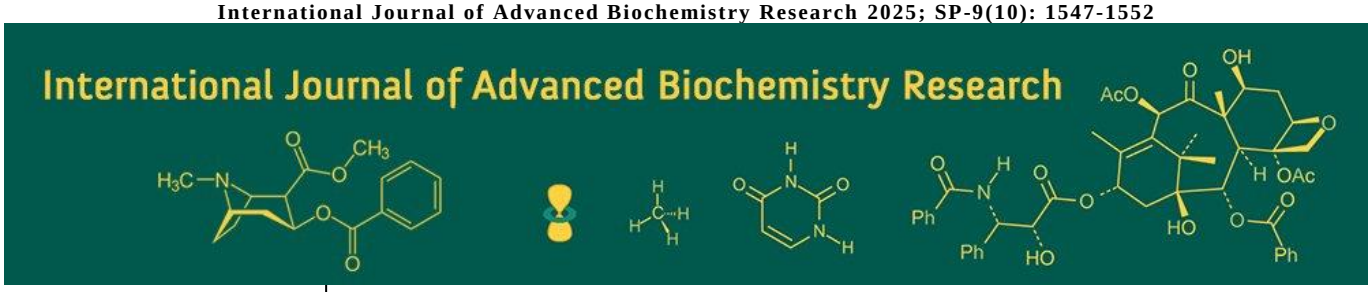

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Evaluation of seed quality parameters of different tomato (*Solanum lycopersicum* L.) genotypes

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Abstract
The present study was carried out on 32 tomato genotypes at Indian Agricultural Research Institute, New Delhi during 2021-22 with the objective to evaluate seed quality parameters of freshly harvested seeds from fully ripe tomato fruits. Among the seed quality parameters, germination percentage, shoot length, root length, total seedling length, seedling dry weight and seedling vigour index had been studied under the study. This study showed significant differences among 32 tomato genotypes for all the seed quality parameters, except root length. The germination percentage freshly harvested tomato seeds were ranged from 99% (H 410) to 4% (904117) across the genotypes. Highest seedling length observed in genotype H 412, whereas significantly lower seedling length demonstrated by genotype 904117. The genotype H 162 was found with significantly higher seedling dry weight, whereas genotype 904117 had significantly lowest seedling dry weight. Highest seedling vigour index I and seedling vigour index II observed in genotype H 410 and P. 120, respectively. Whereas lowest seedling vigour index had been observed in 904117 genotype. Among 32 tomato genotypes, H 391, H 410, H 412, and P. 120 were found to have significantly better seed quality after harvesting at fully ripe stage.

Keywords: Tomato, germination, seedling length, seedling dry weight and seedling vigour

1. Introduction
Tomato, *Solanumlycopersicum* (2n = 24) (Solanaceae; order Solanale), is the is one of the most important edible and nutritious vegetable crops, widely cultivated in tropical, sub-tropical and temperate climates in the world (Debela *et al.*, 2016) [4]. The origin of tomato is Peru of South America and name of crop came from the Aztec word "Tomato". China is leading country in tomato production across the world, whereas India ranks second in tomato production. The major tomato producing states in the country are Andhra Pradesh, Madhya Pradesh, Karnataka, Gujarat, Odisha, West Bengal, Maharashtra, Chhattisgarh and Bihar (Ravuri and Kumar, 2018) [10].

Numerous factors influence the germination, establishment of seedlings, and subsequent growth and development of any agricultural crop. Among these factors, seed quality is one of the most important factorto affect the success of crops. Various environmental factors significantly affect the seed quality during seed development, as well as harvesting, handling, and storage conditions (Finch, 2020) [6]. For sustainable and profitable crop production, good seedling establishment and seedling vigor are essential traits as critical stage of developing crop. Both the number of emerging seedlings, and the timing and uniformity of seedling emergence are greatly influenced by low seed vigour, which has major impact on crop production that determine cost effectiveness and the inputs required, and also has direct influence on the yield and marketing quality of a crop (McDonald, 1998) [9].

Among the seed of different tomato species, huge phenotypic variation has been observed. The wild species have several times smaller seed compared to cultivated tomato that derived from them through domestication and breeding (Khan *et al.*, 2012) [7]. Many studies have shown that initial seedling size is positively related to seed size, and larger seeds have better seedling survival rate as well as higher competitiveness both within species and among species. Root systems perform the crucial task of providing water, nutrients and physical support to the plant. The length of the main root and the density of the lateral roots determine the architecture of the root system in tomato and other dicots and play a major role in

determining whether a plant will succeed in a particular environment (Malamy *et al*., 1997) [8]. Evaluation of seed quality parameters is essential to identify the quality seed after harvesting and make available the quality seeds for next sowing.

2. Material and Methods

In this study, 32 tomato genotypes were used for the evaluation seed quality parameters. In which 17 were hybrids (H 81, H 162, H 319, H 391, H 403, H 405, H 406, H 408, H 409, H 410, H 411, H 412, H 413, H 414, H 415, H 416, and H 418), nine were parental lines (700933, 751806, 814915, 814916, 814917, 904111, 904113, 904115, and 904117), and six were varieties (Pusa Ruby, Pusa Gaurav, Pusa Rohini, MIDM, 396 TLCV, and Pusa 120). The freshly harvested seeds from fully ripe tomato fruits were used for present study.

2.1 Germination percentage

The germination test was conducted using the top of paper method according to the procedure given by ISTA (2021). The freshly harvested seeds from fully ripe tomato fruits were used for germination test. Before the germination test, the seeds of each tomato genotype were moistened for 18 hours and then dried at room temperature. The filter paper was moistened by dipping in double distilled water and excess water was removed by tilting the Petri plate. Twenty-five seeds of each replication were arranged properly in different Petri plates using filter paper as a substratum. These plates were placed inside the germination chamber at a regulated temperature of 25 ± 1 °C and 90 percent relative humidity. The number of germinated seeds was counted on the day of first count; and number of germinated, hard, diseased, and fresh ungerminated seeds were recorded on the day of final count. The germination percentage was calculated as follows:

$$Germination\ (\%) = \frac{Number\ of\ germinated\ seeds}{Total\ number\ of\ seeds\ kept\ for\ germination} \times 100$$

2.2 Shoot length (cm)

Five normal seedlings were randomly selected from each replication of the germination test. Shoot length of seedlings was measured in centimeters from shoot tip to the base of seedling.

2.3 Root length (cm)

Root length of seedlings were measured in centimeters from primary root tip to the base of seedling using the seedlings which has been used for the measurement of shoot length.

2.4 Total seedling length (cm)

Total seedling length was measured in centimeters through the sum of shoot length and root length.

Seedling length (cm) = Shoot length (cm) + Root length (cm)

2.5 Seedling dry weight (mg)

Five seedlings which had been used for the measurement of shoot length and root length were rolled inside butter paper after the measurement of fresh weight; and placed inside a hot air oven for 24 hours at 80 °C. The dry weight of each seedling was recorded by using a weighing balance and expressed in mg/5 seedlings.

2.7 Seedling vigor index

The vigour index was calculated using the method suggested by Abdul-Baki and Anderson (1971). The formulae used were as follows:

Seedling vigour index I = Germination (%) × Mean Seedling length

Seedling vigour index II=Germination (%) × Mean seedling dry weight

Statistical Analysis

All the experiments were performed in three replications and the data recorded were statistically analyzed in order to find out significant variation at 5% level of significance in studied parameters using one-way analysis of variance (ANOVA) and Tukey's test at $P \leq 0.05$ level of probability using SPSS Software (Release 15.0; SPSS Inc., Chicago, IL, USA).

3. Results and discussion

3.1 Germination percentage

The germination percentage was found significantly different among the genotypes with a standard deviation of 28 percent. The genotype H 410 was found with significantly higher germination percentage (99 percent), whereas the genotype 904117 had significantly lower germination percentage (4 percent) than all other genotypes under study. Out of 32 genotypes, 14 genotypes (H 81, H 408, H 409, H 413, H 415, H 416, H 418, 396 TLCV, 751806, 814915, 814916, 814917, 904113 and 904117) had <50 percent, 11 genotypes (H 162, H 319, H 405, H 406, H 411, H 414, P. Rohini, MIDM, 700933, 904111 and 904115) showed >50 but less than 80 percent, and seven genotypes (H 391, H 403, H 410, H 412, P. Ruby, P. Gaurav and P. 120) demonstrated >80 percent germination percentage (Figure 1).

Standard germination percentage is highly influenced by genetic constitution, storage condition, temperature and relative humidity (Ajala and Ajani, 2007 and Alhamdan *et al*., 2011). Ajala and Ajani (2007) reported standard germination percentage ranged from 29.0 to 95.0 percent in seven tomato genotypes across the two environments. The huge variability in germination (percent) warrants for research on seed quality enhancement treatments to improve the plant stand in nursery of tomatoes.

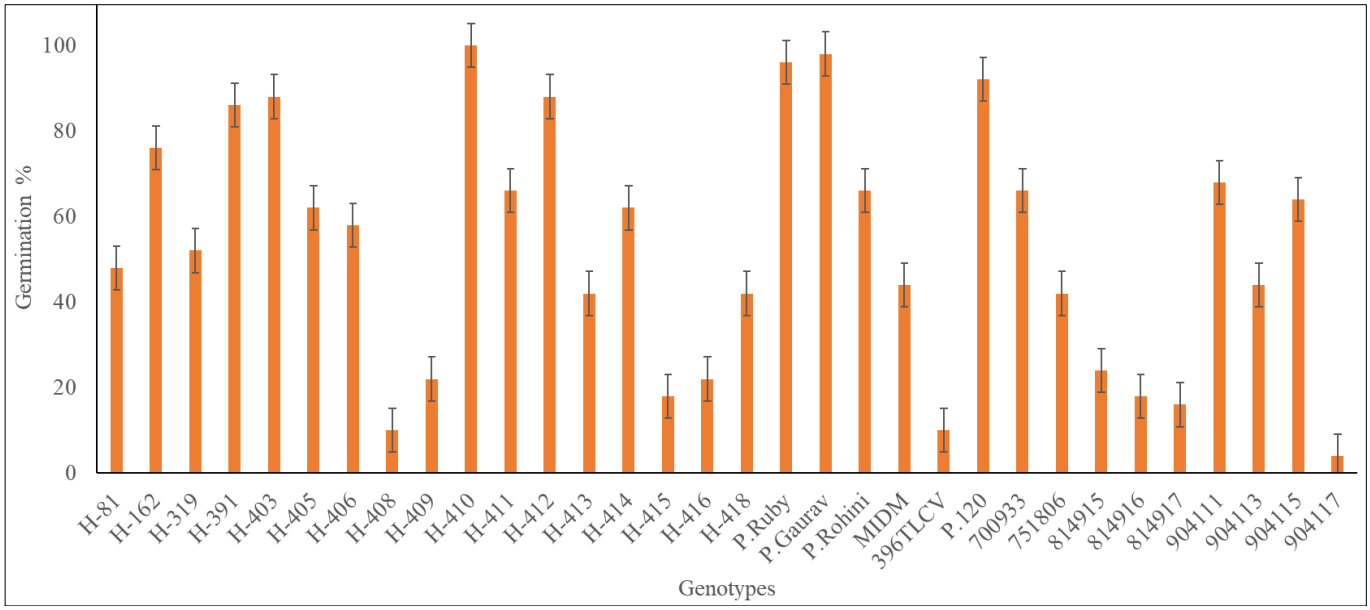

Fig 1: Variability in different tomato genotypes for germination percentage

3.2 Shoot length (cm)

Significant variations were observed among the genotypes for shoot length with a standard deviation of 1.85 cm. The genotype H 412 showed significantly higher shoot length (9.74 cm), whereas genotype 904117 had significantly lower shoot length (3.13 cm) compared to other genotypes. Out of 32 genotypes, five genotypes (H 409, H 415, H 416, 396 TLCV and 904117) observed with <5.00 cm, 15 genotypes (H 81, H 319, H 403, H 406, H 408, H 413, H 414, H 418, 700933, 751806, 814915, 814916, 814917, 904111 and 904113) showed >5.00 and <7.00 cm, eight genotypes (H 162, H 405, H 410, H 411, P. Ruby, P. Gaurav, MIDM and 904115) had >7.00 and <9.00 cm, and remaining four genotypes (H 391, H 412, P. Rohini and P. 120) had >9.00 cm shoot length (Figure 2).

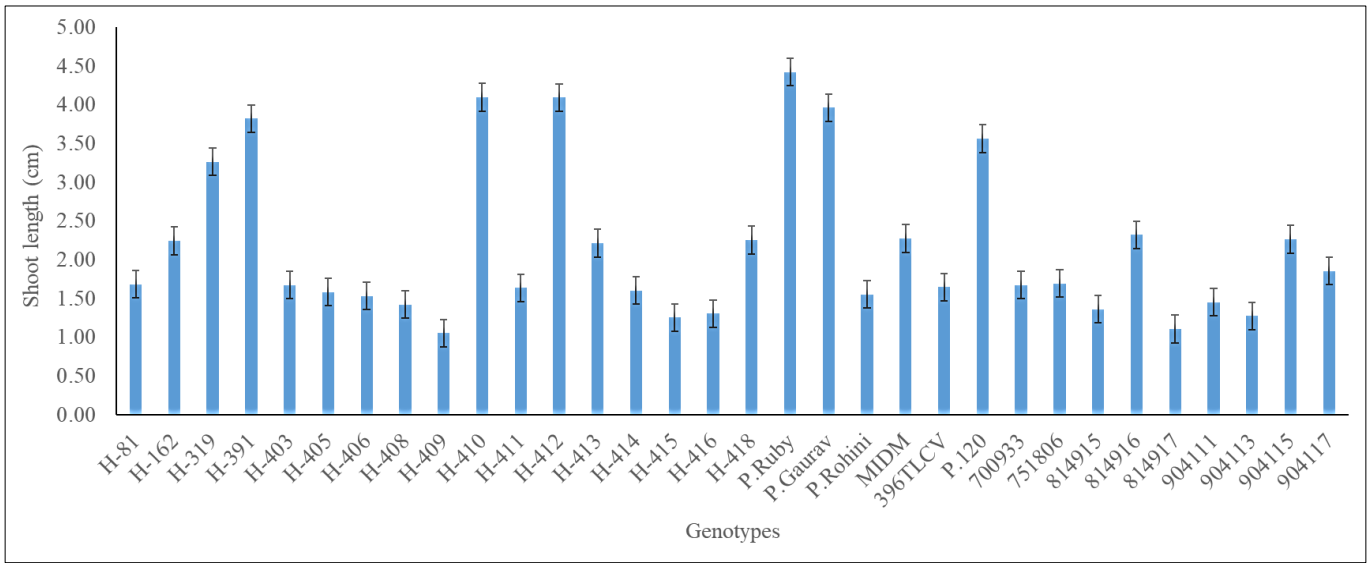

Fig 2: Variability in different tomato genotypes for shoot length (cm)

3.3 Root length (cm)

Non-significant differences were observed among the genotypes. The root length ranged from 1.28 cm to 3.95 cm in the genotypes with the average root length 2.34 cm. The genotypes. Numerically smaller root length (1.00-2.00 cm) was noticed in 15 genotypes viz.; H 408, H 409, H 415, H 416, P. Rohini, 396 TLCV, 700933, 751806, 814915, 814916, 814917, 904111, 904113, 904115 and 904117. Higher root length (>2.00 cm) was noticed in 17 genotypes viz.; H 81, H 162, H 319, H 391, H 403, H 405, H 406, H 410, H 411, H 412, H 413, H 414, H 418, P. Ruby, P. Gaurav, MIDM and P. 120 (Figure 3).

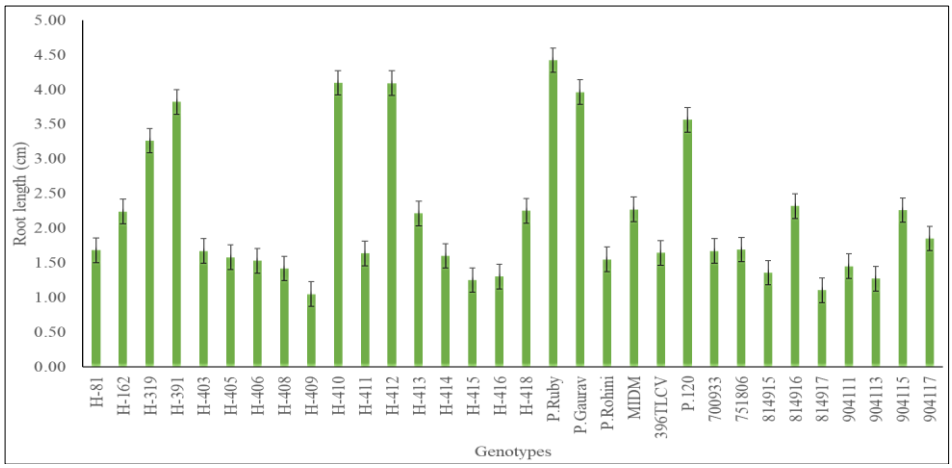

Fig 3: Variability in different tomato genotypes for root length (cm)

3.4 Total seedling length (cm)

The total seedling length was found significantly different among the genotypes with a standard deviation of 2.56 cm. Significantly higher seedling length was exhibited by genotype H 412 (13.29 cm), whereas significantly lower seedling length demonstrated by genotype 904117 (4.98 cm) than other genotypes under the study. In total, six genotypes (H 408, H 409, H 415, H 416, 396 TLCV and 904117) were found with <7.00 cm, 17 genotypes (H 81, H 319, H 403, H 405, H 406, H 411, H 413, H 414, H 418, MIDM, 700933, 751806, 814915, 814916, 814917, 904111 and 904113) showed >7.00 and <10.00 cm, seven genotypes (H 162, H 391, H 410, P. Ruby, P. Gaurav, P. Rohini and 904115) had >10.00 and <13.00 cm, and only two genotypes (H 412 and P. 120) had >13.00 cm seedling length (Figure 4).

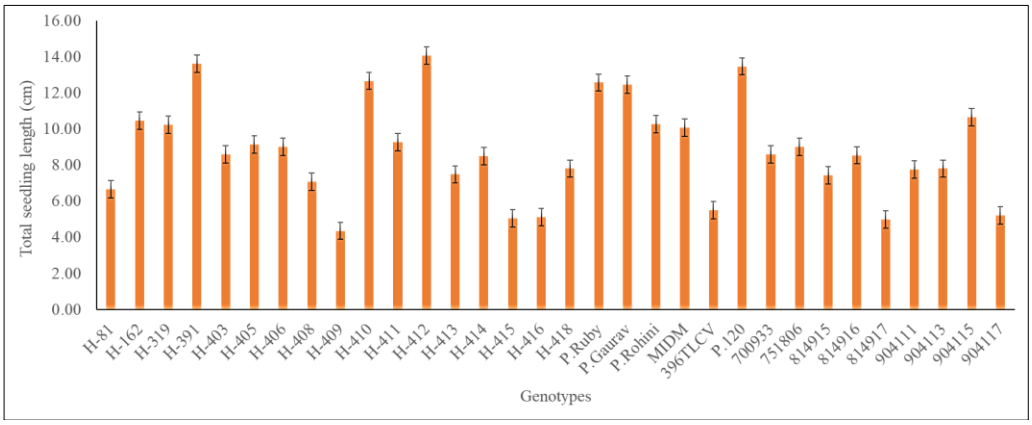

Fig 4: Variability in different tomato genotypes for total seedling length (cm)

3.5 Seedling dry weight (mg)

Significant differences were observed among the genotypes for seedling dry weight with a standard deviation of 0.63 mg. The genotype H 162 was found with significantly higher seedling dry weight (2.68 mg), whereas genotype 904117 had significantly lower seedling dry weight (0.72 mg) compared to all other genotypes. Nine genotypes (H 414, H 415, H 416, 700933, 814915, 814917, 904111, 904113 and 904117) demonstrated <1.00 mg, 14 genotypes (H 81, H 403, H 405, H 406, H 408, H 409, H 410, P. Gaurav, P. Rohini, MIDM, 396 TLCV, 751806, 814916 and 904115) showed >1.00 and <2.00 mg, and remaining nine genotypes (H 162, H 319, H 391, H 411, H 412, H 413, H 418, P. Ruby and P. 120) had >2.00 mg seedling dry weight (Figure 5).

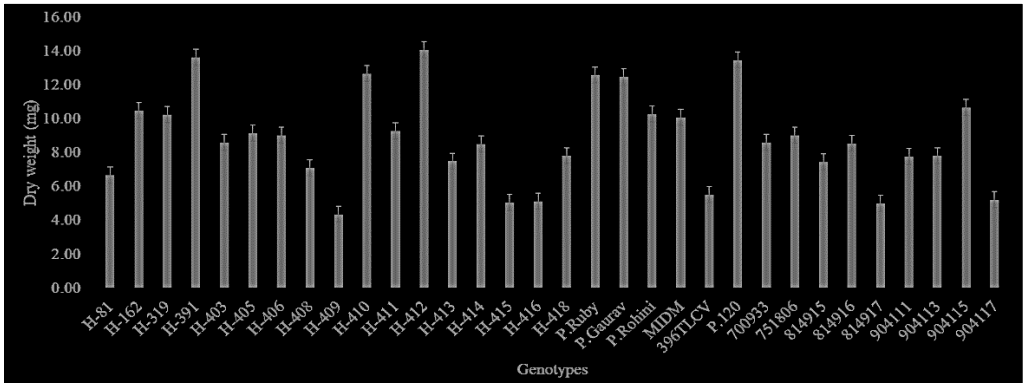

Fig 5: Variability in different tomato genotypes for dry weight (mg)

Demir and Ellis (1992) [5] observed maximum mean seedling dry weight in seeds harvested 75 days after anthesis in the third truss compared to second and third truss. Earlier studies observed small difference in seedling dry weight as it was ranged from 0.63 to 1.07 mg across nine tomato varieties (Debela *et al*., 2016) [4].

3.6 Seedling vigour index

The seed vigour index I was found significantly different among the genotypes with a standard deviation of 379. The genotype H 410 exhibited significantly higher seed vigour index I (1223), whereas genotype 904117 showed significantly lower seed vigour index I (20) compared to all other genotypes under the study. Out of 32 genotypes, nine genotypes (H 408, H 409, H 415, H 416, 396 TLCV, 814915, 814916, 814917 and 904117) were found with <300, 13 genotypes (H 81, H 319, H 405, H 406, H 411, H 413, H 414, H 418, MIDM, 700933, 751806, 904111 and 904113) showed >300 and <600, four genotypes (H 162, H 403, P. Rohini and 904115) had >600 and <900, five genotypes (H 391, H 412, P. Ruby, P. Gaurav and P. 120) had >900 and <1200, and only one genotype (H 410) had >1200 seed vigour index I (Figure 6).

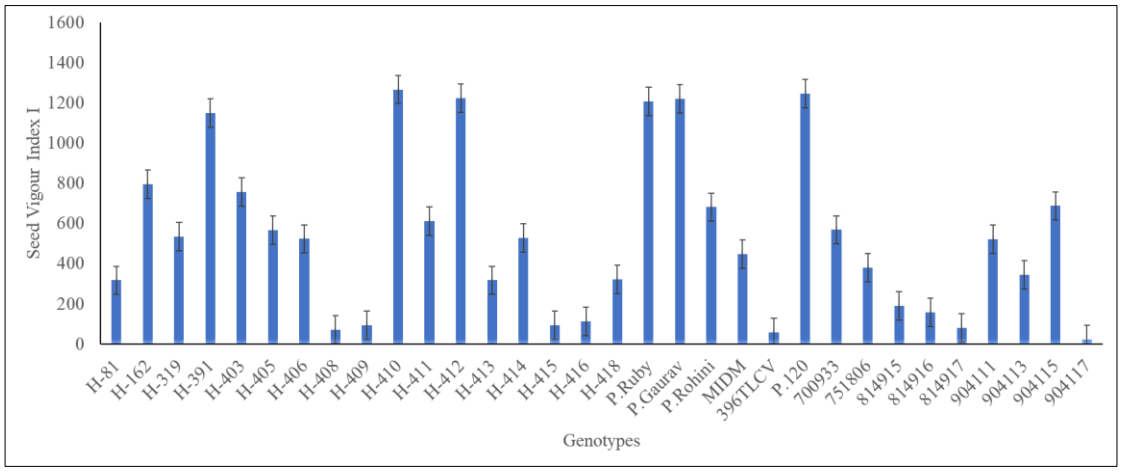

Fig 6: Variability in different tomato genotypes for Seed Vigour Index I

Significant differences were found among the genotypes for seed vigour index II with a standard deviation of 0.067. The genotype P. 120 was observed with significantly higher seed vigour index II (0.223), whereas genotype 904117 had significantly lower seed vigour index II (0.003) compared to other genotypes under the study. In total, 18 genotypes (H 81, H 408, H 409, H 414, H 415, H 416, H 418, MIDM, 396 TLCV, 700933, 751806, 814915, 814916, 814917, 904111, 904113, 904115 and 904117) demonstrated <0.100, 11 genotypes (H 319, H 391, H 403, H 405, H 410, H 411, H 413, P. Ruby, P. Gaurav and P. Rohini) showed >0.100 but less than 0.200, and only three genotypes (H 162, H 412 and P. 120) had >0.200 values of seed vigour index II (Figure 7).Seedling vigour index is governed by multigene hence it shows low heritability and heavily influenced by environmental factors (Ajala and Ajani, 2007).

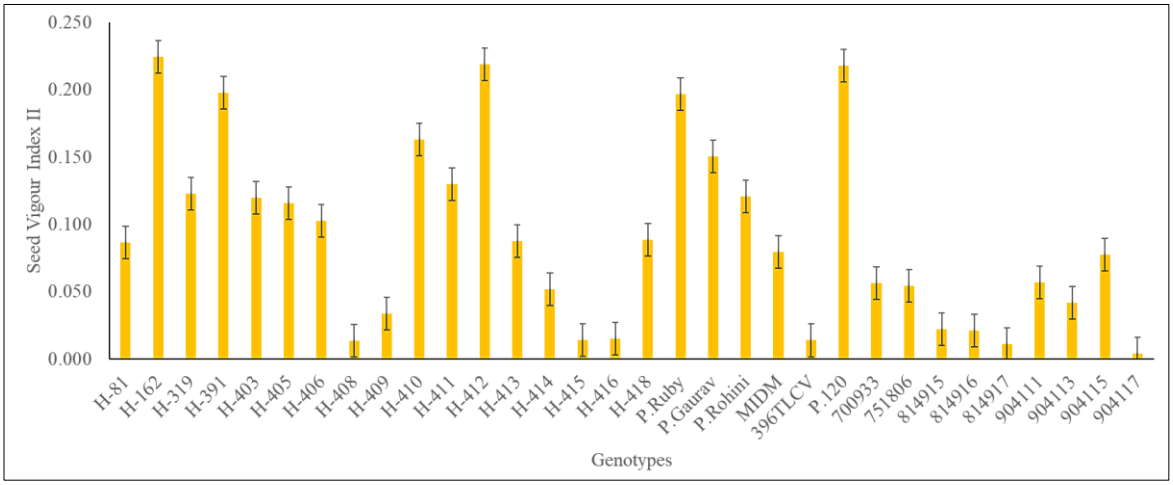

Fig 7: Variability in different tomato genotypes for Seed Vigour Index II

Summery and Conclusion

The different seed quality parameters of the freshly harvested/extracted seeds from the fully ripe tomato fruits of 32 genotypes were studied *viz.;* the seed quality parameters were; germination percentage, shoot length, root length, total seedling length, seedling dry weight, seed vigour index I and seed vigour index II. Significant variations were observed in seed quality parameters, except root length. Most of the seeds of parental lines were found to have inferior quality compared to varieties and hybrids, mainly; seedling dry weight and SVI-II. The genotypes H 391, H 403, H 410, H 412, P. Ruby, P. Gaurav and P. 120 were found to have significantly better seed quality after harvesting at fully ripe stage.

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