**Assessment of Seed Quality in Naturally Aged Seed Lots of Fenugreek (*Trigonella foenum graecum* L.) germplasm**

**ABSTRACT**

 In the present study, the seed of two seed lots, *viz*. L1 (fresh harvested seed) and L2 (one year old seed) of each of six genotypes *viz*., RMT-361, RMT-303, RMT-354, RMT-351, RMT-305 and NRCSS-AM-1 of fenugreek were taken and stored under ambient conditions. All the genotype-lot combinations were studied in the laboratory as well as in the field. All the seed lots of six genotypes were subjected to various vigour tests and observations were recorded on test weight (g), seed density (g/cc), standard germination (%), seedling length (cm), seedling dry weight (mg), vigour index-I, vigour index-II, field emergence index (FEI), mean emergence time (MET, days) and total seedling establishment (SET, %). Considering all the seed vigour parameters, L1 seed lots of all the genotypes were found to be more vigorous than L2 seed lots of respective genotypes. The variety NRCSS-AM-1 was found more vigorous, followed by RMT-305 and RMT-354, whereas RMT-351 was found low vigorous.

**Keywords:** fenugreek, germination, seed lots, genotypes, vigour test

**INTRODUCTION**

 Fenugreek, commonly known as ‘methi’, is very important as a food, fodder and medicine. In North India, the crop is grown during the winter season as a leafy vegetable, seed or leaf spice for human consumption and fodder for the animals. Fenugreek seeds and leaves are a rich source of vitamin A, vitamin C, protein and minerals. The leaves are used as vegetable for human consumption and the seeds as a spice for adding nutritive value and flavour to the food articles and forage for animals and to some extent for medicinal purposes, being used as carminative, antipyretic, anthelmintic, tonic, aphrodisiac and cooling drink and have the anti-fertility actions too (Sethi et al. 1990; John 2003). Fenugreek has now assumed the status of an important export commodity.

 Fenugreek belongs to the Leguminosae family, is an important multi-use seed spice crop cultivated in India. There are two cultivated species of methi (Trigonella foenum-graecum and Trigonella corniculata) which are grown in the states of Rajasthan, Gujarat, Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, Maharashtra, Tamil Nadu and Andhra Pradesh. Quality seeds are a basic input for realising higher yields per unit area. The quality of a seed is usually determined by its purity, germination and health. Nowadays, seed vigour as a potential quality attribute has gained significance as germination alone does not reflect the field performance potential of a seed lot/variety under varied environmental conditions. The advantages of higher vigour seeds are most apparent in early seedling growth and are often associated with rapid and high rates of emergence and plant establishment.

The seed vigour comprises those seed properties which determine the potential for rapid, uniform emergence and development of normal seedlings under a wide range of field conditions (McDonald, 1980). Thus, seed vigour is a highly complex character governed by many parameters and requires the indexing of many components. A number of tests/parameters have been developed to evaluate seed vigour. With this enormous array of possible vigour tests available, appropriate procedures for choosing the best single or multiple predictors of seed performance are necessary.

**MATERIALS AND METHODS**

The present investigation was conducted using seeds of six fenugreek (Trigonella foenum-graecum L.) genotypes, namely RMT-361, RMT-303, RMT-354, RMT-351, RMT-305, and NRCSS-AM-1. These seed lots were stored under ambient laboratory conditions and evaluated through both laboratory and field studies. A comprehensive assessment of seed vigour was undertaken at the Seed Testing Laboratory, Department of Seed Science and Technology, Institute of Agricultural Sciences, Bundelkhand University, Jhansi (U.P.), using the following parameters: test weight (g), seed density (g/cc), standard germination (%), seedling length (cm), seedling dry weight (mg), vigour index-I, vigour index-II, field emergence index (FEI), mean emergence time (MET, days), and seedling establishment percentage (SET, %).

Laboratory studies were conducted using a factorial Completely Randomized Design (CRD), while field experiments followed a Randomized Block Design (RBD). Data were statistically analyzed following the procedures outlined by Panse and Sukhatme (1985). The formulas used for calculation of key vigour indices are as follows:

- **Vigour Index-I** = Germination (%) × Mean seedling length (cm)

 (Abdul-Baki and Anderson, 1973)

- **Vigour Index-II** = Germination (%) × Seedling dry weight (mg)

 (Abdul-Baki and Anderson, 1973)

- **Field Emergence Index (FEI)** =

 E1/D1 + (E2 - E1)/D2 + ... + (En - En-1)/Dn

 Where E is the cumulative number of seedlings emerged on day D

 (Maguire, 1962)

- **Mean Emergence Time (MET)** =

 Σ(n × D) / Σn

 Where n is the number of seedlings emerged on day D

 (Ellis and Roberts, 1981)

- **Seedling Establishment (%) (SET)** =

 (Number of seedlings established / Total seeds sown) × 100

**RESULTS AND DISCUSSION**

Significant differences were found among all the genotypes and their lots for vigour parameters. the test weight (1000-seed wt.) ranged from 1.367g to 1.467g, whereas seed density ranged between 1.193 to 1.293. Statistical analysis indicated significant differences among varieties and lots. On a mean basis, the genotype RMT-351 had low seed weight and high density, whereas genotype RMT-303, followed by genotype NRCSS-AM-1 recorded high test weight and low seed density. Moreover, both these characters were not found significantly associated with each other, indicating that it was not necessary that bold seeds have high density. The mean values of these physical parameters were found to be higher in fresh seed lots (L1) as compared to one-year-old lots (L2) of the genotype studied. It may also be due to ageing in ambient storage and environmental conditions prevailing at the time of seed development and maturation of the crop in respective seasons. Similar findings regarding significant variability in seed vigour traits due to genotype and storage conditions have also been reported in lettuce (Lactuca sativa) by Zhang et al. (2016), in soybean (Glycine max) by Singh and Mehta (2014), and in coriander (Coriandrum sativum) by Sharma et al. (2012), emphasizing the universal impact of genetic makeup and seed quality on seedling performance and establishment.

Among physiological parameters, the standard germination is the most widely used test for assessment of seed quality, seed vigour potential and planting value of different seed lots/varieties. The standard germination ranged from 71.33 to 82.00 per cent. Significant differences were observed within genotypes and lots. The genotypes RMT-305, followed by NRCSS-AM-1 and RMT-351, exhibited maximum and minimum germination, respectively. A little decline in germination (4.33%) was observed in one-year-old seed lot (L2, 74.00%) in comparison to the fresh harvested seed lot (L1, 78.00%). Similar results were reported in Indian mustard (Verma et al., 2003), turnip (Khan et al., 2005) and coriander (Desraj, 2002; Kumar, 2007 and 2010).

The growth parameters, like seedling length, dry matter accumulation, were used to determine the vigour indices (VI-I and VI-II) of seed lots/genotypes. The values of these parameters narrowly ranged from 8.01 to 8.64 cm and 0.009 to 0.011 mg per seedling, respectively. However, significant differences were noticed between lots for seedling length. Long seedlings were recorded in the genotype RMT-351, followed by RMT-303, while genotype NRCSS-AM-1 produced small seedlings among the genotypes. Similar findings were reported by Singh et al. (2003) in urdbean and mungbean, Nagarajan et al. (2004) in okra, Kumar (2004) in onion, Khan et al. (2005) in turnip. Magnitudes of the vigour index-I (VI-I) ranged between 578.00 to 679.26, whereas vigour index-II (VI-II) ranged between 0.667 to 0.867. Significant differences were observed among lots. Higher magnitudes for L1 seed lots than L2 lots clearly indicated that the seedling length decreased with the progression of the ageing period, as reported in turnip (Khan et al., 2005) and coriander (Kumar, 2010). High values of vigour indices were recorded for genotypes RMT-305 and NRCSS-AM-1 while low values for genotypes RMT-303 and RMT-351 revealed that the genotypes possessed comparatively high and low vigour, respectively. Field emergence index (FEI), mean emergence time (MET), and total seedling establishment (SET) varied from 3.66 to 4.90, 11.26 to 12.76 days and 40.667 to 56.667% among genotype-lot combinations, respectively.

The seed lots were observed as the main source of variation, due to which differences were found among genotype-lot combinations. Usually, seedlings of fresh seed lots (L1) emerged comparatively more rapidly and uniformly than one-year-old seed lots (L2). However, seedlings emerged almost uniformly across the genotypes. On the basis of field parameters, the genotype NRCSS-AM-1 emerged earlier and faster (FEI: 4.90 and MET: 11.26 days) and recorded maximum seedling establishment (56.66%), which indicated the highest seed vigour potential. In contrast, the genotype RMT-354 emerged slowly and late (FEI 3.66 and MET 12.76 days) and had minimum seedling establishment (40.66%), indicating its poor seed vigour potential. Thus, the genotype that emerged uniformly at a faster rate had better seedling establishment in the field. Pinthus and Kimel (1979) suggested speed of germination as a criterion of seed vigour in soybean. The values of field emergence of all the treatment combinations were found to be lower than the standard germination test. Moreover, it was also evident that the field parameters were greatly influenced by genotypic, edaphic and environmental factors. Similar findings were reported by Yanping et al. (2000) in onion, Desraj (2002) in coriander, Vijay Kumar (2003) in okra, and Demir et al. (2005) in brinjal.

**Table 1. Mean values of physical vigour parameters**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Test Weight (g)** | **Seed Density (g/cc)** | **Standard Germination (%)** |
| **Genotype** | **L1** | **L2** | **Mean** | **L1** | **L2** | **Mean** | **L1** | **L2** | **Mean** |
| RMT-361 (V1) | 1.46 | 1.38 | 1.42 | 1.260 | 1.23 | 1.24 | 78.66 | 72.00 | 75.33 |
| RMT-303 (V2) | 1.46 | 1.40 | 1.43 | 1.273 | 1.24 | 1.25 | 76.66 | 72.66 | 74.66 |
| RMT-354 (V3) | 1.45 | 1.40 | 1.42 | 1.280 | 1.23 | 1.25 | 78.66 | 71.33 | 75.00 |
| RMT-351 (V4) | 1.37 | 1.36 | 1.37 | 1.293 | 1.26 | 1.27 | 74.00 | 72.00 | 73.00 |
| RMT-305 (V5) | 1.45 | 1.39 | 1.42 | 1.260 | 1.24 | 1.25 | 82.00 | 79.33 | 80.66 |
| NRCSS-AM-1(V6) | 1.45 | 1.42 | 1.44 | 1.267 | 1.19 | 1.23 | 80.00 | 76.66 | 78.33 |
| **Mean** | 1.44 | 1.39 |  | 1.272 | 1.23 |  | 78.33 | 74.00 |  |
| **Range** | 1.37-1.46 | 1.36-1.42 |  | 1.260-1.293 | 1.19-1.26 |  | 74.00-82.00 | 71.33- 79.33 |  |
| **CD at 5%** |
| **Variety (A)** | 0.02 | 0.02 | 3.68 |
| **Lot (B)** | 0.01 | 0.01 | 2.12 |
| **(A X B)** | 0.03 | NS | NS |
| **CV (% )** | 1.2 | 2.5 | 4.1 |

**Table 2. Mean values of physiological vigour parameters**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Seedling length (cm)** | **Seedling dry weight (mg)** | **Vigour index-I** | **Vigour index-II** |
| **Genotype** | **L1** | **L2** | **Mean** | **L1** | **L2** | **Mean** | **L1** | **L2** | **Mean** | **L1** | **L2** | **Mean** |
| RMT-361 (V1) | 8.45 | 8.16 | 8.30 | 0.01 | 0.01 | 0.01 | 663.96 | 588.20 | 626.08 | 0.80 | 0.76 | 0.78 |
| RMT-303 (V2) | 8.63 | 8.23 | 8.43 | 0.09 | 0.09 | 0.09 | 661.56 | 598.00 | 629.78 | 0.70 | 0.66 | 0.68 |
| RMT-354 (V3) | 8.63 | 8.14 | 8.38 | 0.10 | 0.10 | 0.10 | 679.26 | 580.13 | 629.70 | 0.80 | 0.70 | 0.75 |
| RMT-351 (V4) | 8.64 | 8.03 | 8.33 | 0.10 | 0.09 | 0.10 | 639.86 | 578.00 | 608.93 | 0.73 | 0.66 | 0.70 |
| RMT-305 (V5) | 8.27 | 8.24 | 8.25 | 0.01 | 0.09 | 0.10 | 678.43 | 653.96 | 666.20 | 0.86 | 0.70 | 0.78 |
| NRCSS-AM-1 (V6) | 8.15 | 8.01 | 8.08 | 0.01 | 0.10 | 0.11 | 652.03 | 614.06 | 633.05 | 0.86 | 0.80 | 0.83 |
| **Mean** | 8.46 | 8.13 |  | 0.01 | 0.01 |  | 662.52 | 602.06 |  | 0.79 | 0.71 |  |
| **Range** | 8.15-8.64 | 8.01-8.24 |  | 0.10-0.01 | 0.10-0.01 |  | 639.86-679.26 | 578.00-653.96 |  | 0.70-0.86 | 0.66-0.80 |  |
| **CD at 5%** |
| **Variety (A)** | NS | NS | NS | NS |
| **Lot (B)** | 0.18 | NS | 20.49 | 0.07 |
| **(A X B)** | NS | NS | NS | NS |
| **CV (%)** | 3.2 | 1.2 | 4.7 | 13.9 |

**Table 3. Mean values of field parameters**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Field emergence index** | **Mean emergence time (days)** | **Total seedling establishment (%)** |
| **Genotype** | **L1** | **L2** | **Mean** | **L1** | **L2** | **Mean** | **L1** | **L2** | **Mean** |
| RMT-361 (V1) | 4.60 | 4.13 | 4.36 | 12.10 | 12.76 | 12.43 | 50.33 | 51.00 | 50.66 |
| RMT-303 (V2) | 4.43 | 3.83 | 4.13 | 11.80 | 12.76 | 12.28 | 49.00 | 44.33 | 46.66 |
| RMT-354 (V3) | 4.20 | 3.63 | 3.91 | 12.10 | 12.76 | 12.43 | 48.00 | 41.33 | 44.66 |
| RMT-351 (V4) | 4.73 | 4.36 | 4.55 | 12.16 | 12.50 | 12.33 | 55.66 | 49.66 | 52.66 |
| RMT-305 (V5) | 4.66 | 4.06 | 4.36 | 11.80 | 12.26 | 12.03 | 52.33 | 45.66 | 49.00 |
| NRCSS-AM-1 (V6) | 4.90 | 3.83 | 4.37 | 11.26 | 12.63 | 11.95 | 56.66 | 40.66 | 48.66 |
| **Mean** | 4.58 | 3.97 |  | 11.87 | 12.61 |  | 52.00 | 45.44 |  |
| **Range** | 4.20-4.90 | 3.63-4.36 |  | 11.26-12.16 | 12.26-12.76 |  | 48.00-56.66 | 40.66-51.00 |  |
| **CD at 5%** |
| **Variety (A)** | NS | NS | NS |
| **Lot (B)** | 0.24 | 0.29 | 3.24 |
| **(A X B)** | NS | NS | NS |
| **CV ( % )** | 8.4 | 4.2 | 9.8 |

**CONCLUSION**

The present investigation clearly demonstrated the presence of substantial genetic variability among the six fenugreek genotypes and their respective seed lots for key seed vigor and field emergence parameters. Significant differences were observed for most traits, highlighting the influence of both genotype and lot condition on seed quality. The L1 seed lots consistently exhibited superior performance in terms of standard germination, vigor indices, field emergence index, and seedling establishment percentage, underscoring the critical role of seed freshness in maintaining physiological quality.

Among the genotypes evaluated, NRCSS-AM-1 emerged as the most vigorous, followed by RMT-305 and RMT-354, whereas RMT-351 exhibited relatively poor vigor, indicating the need for further improvement or careful lot selection for its commercial use. The findings reaffirm the importance of selecting genetically superior genotypes and maintaining high-quality seed lots to ensure better seedling establishment and ultimately enhance crop productivity in fenugreek.

This study contributes valuable insights for seed technologists and plant breeders aiming to improve seed quality and establish robust screening protocols for vigor evaluation in fenugreek and similar legumes

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author (s) hereby declare that no generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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