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Influence of Ty Gene on Seed Quality of Tomato (*Solanaum lycopersicon* Mill.)

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Abstract

Tomato (*Solanam lycopersicon* Mill.) is most popular vegetable crop cultivated across India and can be considered as indispensable vegetable in the kitchen. The productivity of crops is affected by the seed quality which determines seed germination, vigour and viability. The experiment was conducted to evaluate the performance of tomato genotypes for identifying the suitable genotypes with higher seed quality in the Department of Seed Science and Technology during the year 2020-21. The results revealed that there is a significant differences among genotypes and the range and the mean performance of genotypes for seed quality traits *viz.,* seed germination (55.75-98.75%, 83.54), root length (2.5-9.1cm, 4.97 cm), shoot length (5.72-10.64 cm, 8.38 cm), seedling length (9.67-19.01cm, 13.35 cm), seedling fresh weight (247- 463 mg/10 seedlings, 369.60 mg/10 seedlings), seedling dry weight (24.65- 52.65 mg/ 10 seedlings, 36.91 mg/10 seedlings), seedling vigour index-I (687 -1568, 1119.40) and seedling vigour index-II (163-502, 309.59), electrical conductivity (31.30-82.01 µS/cm/g, 49.71 µS/cm/g) and total dehydrogenase activity (0.065-1.050, 0.43). The assessment revealed that the genotypes NBLTM-10, NBLTM-17, NBLTM-18, NBLTM-24 and NBLTM-25 which were superior in respect of their seed quality parameters taken under observation and they can be used for further breeding programmes.

Keywords : Tomato genotypes, Ty gene, Seed quality

Tomato (*Solanum lycopersicon* Mill.) is one of the most important and popular fruit vegetable in the world. It is a self-pollinated annual crop and belongs to the family Solanaceae with chromosome number 2n=2x=24 and is most widely known as vegetable for processing and protective food. It is originated in Tropical America (Salunkhe *et al*., 1987). It is mostly used for salads, soups, pickles, sauces etc. It has higher contents of vitamin A, B and C, Calcium, Carotene and rich in medicinal value. Davies and Hobes (1981) revealed that tomato has a significant role in nutrition as it is rich source of lycopene, minerals and ß-carotene which has anti-oxidants and promote good health. The well ripe tomato (per 100 g of edible portion) contains water (94.1 %), energy (23 calories), calcium (1.0 g), magnesium (7.0 mg), vitamin A (1000 IU), ascorbic acid (22 mg), thiamin (0.09 mg), riboflavin (0.03 mg) and niacin (0.8 mg). It also contains organic acids like citric, malic and acetic acids which are found in fresh tomato fruit, promotes gastric secretion, acts as a blood purifier and works as intestinal antiseptic. It is anti-cancerous in nature due to lycopene, helps to counteract the harmful effects of free radicals, which contributes to age-related processes (Masroor *et al*., 1988).

With the expansion of tomato users, the 20th century was marked by the development of private seed industries which developed the principle of the F_1 hybrid (Bai and Lindhout, 2007). Among all the

diseases of tomato, the tomato leaf curl virus (ToLCV) is the most destructive viral disease and causes loss of yield between 85 per cent and 100 per cent. ToLCV is transmitted by the whitefly *Bemisia tabaci* (Ghanim and Czosnek, 2000). Although *Ty-3* gene provides wide resistance, the *Ty-3a* gene is mostly preferred in breeding program because of many undesirable morphological traits that are related with *Ty-3* gene. There is no effective chemical treatment to control viral diseases that results in severe damage, such as ToLCV. Therefore, use of resistant varieties is the best and environmentally friendly method for pathogen management (Oerke, 2006 and Mutlu *et al*., 2015).

Systematic studies and evaluation of genotypes is of great importance for current and future improvement of crop both agronomically and genetically (Singh *et al*., 2006). Reshuffling the genes through recombination is the principle way of developing improved genotypes. The breeding strategy involves assembling or generating and developing the different source of resistance and selection of superior genotypes for using hybridization. There will be a wide range of variation in tomato genotypes for all the characters right from seedling stage, vegetative stage and reproductive stage (Raghavendra *et al*., 2019). The environment and genotype influences on the development of character and the quality of the seed. The genotypes with good quality is assessed, helps in planning for storage and that helps in breeding programme. The objective of this preliminary study was to examine the seed quality traits of tomato genotypes.

Material and Methods

The seed material for the study comprised of 30 genotypes (Table 1) of tomato were collected from Noble Seeds Pvt. Ltd., Yelahanka, Bengaluru. The freshly harvested seeds were used to assess the seed quality traits *i.e.,* seed germination (%), root length (cm), shoot length (cm), seedling length (cm), electrical conductivity (µS/cm/g), seedling fresh weight (mg/10 seedling), seedling dry weight (mg/10 seedling), seedling vigour index I and II and total dehydrogenase activity (A_{480} nm).

Details of the Experiment

Crop : Tomato
Design : Completely Randomised Design
Treatment : 30 genotypes
Replication : 4

Table 1
List of Genotypes used in the study

Genotype	Gene present	Genotype	Gene present
NBLTM-1	Ty-3	NBLTM-16	No genes
NBLTM-2	Ty-3	NBLTM-17	Ty-3
NBLTM-3	Ty-3	NBLTM-18	Ty-3
NBLTM-4	Ty-3	NBLTM-19	Ty-3
NBLTM-5	Ty-3	NBLTM-20	Ty-3
NBLTM-6	Ty-6	NBLTM-21	No genes
NBLTM-7	Ty-3	NBLTM-22	No genes
NBLTM-8	Ty-3	NBLTM-23	No genes
NBLTM-9	Ty-3	NBLTM-24	Ty-6
NBLTM-10	Ty-3	NBLTM-25	No genes
NBLTM-11	Ty-3	NBLTM-26	Ty-2 and Ty-3
NBLTM-12	Ty-2 and Ty-3	NBLTM-27	Ty-2 and Ty-6
NBLTM-13	No genes	NBLTM-28	Ty-2
NBLTM-14	Ty-2 and Ty-3	NBLTM-29	Ty-2, Ty-3 and Ty-5
NBLTM-15	Ty-6	NBLTM-30	Arka Vikas

Seed Quality Parameters

Seed Germination (%)

The standard germination test was carried out by using between paper method as per the ISTA procedure. Hundred seeds in four replications were taken from each treatment and placed on germination paper uniformly. The rolled towels were kept in a germination chamber maintained at 25 ± 1^{0}C temperature and 90 ± 5 per cent relative humidity. The first and final count were taken on 5th and 14th day of germination test respectively. The number of normal seedlings from each replication were counted and the mean germination was expressed in percentage (ISTA, 2013).

Shoot Length (cm)

From the germination test, ten normal seedlings were selected randomly from each treatment from all the replications on 14th day. The shoot length was measured from the base of the primary leaf to the base of the hypocotyl and mean shoot length was expressed in centimetre.

Root Length (cm)

From the germination test, ten normal seedlings were selected randomly from each treatment from all the replications on 14th day. The root length was measured from the tip of the primary root to base of hypocotyl and mean root length was expressed in centimetre.

Mean Seedling Length (cm)

Ten normal seedlings from each of the replication of the germination test were carefully removed on 14th day and used for measuring seedling length. The seedling length from tip of shoot to tip of root was measured and the average length of the seedling was expressed in centimetre.

Mean Seedling Fresh Weight (mg)

From the germination test, the same ten seedlings used for measuring the root and shoot length were used to take the fresh weight of seedlings. The fresh weight of seedlings was recorded by using electronic balance and it was expressed in milligrams

Mean Seedling Dry Weight (mg)

From the germination test, the same ten seedlings used for measuring the root and shoot length were kept in a butter paper packet and dried in hot air oven maintained at 70° ± 1°C for 24 hours. Then the seedlings were cooled in a desiccator for 30 minutes and the dry weight of the seedlings was recorded by using electronic balance and was expressed in milligrams.

Seedling Vigour Index (SVI)

The seedling vigour index-I and II were calculated by employing the formula given by Abdul-Baki and Anderson (1973).

SVI I = Germination (%) x Total seedling length (cm)

SVI-II = Germination (%) x Mean seedling dry weight (mg)

Electrical Conductivity (µS/cm/g)

Five grams of seeds in four replications were soaked in acetone for half a minute and thoroughly washed three times in distilled water. Then, the seeds were soaked in 25 ml of distilled water and kept in an incubator maintained at 25°C ± 1°C for 12 h. The seed leachate was collected and the volume was made up to 25 ml by adding distilled water. The electrical conductivity of the seed leachate was measured in the digital conductivity bridge (ELICO) with a cell constant 1.0 and the mean values were expressed in micro siemens per centimetre per gram (Milosevic *et al*., 2010).

Total Dehydrogenase Activity

The total dehydrogenase activity was determined by method described by Perl *et al*. (1978). After soaking seeds in distilled water were used to determine the total dehydrogenase activity. Seed coat of these imbibed seeds were carefully removed and then soaked with 0.5 per cent tetrazolium solution at 30 ± 1ºC for a period of 24 hours. Then they were washed thoroughly in distilled water. The red colour (Formazan) was diluted from the stained embryos by soaking in 5ml of 2 methoxyethanol (methyl cello solve) for 24 hours in an air tight screw capped vials.

The extract was decanted and the colour intensity was measured with the help of Spectrophotometer (Model-Systronics UV-VIS spectrophotometer) at 480 nm. The dehydrogenase activity was expressed in terms of optical density at 480 nm.

Results and Discussion

The performance of tomato genotypes based on seed quality parameters (Table 2 and 3) studied are summarised here.

The data obtained from the experiment indicated that significant variations in all the genotypes for seed quality parameters (Table 2). Variation of germination percentage among the different genotypes is shown in Fig. 1. The highest seed germination per cent was recorded in NBLTM-24 and NBLTM-18 (98.5 %) followed by NBLTM-23 (97.5 %), NBLTM-12 (96.0 %) and NBLTM-25 (95.25 %) and the lowest (55.8 %) was found in NBLTM-26. Among 30 genotypes studied 24 genotypes had better seed germination than their overall mean performance (83.5 %).

The response of the genotype towards the insertion of resistant gene is independent. Hence, the resistant gene effect on particular genotype is specific and observed the lower seed germination in specific Ty-3 gene in few genotypes. It may also paralleled with higher test weight with superior quality in terms of seed germination and seedling vigour. The lowest seed germination percentage could be attributed to immature embryos and lower food reserves. The similar findings were reported in carrot (Pereira *et al*., 2008).

The results root, shoot and seedling length varied significantly among genotypes (Table 2). The highest (9.15 cm) root length is observed in the NBLTM-2 followed by NBLTM- 10 (8.48 cm) and the lowest (2.48 cm) root length was observed in the NBLTM-29. Among the genotypes the significant difference was also observed for the shoot length. The highest shoot length (10.64 cm) was observed in NBLTM-7 and followed by NBLTM-14 and NBLTM- 10 (10.56 and 10.53 cm, respectively). Whereas, the lowest (5.72 cm) shoot length was found in NBLTM-3. The seedling length was also found significant among the genotypes. The highest (19.01 cm) seedling length was observed in NBLTM-10, followed by NBLTM-2 (18.05 cm) and the lowest (9.67 cm) was found in NBLTM-29. The results on higher seedling quality parameters implies the earliness of the genotype with respect to seed germination. Increasing the trend of seedling length in the genotypes was accompanied with good germination capacity of the seeds. These

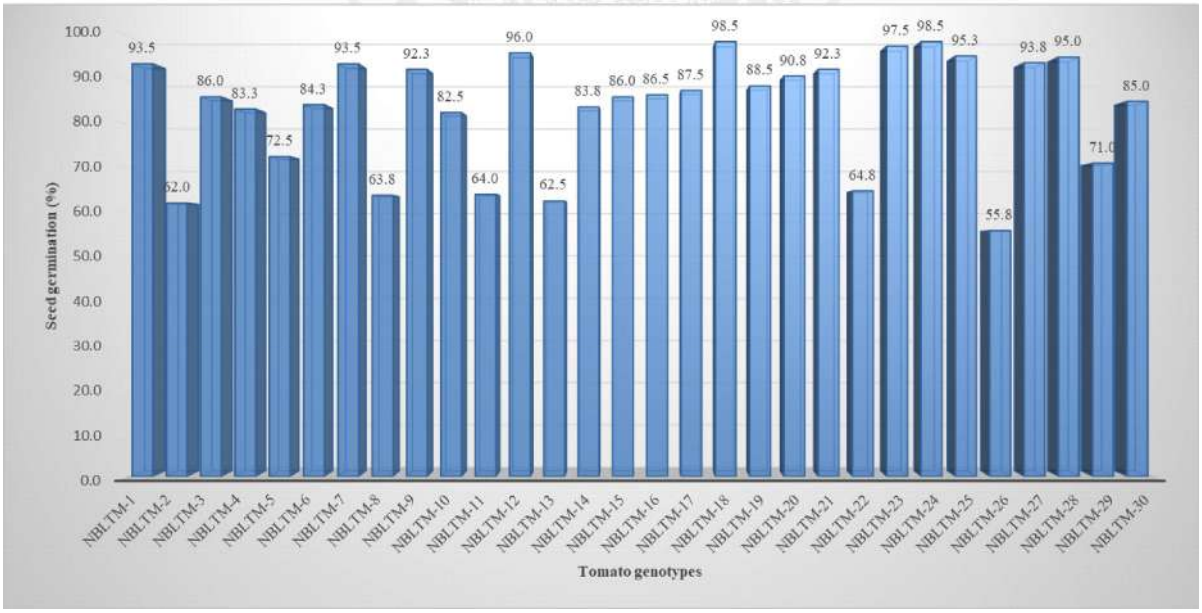

Fig. 1 : Influence of Ty gene on seed germination (%) of different tomato genotypes

TABLE 2

Influence of Ty gene on seed germination (%), root length (cm), shoot length (cm), seedling length (cm) and seedling fresh weight (mg/10 seedlings) of tomato

Genotype	Seed germination (%)	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Seedling fresh weight (mg)
NBLTM-1	93.50	4.2	8.38	12.63	34.5
NBLTM-2	62.00	9.1	8.90	18.05	41.3
NBLTM-3	86.00	5.9	5.72	11.60	40.9
NBLTM-4	83.25	4.3	8.10	12.44	37.6
NBLTM-5	72.50	2.6	8.64	11.22	41.1
NBLTM-6	84.25	4.5	8.42	12.92	34.0
NBLTM-7	93.50	4.1	10.64	14.78	38.8
NBLTM-8	63.75	3.7	7.75	11.43	38.1
NBLTM-9	92.25	4.1	7.67	11.75	27.9
NBLTM-10	82.50	8.5	10.53	19.01	45.8
NBLTM-11	64.00	3.7	8.04	11.79	30.1
NBLTM-12	96.00	4.6	9.85	14.50	34.5
NBLTM-13	62.50	4.8	7.99	12.76	39.5
NBLTM-14	83.75	4.7	10.56	15.24	41.8
NBLTM-15	86.00	4.3	7.21	11.54	33.5
NBLTM-16	86.50	8.1	7.04	15.18	32.0
NBLTM-17	87.50	4.2	9.11	13.29	46.3
NBLTM-18	98.50	5.1	8.96	14.10	39.6
NBLTM-19	88.50	5.1	7.55	12.64	39.0
NBLTM-20	90.75	6.2	6.41	12.64	34.9
NBLTM-21	92.25	4.4	7.53	11.90	34.9
NBLTM-22	64.75	5.2	7.29	12.45	39.6
NBLTM-23	97.50	5.6	9.13	14.74	38.0
NBLTM-24	98.50	6.3	8.98	15.25	36.6
NBLTM-25	95.25	5.4	10.43	15.87	52.7
NBLTM-26	55.75	4.3	8.35	12.64	29.2
NBLTM-27	93.75	4.0	6.91	10.94	29.7
NBLTM-28	95.00	5.0	8.41	13.37	34.3
NBLTM-29	71.00	2.5	7.19	9.67	24.7
NBLTM-30	85.00	4.5	9.64	14.13	37.9
Mean	83.54	4.97	8.38	13.35	36.96
S±Em	0.69	0.3	0.06	0.34	1.17
CD	2.55	1.3	0.21	1.27	4.34
CV	1.64	6.3	1.32	5.10	0.63

TABLE 3

Influence of Ty gene on seedling dry weight (mg/10 seedlings), seedling vigour index I, Seedling vigour index II, electrical conductivity (µS/cm/g) and Total

Genotype	Seedling dry weight (mg)	Seedling vigour index I	Seedling vigour index II	Electrical conductivity (µS/cm/g)	Total dehydrogenase activity (A480nm)
NBLTM-1	3.45	1180	323	47.8	1.050
NBLTM-2	4.13	1121	256	63.6	0.146
NBLTM-3	4.10	998	352	32.41	0.501
NBLTM-4	3.80	1035	313	37.43	0.468
NBLTM-5	4.11	813	298	49.44	0.092
NBLTM-6	3.40	1089	287	79.59	0.284
NBLTM-7	3.90	1381	363	52.84	0.372
NBLTM-8	3.81	729	243	62.33	0.362
NBLTM-9	2.79	1084	257	51.2	0.301
NBLTM-10	4.58	1568	378	39.69	0.749
NBLTM-11	3.01	754	193	66.57	0.364
NBLTM-12	3.45	1392	331	41.02	0.417
NBLTM-13	3.95	797	247	47.09	0.863
NBLTM-14	4.18	1276	350	73.88	0.246
NBLTM-15	3.35	992	288	37.7	0.695
NBLTM-16	3.20	1313	277	47.84	0.272
NBLTM-17	4.63	1163	405	37.17	0.548
NBLTM-18	3.95	1389	390	59.34	0.431
NBLTM-19	3.90	1118	345	50.85	0.209
NBLTM-20	3.49	1147	317	45.82	0.488
NBLTM-21	3.49	1098	322	35.06	0.382
NBLTM-22	3.11	806	256	82.01	0.537
NBLTM-23	3.80	1437	370	39.95	0.309
NBLTM-24	3.70	1502	360	31.39	0.329
NBLTM-25	5.27	1512	502	40.52	0.449
NBLTM-26	2.92	704	163	59.59	0.816
NBLTM-27	2.65	1025	279	31.1	0.399
NBLTM-28	3.43	1270	326	39.87	0.439
NBLTM-29	2.47	687	175	80.73	0.446
NBLTM-30	3.79	1201	322	27.54	0.065
Mean	3.69	1119.40	309.59	49.71	0.43
S±Em	0.12	23.71	10.51	1.68	0.0012
CD	0.43	88.21	39.09	6.27	0.0046
CV	0.63	4.24	6.79	6.78	0.5726

dehydrogenase activity (A480nm) of tomato

results are in conformity with Kumar (2007), Pant (2008) and Prasad (2009) in pea.

The data on the fresh weight (Table 2) and dry weight (Table 3) of the seedlings found significant among genotypes. The highest (52.70 mg) seedling fresh weight was recorded in NBLTM- 25 followed by NBLTM-17 (46.30 mg) and NBLTM-10 (45.80 mg). The lowest (24.7 mg) seedling fresh weight was observed in NBLTM- 29. The highest (52.65 mg) seedling dry weight recorded in NBLTM-25, followed by the NBLTM-17 and NBLTM-10 (4.63 mg and 4.58 mg, respectively). Whereas, the lowest (2.47 mg) seedling dry weight was found in NBLTM- 29.

The data on seedling vigour index I and II varied among the genotypes that dependent on the length and weight of seedlings respectively (Table 3, Fig. 2). The highest (1568) seedling vigour index I was recorded in NBLTM-10 followed by NBLTM-25 (1512) and NBLTM (1504) and the lowest (687) was found in NBLTM-29. The highest (502) seedling vi was noticed in NBLTM-25 followed by NBLTM-17 and NBLTM-18 (405 and 390, respectively). Whereas, the lowest (163) was observed in NBLTM-26.

The fresh mass, dry mass and vigour of seedling is specific and varies among the genotypes. The increase in seedling length, seedling fresh weight, seedling dry weight, vigour index-I, vigour index-II parameters are related with germination rate and per cent germination of seedlings. The seedling root and shoot length, also influences the seedling characters that can be attributed to the inherent genotypic capacity and differential response for seedling vigour indices. These results were in conformity with Kaya *et al*. (2008) in Chickpea and Kumar *et al*. (2017) in Coriander.

The genotypes differed significantly for electrical conductivity (Table 3). The lowest (27.54 µS/cm/g) electrical conductivity was found in NBLTM- 30, followed by NBLTM-27 and NBLTM-24 (31.30 and 31.39 µS/cm/g, respectively) and the highest (82.01 µS/cm/g) electrical conductivity was found in NBLTM-22. The conductivity of leachates will reflect to the vigour of seed, where it depends on the membrane integrity, more leakage of solutes are lesser the content of electrical conductivity and vice versa. This might be due to there is strong correlation between conductivity of seed leachates and membrane integrity. Similar results were also reported by Mewael *et al.* (2010) in soybean, Ranganayaki and Ramamoorthy (2015) and Gangaraju & Balakrishna (2016) in blackgram.

The data on total dehydrogenase activity was differed significantly among the genotypes. The highest (1.050) TDH recorded in NBLTM-1 followed by the

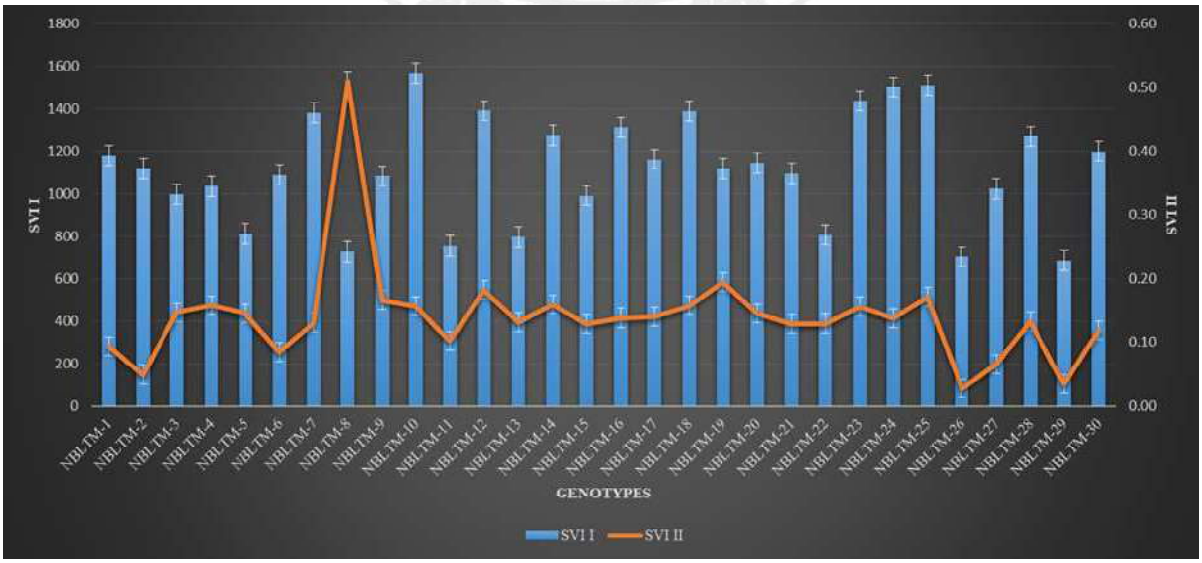

Fig. 2 : Influence of Ty gene on seedling vigour index I and seedling vigour index II of tomato genotypes

NBLTM-13 and NBLTM- 26 (0.8633 and 0.8163 respectively). Whereas, the lowest (0.0953) TDH was found in NBLTM-5. The dehydrogenase activity is directly proportional to the seed vigour and other quality parameters which are positively related with the improved nutrition during seed development and seed filling. Similar results were also reported in onion by Ashok *et al.* (2019).

The present investigation revealed that the performance of the tomato genotypes for seed quality could be significantly differed. The differences influenced the seed quality in various parameters among the genotypes that can be attributed to the diverse genetic makeup of the genotypes, climatic suitability of a region, nutrient availability, harvesting stage, seed weight, seed size during the development and seed filling. It can be concluded that the performance of NBLTM-10, NBLTM-17, NBLTM-18, NBLTM-24 and NBLTM-25 had highest value for most of seed quality parameters. Whereas, NBLTM-26 and NBLTM-29 had maintained lower seed quality characteristics. With the understanding of all these seed quality parameters in tomato genotypes and these results are utilized for further crop improvement programme in the developing of new varieties.

References

Abdul-Baki, A. A. and Anderson, J. D., 1973, Vigour determination in soybean seed by multiple criteria. *Crop Sci.*, **13** (6) : 630 - 633.

Ashok, K., Basavegouda, Vasudevan, S. N., Doddagoudar, S. R., Patil, M. G. and Arunkumar, H., 2019, Effect of foliar spray of micronutrients and growth regulators on growth and seed yield of onion. *Green Farming*, **10** (2) : 230 - 233.

Bai, Y. and Lindhout, P., 2007, Domestication and breeding of tomatoes : What have we gained and what can we gain in the future. *Ann. Bot.*, **100** : 085 - 1094.

Davies, G. M. and Hobes, G., 1981, The constituent of tomato fruit the influence of environment nutrition and genotypes. *Critical Rev. Food Sci. Nutri.*, **15** : 205 - 280.

Gangaraju, N. and Balakrishna, P., 2016, Screening of black gram genotypes for hard seededness and breaking of hard seededness by using various seed treatment methods in black gram (*Vigna mungo* L. Hepper*). Mysore J. Agric. Sci*., **50** (2) : 434 - 437.

Ghanim, M. and Czosnek, H., 2000, Tomato yellow leaf curl gemini virus (TYLCV-Is) is transmitted among whiteflies (*Bemisia tabaci*) in a sex-related manner. *J. Virol*., **74** : 4738 - 4745.

Ista, 2013, International Rules of Seed Testing. *Seed Sci. Technol*., **27** : 25 - 30.

Kaya, M., Kaya, G., Kaya, M. D., Atak, M., Saglam, S., Khawar, K. M. and Ciftci, C. Y., 2008, Interaction between seed size and NaCl on germination and early seedling growth of some Turkish cultivars of chickpea (*Cicer arietinum* L.). *J. Zhejiang University of Science,* **9** : 371 - 377.

Kumar, V., 2007, Studies on seed quality parameter in diffrent pea (*Pisum sativum* L.) genotypes under hill condition. *M.Sc. Thesis* submitted to G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India.

Kumar, V., Malik, T. P., Tehlan, S. K. and Kumar, A., 2017, Association among various seed quality parameters in Coriander. *Int. J. Pure App. Biosci.,* **5** (1) : 876 - 883.

Masroor, Khan, A., Champa, Firoz, Manzer and Naeem, H., 1988, Effect of indole acetic acid spray on performance of tomato. *Turk. J. Biol.,* **30** : 11 - 16.

Mewael, K. A., Ravi, H., Koti. R. V. and Biradarpatil, N. K., 2010, Enhancement of seed quality in soybean following priming treatments. *Karnataka J. Agric. Sci*., **23** (5) : 787 - 789.

Milosevic, M. M., Vujakovic, D. and Karagic, 2010, Vigour tests as indicators of seed viability. *Genetika,* **42** (1) : 103 - 118.

Mutlu, N., Demirelli, A., Ilbi, H. and Ikten, C., 2015, Development of co-dominant SCAR markers linked to resistant gene against the *Fusarium oxysporum* f. sp. *radicis-lycopersici*. *Theor. Appl. Genet*., **128** (9) : 1791 - 1798.

OERKE, E. C., 2006, Crop losses to pests. *J. Agril. Sci.,* **144** (1) : 31 - 43.

PANT, M.,, 2008, Studies on morphological and seed quality parameters of vegetable pea (*Pisum sativum* L.). *M.Sc. Thesis* submitted to G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India, pp. : 43-55.

PEREIRA, R. S., NASCIMENTO, W. M. AND VIERIRA, J. V., 2008, Carrot seed germination and vigor in response to temperature and umbel orders. *Scientific Agril.,* **65** : 145 - 150.

PERL, M., LURIA, I. AND GELMOND, H., 1978, Biochemical changes in sorghum seeds affected by accelerated ageing. *J. Expt. Bot*., **29** : 497 - 501.

PRASAD, S., 2009, Effect of moisture stress on germination and seedling growth of vegetable pea (*Pisum sativum* L.). *M.Sc. Thesis* submitted to G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India, pp. : 48 - 74.

RAGHAVENDRA, A., FAKRUDDIN, B., SAVITHRAMMA, D. L., RANGASWAMY, K. T., KEDARNATH, N. NAGARAJU AND PRAMEELA, H. A., 2019, *In vitro* evaluation of tomato germplasm and private sector hybrids for resistance to tomato leaf curl virus. *Mysore J. Agric. Sci*., **53** (2) : 38 - 46.

RANGANAYAKI, P. R. AND RAMAMOORTHY, K., 2015, Enhancing planting value of marginal seed lots of blackgram through hydration-dehydration (HD) treatment. *Res. J. Seed Sci*., **8** : 22 - 29.

SALUNKHE, D. K., DESAI, B. B. AND BHAT, N. R., 1987, Vegetable and flower seed production. First *Edn, Agricole pub. Acad.,* New Delhi, India, **135**.

SINGH, P. K., SINGH, B. AND PANDEY, S., 2006, Genetic variability character association analysis in tomato. *Indian J. Genet. Plant Breed*.,**19** : 196 - 199.