3.4	4.2	2.4	213.5
3	UM-131	13.5	10.7	15.2	13.1	62.5	113.3	5.8	3.2	1.4	365.0
4	UM-143	7.3	10.3	14.0	13.8	65.8	116.8	3.3	4.8	2.0	203.5
5	UM-118	15.3	10.2	17.3	13.2	69.7	118.5	3.1	3.9	1.6	202.0
6	UM-114	8.7	10.3	18.3	13.7	70.2	114.5	3.9	3.7	1.6	256.5
7	UM-116	26.0	10.5	20.8	13.5	69.2	123.0	6.6	3.9	1.5	439.5
8	UM-121	17.7	11.1	14.7	13.9	67.8	122.8	3.5	4.3	2.1	229.5
9	UM-123	23.8	11.4	14.7	14.9	66.7	122.0	5.3	3.8	1.4	348.0
10	UM-120	15.7	9.5	18.0	13.2	68.7	117.5	3.5	3.4	1.5	214.5
11	UM-128	25.2	11.0	13.7	12.6	65.5	121.2	2.7	3.2	1.9	171.5
12	UM-133	15.3	10.5	17.5	13.9	68.8	120.4	2.1	4.3	1.5	124.5
13	UM-132	23.8	9.0	14.2	15.0	68.3	117.3	1.7	4.8	1.8	115.5
14	UM-125	19.5	13.1	16.5	13.0	65.8	118.7	2.7	4.1	1.1	179.0
15	UM-130	27.3	11.6	16.0	13.5	65.5	116.8	1.3	4.5	1.6	92.0
16	UM-138	19.2	10.5	18.7	13.6	67.5	122.1	1.8	2.8	1.6	126.0
17	UM-129	15.3	10.6	13.3	12.9	64.5	118.9	1.6	3.2	1.3	98.5
18	UM-135	19.8	10.4	16.3	13.6	65.5	114.6	1.6	4.0	1.3	105.5
19	UM-113	42.3	12.0	14.0	14.1	67.5	116.3	1.3	4.1	1.5	84.5
20	RMT-361	17.8	11.0	16.8	13.0	64.5	123.7	2.6	4.2	1.3	169.0
21	UM-144	13.2	11.3	14.5	14.0	64.7	114.3	2.9	3.3	1.2	175.0
22	HM-267	12.7	10.0	13.3	14.2	63.3	118.4	2.4	3.6	1.3	160.0
23	HM-281	13.3	11.9	20.0	14.0	65.0	114.0	4.0	3.3	1.4	255.5
24	HM-279	47.0	10.6	22.2	13.8	64.2	115.5	4.8	4.3	1.4	315.5
25	HM-282	15.5	9.7	20.8	14.1	63.5	115.5	4.0	3.6	1.5	266.0
26	HM-278	20.7	9.9	18.5	13.7	63.7	112.9	1.4	3.4	1.6	87.0
27	HM-271	9.5	10.3	10.7	14.1	62.7	121.7	2.3	3.1	1.2	147.5
28	HM-258-1	20.3	11.7	14.5	13.8	62.7	114.8	3.1	3.7	1.4	205.5
29	HM-280	13.8	9.1	14.0	12.8	63.5	115.9	2.6	3.5	0.9	169.0
30	HM-258	10.0	11.4	13.8	13.2	63.5	117.8	3.1	5.1	1.3	200.5
31	HM-280-1	10.2	9.2	14.7	12.9	64.3	119.7	3.5	4.0	1.5	184.5
32	HM-259	34.0	10.4	11.5	13.7	62.5	114.9	3.2	3.6	1.1	211.0
33	HM-277	19.5	11.0	12.8	13.6	64.7	116.6	2.4	4.9	1.7	134.5
34	HM-277-1	13.7	9.2	15.8	13.2	64.7	115.7	3.1	2.8	1.1	197.0
35	HM-273	11.2	10.6	10.0	13.0	63.3	116.2	2.1	4.5	1.6	119.5
36	HM-260	16.5	13.4	7.3	13.6	64.2	117.0	2.6	4.4	1.3	158.5
37	NDM-8	33.7	9.0	16.7	13.3	67.8	115.3	3.5	4.2	1.4	217.0

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No.	Genotypes	No of pods/plant	Pod length (cm)	No of seeds/pod	1000-seed weight (g)	Days to 50% flowering	Days to 75% maturity	Seed yield /plant (g)	Seed size (mm)	Vegetative yield (kg)	Seed yield /plot (g)
38	NDM-7	15.2	10.4	12.8	12.8	68.2	115.8	3.7	3.9	1.3	229.0
39	NDM-6	16.3	9.6	13.3	13.6	67.7	119.2	2.0	4.5	1.5	123.0
40	NDM-5	32.3	11.9	9.5	13.3	68.8	121.3	5.4	3.4	1.5	346.0
41	NDM-4	15.8	12.5	20.0	14.4	68.3	118.0	3.2	3.6	1.6	199.5
42	NDM-10	24.2	10.4	15.5	13.6	68.3	118.6	3.2	3.9	1.6	206.5
43	NDM-3	17.0	12.3	14.8	14.0	71.5	118.2	4.3	3.4	1.7	288.0
44	NDM-2	33.5	11.8	12.5	13.9	70.5	121.6	4.4	4.8	1.4	268.0
45	NDM-1	17.2	11.2	14.3	13.8	70.2	117.1	5.8	3.9	1.5	364.5
46	NDM-25	23.7	11.0	12.5	13.4	70.7	119.4	4.7	3.0	1.4	289.0
47	NDM-18	21.7	10.5	13.0	14.4	71.7	119.5	6.4	3.6	1.8	419.0
48	NDM-19	21.7	14.7	15.0	13.4	72.2	118.3	5.1	3.4	1.5	320.0
49	NDM-20	19.3	9.6	15.8	13.9	67.2	121.9	6.3	4.4	1.8	404.5
50	NDM-26	18.7	10.9	11.3	13.1	66.3	123.3	4.4	4.2	1.2	278.5
51	NDM-15	16.2	9.0	12.8	13.3	66.2	115.7	1.2	4.2	1.1	82.0
52	NDM-14	15.2	12.2	17.7	13.8	65.0	119.1	3.1	3.9	1.5	204.5
53	NDM-13	23.5	11.3	10.7	13.5	65.5	118.6	2.4	4.2	1.4	154.0
54	NDM-21	27.8	10.8	14.3	13.0	64.5	118.0	3.2	4.7	1.0	203.0
55	NDM-11	24.5	11.6	14.0	13.4	65.2	117.7	2.6	3.6	1.3	170.5
56	NDM-12	30.2	11.0	10.8	13.8	65.3	114.6	2.7	3.3	1.4	178.0
57	NDM-33	29.2	12.1	14.8	13.5	64.3	111.8	2.0	4.1	1.5	127.5
58	NDM-24	19.5	9.5	13.3	13.2	65.5	116.5	3.6	3.0	1.5	248.0
59	NDM-23	42.5	11.9	13.2	14.1	65.7	114.0	1.9	3.1	1.4	124.5
60	NDM-22	21.8	9.8	11.8	13.1	65.5	117.3	2.0	3.9	1.6	123.5
61	NDM-27	24.3	13.1	10.8	13.6	65.5	119.3	1.4	3.5	1.3	94.5
62	NDM-32	19.2	9.6	10.3	14.2	63.0	116.4	1.9	4.5	1.5	116.5
63	NDM-31	17.3	12.4	14.5	14.1	67.3	115.1	1.4	4.0	1.1	88.0
64	NDM-28	14.0	11.8	13.7	12.5	64.3	115.0	2.6	4.3	1.3	131.0
65	NDM-30	25.3	12.1	11.3	13.9	65.5	117.6	3.7	4.3	1.9	236.5
66	NDM-29	5.5	11.3	16.0	14.6	66.7	117.6	5.0	3.6	1.7	321.5
67	RM-33	31.2	9.6	14.0	13.8	65.8	115.1	3.3	2.9	1.5	212.0
68	RM-27	5.3	11.7	12.5	13.5	66.0	118.0	2.2	4.2	1.2	135.0
69	RM-195	13.2	9.8	14.7	13.7	65.8	118.5	1.3	3.6	1.6	83.0
70	RM-187	22.3	10.1	14.8	12.8	64.3	114.5	4.0	4.6	1.1	268.5
71	RM-185	7.2	11.3	13.8	13.6	64.7	116.6	3.6	3.3	1.5	238.5
72	RM-16	8.3	10.3	11.5	13.6	65.3	116.6	4.1	3.4	1.1	262.0
73	RM-190	12.0	10.2	12.3	13.8	66.3	118.0	3.7	3.6	1.1	236.5
74	RM-14	16.5	11.3	15.3	13.1	67.2	119.0	3.9	3.4	1.9	247.5

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No.	Genotypes	No of pods/plant	Pod length (cm)	No of seeds/pod	1000-seed weight (g)	Days to 50% flowering	Days to 75% maturity	Seed yield /plant (g)	Seed size (mm)	Vegetative yield (kg)	Seed yield /plot (g)
75	RM-15	14.3	10.6	11.3	13.6	61.5	115.6	3.5	3.9	1.9	233.0
76	RM-18	15.3	13.5	16.3	13.6	62.5	117.1	2.0	3.7	1.3	122.0
77	RM-13	14.8	10.4	18.2	13.4	64.5	117.0	2.0	4.6	1.5	125.0
78	RM-186	17.3	12.2	16.0	13.5	64.5	118.6	2.1	3.6	2.1	127.5
79	RM-199	24.2	12.0	16.3	12.8	64.5	119.3	2.0	4.8	1.3	122.0
80	RM-189	14.3	11.4	16.5	13.9	63.5	116.8	2.6	4.2	1.2	166.0
81	RM-70	13.2	10.3	16.3	13.5	62.5	115.6	3.9	2.9	1.4	256.0
82	RM-28	25.0	11.3	15.5	13.4	61.5	112.7	2.2	4.8	1.7	131.0
83	RM-424	11.8	12.2	15.7	13.2	62.2	116.3	2.7	4.1	1.7	179.0
84	RM-198	16.7	10.3	18.2	13.7	63.5	117.6	1.1	3.3	1.5	74.5
85	RM-10	20.7	10.9	15.2	14.2	65.3	118.1	3.1	3.4	1.2	205.0
86	ACC-002	30.3	11.9	16.7	13.3	62.7	118.1	1.2	3.7	1.3	71.5
87	ACC-001	12.2	12.4	18.2	13.6	64.5	115.1	1.1	4.4	1.4	74.0
88	ACC-003	17.3	10.7	18.7	14.3	63.8	116.7	2.8	4.9	1.6	189.0
89	ACC-017	19.2	13.6	18.2	13.6	62.0	114.7	3.5	3.3	1.5	231.5
90	ACC-010	20.7	13.2	17.0	13.5	64.3	114.6	1.4	4.5	1.7	88.0
91	ACC-009	18.7	13.4	15.8	14.0	65.5	114.7	2.4	3.5	2.3	147.0
92	ACC-006	15.5	10.3	16.7	14.4	65.5	119.1	2.8	2.7	2.4	174.5
93	ACC-004	15.5	11.3	16.2	13.3	64.8	117.8	1.6	3.7	1.4	101.0
94	ACC-012	13.7	12.2	11.2	13.8	69.8	116.2	2.3	4.0	1.0	135.5
95	ACC-007	14.0	14.0	10.7	13.8	65.0	118.5	1.3	3.8	1.1	84.5
96	ACC-013	15.5	10.4	15.3	13.8	64.5	117.6	2.5	3.7	1.6	161.0
97	ACC-021	16.8	12.3	17.7	14.3	64.2	113.1	1.6	3.6	1.3	112.5
98	ACC-020	16.2	10.3	21.5	13.6	64.5	115.9	1.8	4.2	1.6	128.0
99	ACC-019	24.0	10.7	18.7	13.9	62.2	114.3	1.2	4.5	2.1	72.3
100	RMT-1 (C)	20.0	9.5	17.3	14.1	63.8	115.7	2.2	3.4	1.7	132.5
101	GM-2 (C)	19.7	10.9	15.7	13.5	65.5	114.3	2.5	4.4	1.4	151.0
102	PEB (C)	25.2	11.3	20.5	13.1	64.3	115.2	4.0	4.5	1.3	272.0
Mean		19.3	11.0	15.3	13.7	65.5	117.1	2.9	3.9	1.5	187.6
S.E.		3.0	0.5	1.1	0.1	0.5	0.4	0.1	0.1	0.1	2.8
C.D. 5%		8.4	1.3	3.1	0.3	1.3	1.2	0.2	0.2	0.2	7.9

MATERIALS AND METHODS

This study was undertaken during *rabi* seasons of 2009-2010 and 2011-12 at Vegetable Research Farm, Department of Horticulture, JNKVV, Jabalpur (M.P.). The experimental material consisted of 102 diverse genotypes collected and received from different geographic and genetic origin (DASD, Calicut, Kerala, India) and 3 checks namely Pusa Early Bunch, Gujarat Methi-2 and RMT-1 which are locally used and famous high yielding improved varieties. These 102 germplasms line were evaluated in a Randomized Block Design with 3 replications. The seeds were sown directly in the experimental site. The plot size was 1.0 m x 10 m with row–to-row spacing of 30 cm and plant-to-plant spacing of 10 cm. All recommended agronomic practices and plant protection measures were followed. Ten competitive plants were randomly taken to record observation on 9 quantitative characters namely number of primary branches per plant, number of secondary branches per plant, plant height (cm), number of pods on main axis, total number of pods per plant, pod length (cm), number of seeds per pod, test weight and seed yield per plant whereas days to flowering time was recorded on plot basis. The standard agronomic practices were adopted for normal crop growth.

The data on quantitative characters were statistically analyzed on the basis of model described by Cochran and Cox (1950) for randomized block design. In order to test the significance of treatments critical difference was computed (Fisher and Yates, 1963). The data were analyzed by using Indostat (2012) software.

RESULTS

The analysis of variance (ANOVA) analysis for all the characters studied during 2 years revealed significant differences among the genotypes. Results have been presented in Table 1a, 1b and 1c. Pooled analysis has been done for all the traits under study and results have been presented in Table 1c.

On the basis of 2 years investigation pooled mean and range of the 102 genotypes for 24 characters have been depicted in Table 2. Plant height ranged from 7.6 to 18.0, 15.1 to 29.7, 41.6 to 77.7 and 60.5 to 109.0 cm at 30, 45, 60 DAS and at maturity respectively. The overall mean performance in 11.3, 22.6, 54.1 and 82.1 cm was recorded at 30, 45, 60 DAS and at maturity respectively. The maximum plant heights 18.0, 29.7, 77.7 and 109.0 cm were observed in genotypes HM-277-1, GM-2 (C) , NDM-2 and NDM-2 at 30, 45, 60 DAS and at maturity respectively while, the genotypes NDM-21 (7.6 cm), RM-18 (15.0 cm), NDM-26 (41.6 cm) and RM-33 (60.5 cm) recorded the minimum plant heights at 30, 45, 60 DAS and at maturity respectively.

Chlorophyll content varied from 12.4 to 35.6, 18.41 to 56.5 and 11.3 to 60.0 with an overall mean performance of 23.7, 36.3 and 37.3 at 30, 45 and 60 DAS respectively. The genotype viz., UM-122 (35.6), ACC-021 (56.5) and NDM-23 (60.0) exhibited the maximum chlorophyll content at 30, 45 and 60 DAS. Leaf size varied from 2.3 to 3.8 cm with an overall mean performance of 3.1 cm. The largest leaf size (3.8 cm) was observed in genotype UM-114 while, the smallest leaf size (2.3 cm) was recorded in NDM-13. Stem diameter varied from 2.8 to 5.4 mm with an overall mean performance of 3.8 mm. The maximum stem diameter was observed in UM-120 (5.4 mm) while, it was the minimum in UM-117 (2.8 mm). The maximum petiole length was noted in UM-143 (1.7 cm) whereas, the minimum in genotype HM-281 (0.8). Nodulation at 60 DAS ranged between 8.1 and 27.6 with the average mean of 16.7. Genotype UM-143 recorded the maximum (27.6) nodules plant^{-1}.

Number of primary branches plant^{-1} varied from 1.5 to 8.5 branches with an average of 3.9 branches plant^{-1}. Genotype UM-117 (8.5) recorded the maximum primary branches plant^{-1} while, it was the least in genotype HM-281 (1.5). Number of secondary branches plant^{-1} ranged between 0.0 and 6.6 with an average of 0.7 branches plant^{-1}. The maximum secondary branches plant^{-1} was noted in UM-117 (6.6) while, no secondary branches was observed in the genotypes UM-118, UM-114, UM-120, UM-128, UM-138, HM-271, HM-280-1, NDM-6, NDM-20, NDM-29, RM-189 and ACC-021.

Number of pods axis^{-1} varied from 0.0 to 4.0 with an average of 0.5. The maximum (4.0) pods axis^{-1} exhibited in the genotype UM-138 whereas, the minimum pods axis^{-1} (1.0) were recorded in 32 genotypes. Number of pods plant^{-1} ranged between 5.3 and 47.0 with an overall mean performance of 19.3 pods. The maximum (47.0) pods plant^{-1} was recorded in genotype HM-279 while, it was the minimum in genotype RM-27 (5.3).

Pod length varied from 8.9 to 14.6 cm with an overall mean performance of 11.0. Genotype NDM-19 produced the longest pod (14.6 cm), whereas NDM-8 and NDM-15 (9.9 cm) recorded the smallest pod length.

Flowering time varied from 61 to 72 days with an average of 65.5 days. The earliest (61) flowering time was recorded in genotypes RM-15 and RM-28 while; it was found to be late (72) in genotype NDM-19. Days to 75% maturity lied between 111.8 and 123.6 days with an overall mean of 117.1 days. Genotype NDM-33 was observed to be earliest in maturity (111.8 days) while, genotype RMT-361 was found to be late (123.6 days).

Number of seeds per pod^{-1} ranged between 7.3 and 22.1, with its average being 15.2 seeds. The maximum (22.1) seeds pod^{-1} was observed in HM-279 whereas, it was the least (7.3) in genotype HM-260. 1000 seed weight varied from 12.5 to 14.9 g with an overall average weight of 13.6 g. The genotype UM-132 exhibited maximum (14.9) 1000 seed weight, while genotype NDM-28 recorded the minimum (12.5) 1000-seed weight.

The seed size varied from 2.7 to 5.1 mm with an average of 3.9mm. The genotype HM-258 recorded bold (5.1 mm) seeds, whereas; smallest (2.7 mm) seeds were observed in genotype ACC-006. Seed yield plant^{-1} varied from 1.0 to 6.6 g with an average of 2.9 g. The maximum seed yield plant^{-1} was recorded in genotype UM-116 (6.6 g). The trait vegetative yield plant^{-1} ranged between 0.8 and 2.4 kg with an overall mean of 1.4 kg. Genotypes UM-122 and ACC-006 recorded the maximum (2.4 kg) vegetative (leaf) yield plant^{-1} however; it was the minimum in genotype HM-280. Seed yield plot^{-1} varied from 71.5 to 439.5 g and overall means performance of 187.6 g. The maximum seed yield plot^{-1} was recorded in UM-116 (439.5 g).

DISCUSSION

The mean differences due to genotypes were highly significant for all the characters which indicate the presence of substantial genetic diversity in the material studied. Seven characters viz., seed yield plant^{-1}, plant height at maturity, chlorophyll content at 45 and 60 DAS, number of pods plant^{-1}, plant height at 60 DAS and nodulation at 60 DAS recorded mean sum of square values of a higher magnitude. It has been reported that leaf color can indicate the amount and proportion of chlorophyll in leaves which are, in turn, closely related to plant nutrient status. The findings are in agreement with the findings of Datta and Chatterjee (2004), Raje (2004) and Hariharan and Vijayakumar (1997).

Variation in plant height was due to the inherent genetic makeup of the genotypes and their interaction with the environment, which in some way influenced the morphological expression through the activity of endogenous hormonal level and apical dominance. These findings are quite similar to as reported by Kaushik *et al.* (2001), Raje (2004) and Gangopadhyay *et al.* (2009).

The findings of Datta *et al.* (2005) are similar to that of the present findings for chlorophyll content, leaf size and nodulation.

Number of primary branches plant^{-1}, Number of secondary branches plant^{-1} was noted in UM-117 while, no secondary branches was observed in the genotypes UM-118, UM-114, UM-120, UM-128, UM-138, HM-271, HM-280-1, NDM-6, NDM-20, NDM-29, RM-189 and ACC-021. Koli and Sri Karan (2002), Kaushik *et al.* (2001) and Kole and Mishra (2006) observed quite similar results.

Number of pods axis^{-1} varied from 0.00 to 4.00. The maximum pods axis^{-1} exhibited in the genotype UM-138 whereas, the minimum pods axis^{-1} were recorded in 32 genotypes. Number of pods plant^{-1} maximum was recorded in genotype HM-279 while, it was the minimum in genotype RM-27. Similar results were obtained by Chandra *et al.* (2000) and Koli and Sri Karan (2002) for number of pods plant^{-1}. Genotype NDM-19 produced the longest pod, whereas NDM-8 and NDM-15 recorded the smallest pod length. Gangopadhyay *et al.* (2009) reported similar results.

Flowering time varied from 61 to 72 days, the results of this study corroborated the results of Chandra *et al.* (2000) and Kole and Mishra (2006).

Number of seeds per pod^{-1} ranged between 7.33 and 22.16. The maximum seeds pod^{-1} was observed in HM-279 whereas; it was the least in genotype HM-260. Results of the present study are supported by the results of Kaushik *et al. (*2001) and Verma and Korla (2003).

The genotype HM-258 recorded bold seeds, whereas; smallest seeds were observed in genotype ACC-006. The maximum seed yield plant^{-1} was recorded in genotype UM-116. Genotypes UM-122 and ACC-006 recorded the maximum vegetative (leaf) yield plant^{-1} however; it was the minimum in genotype HM-280. Yield is the result of complex polygenic characters which is largely influenced by environmental conditions. The results are consistent with Chandra *et al. (*2000) for seed yield and Kaushik *et al. (*2001) seed yield plot^{-1}.

The great numeral of medicinal properties of this crop has made it very much striking to pharmaceutical industry. However, outstanding genotype x environment interactions, great variability is habitually observed in the yield trends among different germplasms grown under similar environments. Hence to fill local needs of the country, adapted cultivars will be necessary for development cultivars resulting in high yield in both seed as well as vegetative yield.

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