Original Research Article

Response of Fenugreek (*Trigonella foenum-graecum* L.) Genotypes for their germination and early Seedling parameters Grown Under different Saline levels

Abstract

Salinity is most important wide abiotic factors which adversely affected the grain yield due to limits the germination, growth and production of crop in arid and semi-arid regions throughout the world. Seedling establishment is a most critical stage that determined the crop production at later stages, thus it must necessity to study the effect of salt stress on germination and early seedling parameters. This experiment aimed to observe the effect of salt stress on germination and early seedling parameters of fenugreek. Fenugreek (*Trigonella foenum-graecum* L.) is a winter season seed spices crop, used as a condiments and flavorings agent and as a medicinal purpose. It is commonly known as Methi and moderately tolerant to salinity. We took ten genotypes of fenugreek grown under five salinity levels viz., 0.0, 40, 80, 120 and 160 mM NaCl salinity induced by supplementing 0.0, 584.4, 1168.8, 1753.2 and 2337.6 mg NaCl in 250 ml double distilled water, respectively. Results revealed that the average value was found maximum in the control and minimum at higher salinity level for most of traits. Higher reduction was found at higher salinity levels for most of the characters viz., plumule length, radicle length, seedling length, plumule to radicle length ratio, plumule fresh weight, radicle fresh weight, plumule dry weight, radicle dry weight and seedling vigour index but lower reduction in germination percentage. The comparison between mean of different genotypes in control (S_0) versus S_m (mean of S_1, S_2, S_3 and S_4) for each trait also revealed that overall mean was highest in control as compared to the overall mean of salinity levels for all the traits. This investigation concluded that higher level of salinity (above 60 mM) adversely most affected to seed germination and other early seeding traits rather than (below 40 mM) lower salinity levels. Based upon the rank totals of genotype over different salinity levels S_1, S_2, S_3 and S_4 (S_m) and characters, the RMt-303 was found to be most desirable genotype followed by UM-385, RMt-143 and RMt-305. These lines would be used as a viable option under saline conditions and better exploit in hybridization programme.

Key Words: Fenugreek, salinity, effect of salt, seed germination and early seedling traits.

1. Introduction:

Salinity is one of the major abiotic factors present in irrigation water in arid and semi-arid regions that affecting the crop yield by limits the growth and production. It is estimated that 6 percent of world´s total land and 20 per cent of the world´s irrigated areas are affected by salinity. Salinity refers to the soil paste extract which have electrical conductivity is greater than 4 ds/m, ESP is less than 15% and pH is lower than 8.5. Germination is one of the most critical periods for a crop subjected to salinity (Fowler, 1991). Seed germination and seedling establishment is most critical stage for determine the crop yield. Several researchers have observed a decrease in germination rate as salinity increase and the osmotic potential of the germination medium decreases (Greenway, 1973; Redmann, 1974 and Sharma, 1976). Plant growth and metabolism can be altered by saline stress (Misra and Dwivedi, 2004). Fenugreek (*Trigonella foenum-graecum* L.) is a self pollinated, small seeded, annual legume. Taxonomically, it belongs to family fabaceae. Fenugreek is regarded as moderately tolerant to salinity. The objectives of the present investigation were to assess the effect of salt stress on germination and early seedling parameters and to identify the suitable genotype for salinity conditions.

2. Material and Methods:

This study was conducted at the Laboratory of Department of Plant Breeding and Genetics, Sri Karan Narendra College of Agriculture, Jobner (Rajasthan) in *Rabi* season 2016-17. Seeds of ten available fenugreek genotypes were obtained from germplasm collection of All India Coordinated Research Project on Seed Spices, S.K.N. College of Agriculture, Jobner, Jaipur. Seeds were sorted with hand to eliminate broken and small seeds. Uniformly selected seeds were sterilized with 0.1% mercuric chloride for 1 minute and then washed repeatedly for two to three times under running tap water followed by washing with distilled water. The present investigation consisted of evaluations of fenugreek under five levels of salinity viz. 0.0 mM (S_0), 40 mM (S_1) , 80 mM (S_2), 120 mM (S_3) and 160 mM (S_4) NaCl salinity induced by supplementing 0.0, 584.4, 1168.8, 1753.2 and 2337.6 mg NaCl in 250 ml double distilled water, respectively. RBD design was used and replicated three times. Fifteen seeds of each genotype were sown in sterilized petridishes layered with autoclaved germination papers. Each petridish was irrigated with 3 ml of test solutions after draining out the previous days solutions. The temperature was 23 ± 2^0C in the culture room and the set was maintained in dark for the first two days followed by exposure to light achieved by tube lights and incandescent bulbs. A seed was considered to be germinated at the emergence of both radicle

and plumule up to 2 mm length (Chartzoulakis and Klapaki, 2000). The experiment was terminated on 8^{th} day and at the 8^{th} day; data on plumule and radicle length (cm) and fresh weight of plumule, radicle (mg) and seedling vigour index were recorded. The data on plumule and radicle dry weight was recorded after drying in hot air oven at 65^0C for 48 hours.

The germination percentage was determined by using the following formula (Aniat *et al.*, 2012):

$$\text{Germination Percentage} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

The plumule to radicle length ratio of seedling was calculated by the following formula (Kagan *et al.*, 2010).

$$\text{Plumule to Radicle Length Ratio} = \frac{\text{Plumule length}}{\text{Radicle length}}$$

The seedling vigour index was determined by multiplying the sum total of mean length of plumule and radicle of a seedling with germination percentage of the respective seedling by the following formula (Iqbal and Rahmati, 1992):

Seedling Vigour Index (SVI) = (RL+PL) x (GP)

Where,

RL= Mean radicle length

PL= Mean plumule length

GP= Germination percentage

The genotype mean was calculated by formula:

$$\overline{X} = \frac{\sum x}{n}$$

Where,

$\sum x$ = Sum of all observations in a sample

n = Number of observations in a sample

3. Results and Discussion:

Effect of salinity on mean performance

The mean values at different salinity levels for various characters are presented in Table 1 to 10. Perusal of these tables revealed that the mean values of all the characters varied along the salinity gradient. The value was maximum in the control (S_0 salinity level) and minimum at the highest salinity level (S_4) for most of characters.

Germination percentage:

Perusal of tables indicated that the genotypes exhibited significant differences for germination percentage at higher salinity levels 80, 120 and 160 mM NaCl salinity except lower salinity level 0, 40 mM NaCl. This indicated inherent differences among the genotypes. Significant difference indicated presence of sufficient genetic variability in the material used for this investigation. In case of germination, the magnitude of germination percentage decreased with increase in salt concentration. It was highest in S_0 (96.89 %) then decreased progressively in S_1 (93.33 %), S_2 (89.11 %), S_3 (88.44 %) and S_4 (82.67 %). Such results have been also reported by Asaadi, 2009 and Ratnakar and Rai, 2013 in fenugreek and by Ashagre *et al*., 2013 in chickpea

Plumule length, radicle length and seedling length:

Perusal of tables indicated that the genotypes exhibited significant differences for plumule length at all the salinity level. The plumule length was also decreased with increasing level of salinity. It was highest in S_0 (7.16 cm) then decreased progressively in S_1 (6.98 cm), S_2 (5.78 cm), S_3 (4.24 cm) and S_4 (2.71 cm).

The radicle length was decreased with increasing salinity level but it was less affected as compared to plumule length and was highest in S_0 salinity level (4.50 cm) then decreased progressively in S_1 (4.21 cm), S_2 (4.05 cm), S_3 (3.99 cm) and S_4 (2.72 cm).

The seedling length was also decreased with increasing salinity level. It was highest in S_0 (11.65 cm) and then decreased in S_1 (11.19 cm), S_2 (9.83 cm), S_3 (8.23 cm) and in S_4 (5.43 cm).

Such observation was noted earlier in fenugreek (Kapoor and Pande, 2015 and Ratnakar and Rai, 2013), in spinach (Keshavarzi *et al*., 2011) and in oat (Chauhan *et al*., 2016).

Plumule to radicle length ratio, plumule fresh weight and radicle fresh weight:

The plumule to radicle length ratio is a derived character, which showed differential response in different salinity levels. The ratio increased in S_1 (1.69) and decreased in S_0 (1.61) followed by in S_2 (1.45), S_3 (1.07) and S_4 (1.01).

The plumule fresh weight was also highest in S_1 (110.68 mg) then decreased in S_0 (107.78 mg) followed by in S_2 (95.12 mg), S_3 (70.58 mg) and S_4 (54.45 mg).

In case of radicle fresh weight, there was also a decreasing trend with increasing salinity level. It was highest in S_0 and S_1 (31.44 mg) and then decreased in S_2 (31.16 mg), S_3 (28.63 mg) and S_4 (16.36 mg).

The salinity gradient adversely affected the mean values of all the characters with increase in the salinity gradient except in S_1 for plumule to radicle length ratio and plumule fresh weight. There is no difference for radicle fresh weight in S_1 and S_2. Like radicle length that was less affected by salinity because plumule length was found to be more sensitive than radicle length. Radicle fresh weight reduced highly at high salinity levels, it has been observed earlier by Ramoliya *et al*., (2004) and by Asaadi (2009).

Plumule dry weight:

The plumule dry weight was also observed high in S_0 and S_1 (7.84 mg and 7.86 mg) and then decreased with increase in salinity levels i.e. in S_2 (7.76 mg), S_3 (7.03 mg) and S_4 (6.98 mg).

Interestingly reduction in the mean values of plumule dry weight was not much significantly different in 40 mM as compared to the control (0.0 mM). Such stimulatory effect of low salinity has been reported earlier by Jain and Agarwal (1991).

Radicle dry weight and seedling vigour index:

The radicle dry weight also exhibited a decreasing trend with increase in salinity level. It was maximum in S_0 (1.20 mg) and then decreased in S_1 and S_2 (1.15 mg and 1.16 mg), S_3 (1.09 mg) and S_4 (0.88 mg). The seedling vigour index decreased with increased salinity level. It was maximum in S_0 (1129.49) followed by S_1 (1044.68), S_2 (875.46), S_3 (726.85) and S_4 (447.75).

Such observation was reported earlier in fenugreek (Kapoor and Pande, 2015 and Ratnakar and Rai, 2013), in spinach (Keshavarzi *et al*., 2011) and in oat (Chauhan *et al*., 2016).

4. Conclusion:

Present investigation provided the information about the effect of salt stress on seed germination and early seedling traits of fenugreek under different salinity levels. Results

showed that reduction was highest at 120 and 160 mM NaCl in comparison to 0.0 mM, 40 mM and 80 mM NaCl.

- The genotypes exhibited significant differences in all the salinity levels for all the traits except germination percentage in salinity level 0.0 mM and 40 mM indicating inherent differences among the genotypes.

- A wide range of variability was found for all the traits studied. The mean values of all the traits varied along the salinity gradient. The reduction was highest at 120 and 160 mM NaCl in comparison to 0.0 mM, 40 mM and 80 mM NaCl.

- The reduction in mean values was severe in plumule length, plumule fresh weight, seedling length and seedling vigour index. The reduction was lower in germination percentage.

- Based upon the rank totals of a genotype over different salinity levels S_1, S_2, S_3 and S_4 (S_m) and characters, the genotype RMt-303 was found to be most desirable followed by UM-385, RMt-143 and RMt-305.
- The comparison between mean of different genotypes in control (S_0) versus S_m (mean of S_1, S_2, S_3 and S_4) for each trait also revealed that overall mean was highest in control as compared to the overall mean of salinity levels for all the traits.

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Table: 1. The mean value of genotypes over different salinity levels for germination percentage and plumule length (cm)

Genotypes	Salinity levels									
	Germination percentage					Plumule length (cm)				
	S_0	S_1	S_2	S_3	S_4	S_0	S_1	S_2	S_3	S_4
RMt-305	95.55	95.55	95.55	95.55	88.89	7.33	7.30	5.67	3.40	2.05
RMt-351	95.55	91.11	82.22	80.00	84.45	6.95	6.51	5.75	4.01	2.83
RMt-361	97.78	95.55	93.33	91.11	84.45	5.71	6.53	5.07	3.42	2.61
RMt-354	91.11	91.11	84.45	82.22	80.00	7.31	7.27	5.68	4.92	2.68
RMt-365	95.55	91.11	88.89	88.89	75.55	7.41	6.87	5.79	4.19	2.93
UM-383	95.56	95.55	84.45	84.44	77.78	7.79	6.89	5.39	4.36	3.20
RMt-1	100.00	88.89	88.89	86.67	82.22	6.91	6.75	6.03	3.98	2.75
RMT-143	97.78	93.33	86.67	91.11	86.67	6.93	6.83	6.08	5.19	2.75
RMt-303	100.00	97.78	95.55	95.55	91.11	7.49	6.95	5.74	5.17	2.85
UM-385	100.00	93.33	91.11	88.89	75.55	7.73	7.87	6.61	3.71	2.46
Overall mean	96.89	93.33	89.11	88.44	82.67	7.16	6.98	5.78	4.24	2.71

Table: 2. The mean value of genotypes over different salinity levels for radicle length (cm) and seedling length (cm)

Genotypes	Salinity levels									
	Radicle length (cm)					Seedling length (cm)				
	S_0	S_1	S_2	S_3	S_4	S_0	S_1	S_2	S_3	S_4
RMt-305	3.67	3.97	3.85	3.45	2.30	11.00	11.27	9.52	6.85	4.35
RMt-351	3.85	3.74	3.88	4.29	2.94	10.79	10.25	9.63	8.31	5.77
RMt-361	3.69	3.53	4.06	3.69	2.66	9.40	10.06	9.13	7.11	5.27
RMt-354	4.67	4.71	4.45	3.87	3.07	11.98	11.99	10.13	8.79	5.75
RMt-365	4.60	3.47	3.81	3.17	3.00	12.01	10.34	9.61	7.36	5.93
UM-383	5.29	4.36	3.11	4.16	2.43	13.08	11.25	8.49	8.52	5.63
RMt-1	4.69	4.51	3.67	3.89	2.88	11.60	11.25	9.69	7.87	5.63
RMT-143	4.47	5.38	4.79	4.49	2.29	11.40	12.21	10.87	9.67	5.03
RMt-303	4.65	4.53	4.51	4.51	3.16	12.15	11.48	10.25	9.67	6.01
UM-385	5.39	3.94	4.32	4.39	2.43	13.12	11.81	10.93	8.10	4.89
Overall mean	4.50	4.21	4.05	3.99	2.72	11.65	11.19	9.83	8.23	5.43

Table: 3. The mean value of genotypes over different salinity levels for plumule to radicle length ratio and plumule fresh weight (mg)

Genotypes	Salinity levels									
	plumule to radicle length ratio					Plumule fresh weight (cm)				
	S_0	S_1	S_2	S_3	S_4	S_0	S_1	S_2	S_3	S_4
RMt-305	2.00	1.84	1.48	0.99	0.89	122.04	121.31	100.67	70.88	45.40
RMt-351	1.81	1.75	1.48	0.94	0.96	103.77	121.36	99.99	69.59	50.69
RMt-361	1.55	1.87	1.25	0.93	0.99	98.41	108.67	90.59	71.43	53.67
RMt-354	1.57	1.55	1.28	1.28	0.88	105.14	101.41	90.39	68.18	51.94
RMt-365	1.61	2.00	1.52	1.32	0.98	105.95	108.87	70.93	70.59	60.95
UM-383	1.48	1.58	1.73	1.05	1.32	95.53	106.31	86.83	78.00	59.57
RMt-1	1.48	1.50	1.65	1.02	0.96	103.69	78.91	82.20	60.22	46.39
RMT-143	1.55	1.27	1.27	1.16	1.21	95.55	110.24	97.21	81.13	46.33
RMt-303	1.61	1.54	1.29	1.15	0.90	138.83	138.76	119.41	67.16	68.56
UM-385	1.44	2.00	1.54	0.85	1.02	108.90	110.92	112.93	68.65	60.95
Overall mean	1.61	1.69	1.45	1.07	1.01	107.78	110.68	95.12	70.58	54.45

Table: 4. The mean value of genotypes over different salinity levels for radicle fresh weight (mg) and plumule dry weight (mg)

Genotypes	Salinity levels									
	Radicle fresh weight (mg)					Plumule dry weight (mg)				
	S_0	S_1	S_2	S_3	S_4	S_0	S_1	S_2	S_3	S_4
RMt-305	39.56	31.81	29.91	28.23	14.47	9.14	7.81	9.53	8.40	7.20
RMt-351	29.00	23.17	25.72	24.71	17.39	6.69	8.45	6.85	5.48	6.69
RMt-361	27.81	33.41	33.76	30.59	17.27	7.66	7.82	8.40	7.75	6.85
RMt-354	30.50	29.80	29.58	27.07	17.86	7.30	6.80	6.67	6.93	6.87
RMt-365	30.99	33.35	22.60	27.29	13.94	5.92	6.60	7.11	6.77	5.34
UM-383	35.76	37.15	38.86	28.31	17.31	7.89	8.26	6.63	5.67	5.63
RMt-1	32.94	27.19	33.45	24.15	15.81	8.76	5.87	6.10	5.67	7.20
RMT-143	30.46	24.67	30.54	29.41	14.63	6.87	6.75	7.28	7.59	7.11
RMt-303	20.91	42.14	39.38	34.69	17.48	10.25	10.33	10.45	7.42	9.33
UM-385	36.51	31.72	27.78	31.89	17.41	7.97	9.88	8.55	8.58	7.54
Overall mean	31.44	31.44	31.16	28.63	16.36	7.85	7.86	7.76	7.03	6.98

Table: 5. The mean value of genotypes over different salinity levels for radicle dry weight (mg) and seedling vigour index

Genotypes	Salinity levels									
	Radicle dry weight (mg)					Seedling vigour index				
	S_0	S_1	S_2	S_3	S_4	S_0	S_1	S_2	S_3	S_4
RMt-305	1.23	1.17	1.25	1.15	0.98	1051.75	1076.55	910.25	654.87	385.14
RMt-351	1.01	1.13	1.05	1.13	0.83	1032.42	933.10	790.85	664.09	486.55
RMt-361	1.69	1.35	1.27	1.22	0.81	917.94	962.51	851.33	647.90	445.26
RMt-354	0.90	1.16	1.03	1.19	0.86	1092.25	1092.61	852.78	723.30	457.73
RMt-365	0.97	1.03	1.05	0.84	0.74	1145.75	943.45	854.45	653.34	448.25
UM-383	1.29	1.15	1.21	1.18	0.91	1253.61	1074.55	716.24	717.24	437.73
RMt-1	1.27	0.91	0.99	1.00	0.75	1160.00	1000.19	861.30	682.80	462.58
RMT-143	1.22	1.04	1.25	0.85	0.83	1114.52	1141.20	941.15	880.44	436.18
RMt-303	1.27	1.21	1.17	1.15	0.90	1214.67	1122.61	979.67	925.22	548.31
UM-385	1.19	1.33	1.36	1.21	1.17	1312.00	1100.04	996.61	719.25	369.72
Overall mean	1.20	1.15	1.16	1.09	0.88	1129.49	1044.68	875.46	726.85	447.75

Table: 6. The rank total of different genotypes based on mean (S_m) of salinity levels S_1, S_2, S_3 and S_4

Genotype	Germination (%)	Plumule length (cm	Radicle length (cm)	Seedling length (cm)	Plumule/ Radicle length ratio	Plumule fresh weight (mg)	Radicle fresh weight (mg)	Plumule dry weight (mg)	Radicle dry weight (mg)	Seedling vigour index	Total	Rank
RMt-305	2	9	9	9	4	4	5	3	3	5	53	4
RMt-351	9	8	6	6	5	3	10	6	7	10	70	8
RMt-361	3	10	8	10	7	7	3	4	2	8	62	7
RMt-354	9	4	3	3	8	8	6	7	6	4	58	6
RMt-365	7	6	10	8	1	9	9	9	9	9	77	10
UM-383	8	5	7	7	2	6	2	8	4	7	56	5
RMt-1	6	7	5	5	5	10	7	10	10	6	71	9
RMt-143	4	1	1	1	9	5	8	5	8	2	44	3
RMt-303	1	2	2	2	10	1	1	1	4	1	25	1
UM-385	5	3	4	4	3	2	4	2	1	3	31	2

Note : S_0, S_1, S_2, S3 and S_4 represent 0, 40, 80, 120 and 160 mM NaCl , respectively.

Table: 7. The comparison between overall mean of different genotypes in control (S_0) versus S_m (mean of S_1, S_2, S_3, & S_4)

Genotype		Germination (%)	Plumule length (cm	Radicle length (cm)	Seedling length (cm)	Plumule/ Radicle length ratio	Plumule fresh weight (mg)	Radicle fresh weight (mg)	Plumule dry weight (mg)	Radicle dry weight (mg)	Seedling vigour index
RMt-305	S_0	95.55	7.33	3.67	11.00	2.00	122.0	39.56	9.14	1.23	1051.75
	S_m	93.89	4.61	3.39	8.00	1.30	84.57	26.11	8.24	1.14	756.70
RMt-351	S_0	95.55	6.95	3.85	10.79	1.81	103.7	29.00	6.69	1.01	1032.42
	S_m	84.45	4.78	3.71	8.49	1.28	85.41	22.75	6.87	1.04	718.65
RMt-361	S_0	97.78	5.71	3.69	9.40	1.55	98.41	27.81	7.66	1.69	917.94
	S_m	91.11	4.41	3.49	7.89	1.26	81.09	28.76	7.71	1.16	726.75
RMt-354	S_0	91.11	7.31	4.67	11.98	1.57	105.1	30.50	7.30	0.90	1092.25
	S_m	84.45	5.14	4.03	9.17	1.25	77.98	26.08	6.82	1.06	781.61
RMt-365	S_0	95.55	7.41	4.60	12.01	1.61	105.9	30.99	5.92	0.97	1145.75
	S_m	86.11	4.95	3.36	8.31	1.46	77.84	24.30	6.46	0.92	724.87
UM-383	S_0	95.56	7.79	5.29	13.08	1.48	95.53	35.76	7.89	1.29	1253.61
	S_m	85.56	4.96	3.52	8.47	1.42	82.68	30.41	6.55	1.11	736.44
RMt-1	S_0	100.0	6.91	4.69	11.60	1.48	103.6	32.94	8.76	1.27	1160.00
	S_m	86.67	4.88	3.74	8.61	1.28	66.93	25.15	6.21	0.91	751.72
RMT-143	S_0	97.78	6.93	4.47	11.40	1.55	95.55	30.46	6.87	1.22	1114.52
	S_m	89.45	5.21	4.24	9.45	1.23	83.73	24.81	7.18	0.99	849.74
RMt-303	S_0	100.0	7.49	4.65	12.15	1.61	138.8	20.91	10.25	1.27	1214.67
	S_m	95.00	5.18	4.18	9.35	1.22	98.47	33.42	9.38	1.11	893.95
UM- 385	S_0	100.0	7.73	5.39	13.12	1.44	108.9	36.51	7.97	1.19	1312.00
	S_m	87.22	5.16	3.77	8.93	1.35	88.36	27.20	8.64	1.27	796.41
Mean	S_0	96.89	7.16	4.50	11.65	1.61	107.7	31.44	7.85	1.20	1129.49
	S_m	88.39	4.93	3.74	8.67	1.31	82.71	26.90	7.41	1.07	773.68