African Journal of Agricultural Research Vol. 7(46), pp. 6143-6149, 5 December, 2012
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR12.307
ISSN 1991-637X ©2012 Academic Journals

Full Length Research Paper

Germplasm evaluation for yield and fruit quality traits in tomato (*Solanum Lycopersicon* L.)

Rukhsar Ahmad Dar, Jag Paul Sharma, Ambreen Nabi and S. Chopra

Division of Vegetable Science and Floriculture, Sher-e- Kashmir University of Agricultural Sciences and Technology, FOA, Main Campus Chatha-180009 Jammu, India.

Accepted 5 October, 2012

The present investigation was planned and executed during spring and summer seasons of 2007 to 2010 at Vegetable Experimental Farm, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology, Main Campus, Chatha. The experimental material include 60 diverse genotypes of tomato collected from various places including Indian Institute of Vegetable Research Institute (IIVR) Varanasi Uttar Pradesh and some local cultivars. The observations were recorded on yield and quality traits to generate information regarding the extent of genetic variability, heritability and expected genetic advance. Analysis of coefficient of variation revealed that the magnitude of the phenotypic coefficient of variation was higher than that of the genotypic coefficient of variation for all the seven characters under study. The highest values of the phenotypic coefficient of variation (PCV) were recorded for fruit yield, number of locules per fruit and pericarp thickness. High genotypic coefficients of variation (GCV) were recorded for yield polygalacturonase activity and pericarp thickness. High heritability was recorded for most of the characters, namely, pericarp thickness, polygalacturonase activity and alcohol insoluble solids. The above results are quite encouraging for advancing in tomato breeding.

Key words: Germplasm evaluation, tomato, genotypes.

INTRODUCTION

Tomato, the world's largest grown vegetable crop known as a protective food occupies an important place in the economy of human societies because of its high nutritive value and its wide spread production in different agro-climatic conditions. Tomato is an important commercial and dietary crop. Due to the short duration of the crop and the high yield, its area is increasing day by day. Tomato occupies the most prestigious berth not only in the sophisticated, ultra modern kitchen, but also equally in the kitchen of the poor man, because of diverse nutritious and value added products that can be prepared from it. It is often called poor man's orange, because of its high nutritive value.

Keeping in view the nutritional importance of this crop, there is a need for breeding programmes in order to develop cultivars with high quality of fruit as well as yield. Identification of superior genotypes, therefore, becomes imperative to build up gene pool, which can be directly utilized in commercial cultivation and production of promising hybrids.

The plant growth characteristics range from indeterminate to highly determinate type. The branches of indeterminate plants keep on growing and producing fruits until frost kills the plant. Tomato is well fitted in different cropping systems of cereals, grains, pulses and oil seeds. Numerous processed items are being prepared on large scale for consumption as well as for export purpose. Previously tomatoes were grown only in season-wise, but the production scenario has been changed since few years. Nowadays tomatoes are grown round the year.

*Corresponding author. E-mail: drrukhsar@rediffmail.com. Tel: +91-9419048188.

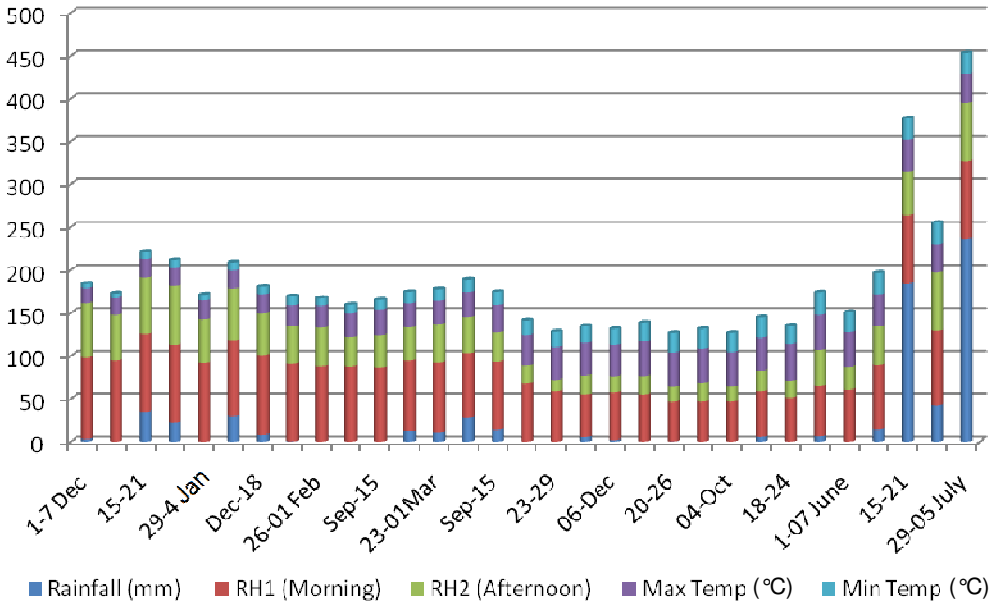

Figure 1. Standard meteorological weekly data for the year 2007 to 2008.

According to (FAO, STAT 2007), the top producers of tomatoes in 2007 were China with a production of 33.64 million tonnes, followed by USA 11.5 million tonnes, Turkey 9.91 million tonnes, India 8.85 million tonnes and Egypt 7.55 million tones The annual production of tomato in India during 2007 to 2008 (NHB, 2008) was 10261 thousand tones from 572000 ha of land. The leading tomato producing states are Uttar Pradesh, Karnataka, Maharashtra, Haryana, Punjab and Bihar. In Jammu, the area under tomato production is 1824 ha that yield 36650 tones, with a productivity of 20.08 tonnes per ha (Anonymous, 2008 to 2009).

Germplasm evaluation studies would help in the identification of genetic material for quality and yield traits in crop plants, effectively to generate noble variants having adaptation and yielding potential far better than parental types (Sekhar et al., 2008). Keeping the above facts in mind, present investigations was carried out considering 60 genotypes with respect to quality and important traits so that feasibility of developing extra quality lines with high yield in tomato can be developed.

MATERIALS AND METHODS

The experimental material included 60 diverse genotypes of tomato collected from various places including IIVR (Indian Institute of Vegetable Research Varnasai U. P), and some local cultivars. We recorded yield and quality traits to calculate genetic variability, heritability, and expected genetic advance. The analysis of variance was calculated using the methology suggested by Gomez and Gomez (1983). Total yield per plot was calculated and then it was converted to hectare. Parameters such as phenotypic coefficient of variation, genotypic coefficient of variation was calculated according to the formula suggested by Burton and Devane (1953), heritability (H) broad sense, was calculated by the formula of Hanson et al. (1956) and expected genetic advance was calculated following the procedure described by Lush (1949). The experimental area was located in the sub-tropical zone of Jammu and Kashmir at 32° 40′ N latitude and 74° 58′ E longitude at an elevation of 332 m above mean sea level during 2007 to 2010. The climate of Vegetable Research Farm at Chatha is sub-tropical with hot dry summer, hot humid rainy and cold winter months. The maximum temperature raises up to 45°C during summers (May to June) and minimum temperature falls to 1°C during winters. The mean annual rainfall is about 1000 to 1200 mm. The information on climatic conditions prevailed during the crop season was recorded at the meteorological observatory located at the University Research Farm, Chatha. Weekly data on the mean maximum and minimum atmospheric temperatures, relative humidity and rainfall are shown in (Figures 1 and 2). For soil chemical analysis, composite soil samples were collected from the experimental site from 0 to 15 cm depth before sowing by random sampling (Peterson and Calvin, 1965). The collected samples were mixed thoroughly and representative samples were air dried, grounded and sieved on 2 mm sieve and stored in cloth bags for subsequent analysis. The details of soil physico-chemical properties are given in Table 1.

The analysis of the soil for physico-chemical properties indicated that the soil of the experimental site was loamy in texture, neutral in soil reaction, low in organic carbon and available nitrogen, but medium in phosphorus and potassium with EC in the safe range.

Experimental layout and design

The experiment was laid out in randomized block design with three replications. All the recommended cultural practices were followed during the growth and development period of the crop in order to raise a healthy crop (Table 2).

Data recorded

Polygalacturonose activity was estimated as per the procedure suggested by (Mazumdar and Majumder, 2001), fruit pH was recorded as per the procedure given by A.O.A.C. (1975), total

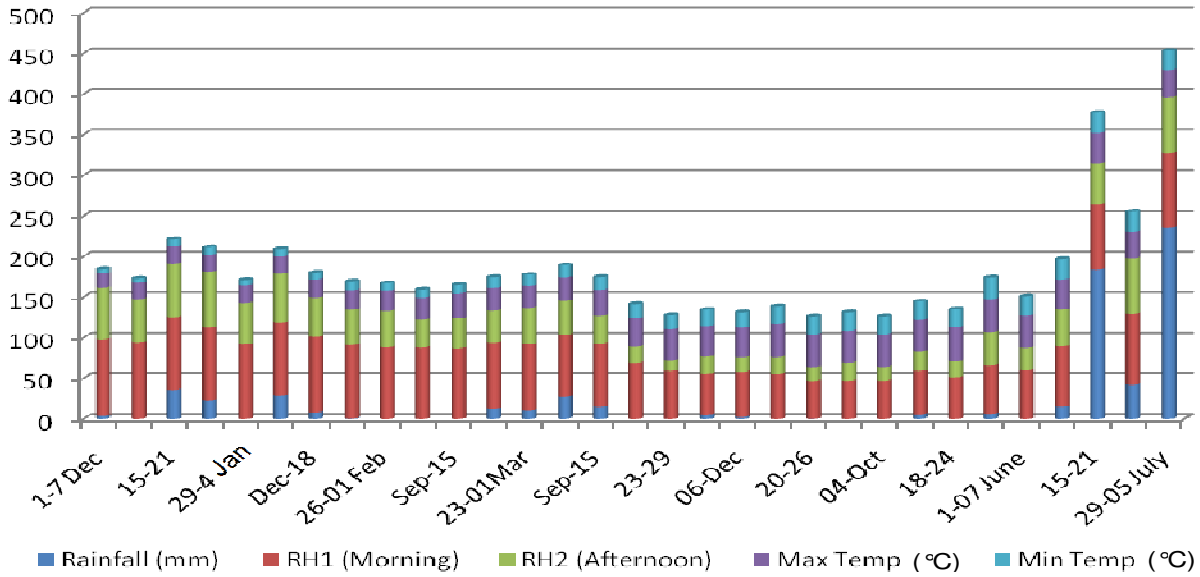

Figure 2. Standard meteorological weekly data for the year 2008 to 2009.

Table 1. Physico-Chemical properties of the experimental field.

S/N	Property	Value	Method employed
1	pH	7.40	1: 2.5 Soil water suspension Beckman glass electrode pH meter (Jackson, 1967)
2	EC (d Sm^{-1})	0.14	1: 2.5 Soil water suspension with systronic conductivity meter (Jackson, 1973)
3	Soil texture (%)		Loamy texture
	Sand	43.4	
	Silt	44.5	International pipette method Piper 1944
	Clay	12.3	
4	OC (%)	0.37	Walkley and Black (1934) method
5	Available nitrogen (Kg ha^{-1})	222.13	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
6	Available phosphorus (Kg ha^{-1})	13.57	Olsen et al. (1954)
7	Available potassium (Kg ha^{-1})	161.37	Ammonium acetate method (Jackson, 1967)

soluble solids value was determined by means of hand refectrometer and estimation was carried out as per procedure given by (Anonymous, 1936).

Alcohol insoluble solid (mg/100 of dry weight)

50 ml of 80% ethanol was added to 0.5 g of dried and powdered sample of tomato. It was heated for 2.5 h on boiling water bath, filtered paper and 70% ethanol. Then residue was dried in oven at 65 ± 2°C and weighed to calculate alcohol insoluble solids as given as follows.

$$\text{Alcohol insoluble solids} = \frac{\text{Weight of residue material (g)}}{\text{Weight of powdered sample (g)}} \times 100$$

Pericarp thickness (mm)

Pericarp thickness of ten randomly picked fruits was measured after cutting the fruits transversely. Measurement was done with digital Vernier Callipper in millimeters and mean value was worked out.

Number of locules per fruit

Five randomly selected fruits from each plot were taken for counting the locule numbers. These were cut horizontally and the number of seed chambers or locules was counted.

Total fruit yield (q per ha)

Total yield per plot was calculated and then it was converted to

Table 2. Experimental layout and design parameter and values.

Parameter	Value
Total number of genotypes	60
Total number of replications	3
Area of individual plot	7.5 m^2
Spacing	60 × 45 cm
Total number of plots	180
Total number of plants per plot	27
Total number of plants in experimental field	4860

hectare.

RESULTS AND DISCUSSION

The analysis of variance showed that there was highly significant difference among the genotypes for all the traits, the significant difference indicated existence of good deal of variability with respect to various traits. The mean values of pooled data over two years are presented in Tables 3 and 4.

From polygalacturonase (PG) activity data it is evident that the genotype EC-363942 recorded the minimum polygalacturonase activity (28.48) which was followed by EC-521067 (35.79) and Punjab Chhuhara (36.86), whereas the maximum polygalacturonase activity was observed in genotype EC-521059 (68.11) (Table 3). That the highest mean value was recorded to be 49.46. Ripening is the final stage of fruit development and represents a complex cascade of events, which eventually gives to the fruit certain qualities rendering it attractive and desirable for consumption. Nowadays polygalacturonase enzyme has attracted much attention and has been strongly implicated as a key determinant of softening during tomato fruit ripening and perhaps in the general regulation of fruit maturation. Bushan (2004) has also reported after evaluation of thirty one genotypes of tomato that minimum polygalacturonase unit (26.91 polygalacturonose unit) was in FT-5, lower than in EC-15998 (28.82 polygalacturonose unit), AD-5 (29.85 polygalacturonose unit), AL-3 (30.09 polygalacturonose unit), AL-11 (30.29 polygalacturonose unit). In that experiment the maximum was in Sel-32 (92.93 polygalacturonose unit).

Highly significant variation among the genotypes was observed for fruit pH. It is evident from the pooled data shown in Table 3 that VTG-86 had the highest fruit pH (4.59) which was at par with PAU-2371 (4.48). Whereas, the minimum fruit pH was observed in genotype CGNT-6 (3.36). The grand mean of the population was noted as 4.08. Koutsos (1994) reported that there was strong variability among cultivars from year to year, particularly in storage of fruit, as the storage in shade or in sun prolonged, all cultivar showed increase in pH or decrease in titrable acidity and in soluble solids (%).

The pooled data shown in Table 3 revealed a high amount of total soluble solids (TSS%) (5.04%) in genotype EC-521041 which was at par with local-2707 (5.0%), followed by EC-521056 (4.99), EC-5888 (4.92%) and EC-9046 (4.90%). On the other hand, the genotype CTS-02 contained the lowest amount of total soluble solids per cent (3.67%). Here the grand mean of the population was found to be (4.41%). The total soluble solids values recorded in this study are in trend of those found by Durvesh and Singh (2006), who reported that quality attributes like total soluble solids of the fruit ranged from 4.0 to 5.0%.

The pooled mean value of genotypes for alcohol insoluble solids (mg/100g), as presented in Table 3 depicted that the maximum alcohol insoluble solids was found in VTG-86 (39.14 mg/100 g) followed by EC-520059 (38.92 mg/100 g) and CGNT-5 (38.05 mg/100 g), whereas genotype EC-2798 scored the minimum amount (23.78 mg/100 g) of alcohol insoluble solids content in tomato fruit. The average mean value of the genotypes for this trait was 33.39 mg/100 g. Ravinder and Cheema (2004) reported that alcohol insoluble solids in 75 genotypes of tomato ranged from 18 mg/100 g to 45 mg/100 g.

The mean values of genotypes for pericarp thickness (mm), as presented in Table 3 showed the maximum value in EC-521067 (5.27 mm) which was closely followed by PAU-2371 (5.20 mm).The minimum was recorded in genotype CGNT-5 (2.58 mm). The grand mean value of the population for this trait was noted to be 4.06 mm. These findings were in close conformity with Durvesh and Singh (2006), who reported that maximum percarp thickness was in Sonali (9.0 mm) and the minimum in DTH-6 (3.7 mm) and was related to firmness of the fruit.

Considerable variability was observed in the number of locules per fruit. It is evident from the pooled data illustrated in Table 3 that the genotype EC-35293 recorded the maximum number of locules per fruit (3.67) which was at par with EC-521056 (3.34), VR (3.34), and CO-2 (3.34). However, in genotype EC-529081, minimum number of locules per fruit was 2.00 recorded. The grand mean value of the population for number of locules per fruit was 2.70, Variation in the number of locules per fruit was also reported by Sharma et.al. (2009), who observed during evaluation of 48 genotypes of tomato that the range of number of locules per fruit was 2.0 to 6.0.

Considerable variability was observed for yield in quintals per hectare (q/ha) between the genotypes. The pooled data of mean values of genotypes depicted in Table 3 revealed that Improved Shalimar registered the maximum yield (556.76 q/ha) which was at par with EC-521086 (525.82 q/ha), EC-538151 (487.11 q/ha) and EC-538151/3 (465.06 q/ha). This suggested that

Table 3. Mean performance of different genotypes of tomato (*Solanum lycopersicon* L.) for yield and quality traits.

Genotype	Poplygalacturonose activity PGU	Fruit pH	Total soluble solids (%)	Alcohol insoluble solids (mg/100 g)	Pericarp thickness (mm)	No. of locules /fruit	Yield q/ha
EC-164660	40.67	4.25	4.42	25.69	4.67	2.17	122.17
EC-363942	28.48	4.41	4.22	28.72	4.17	2.17	394.42
EC-538151	37.51	4.19	4.33	36.14	4.98	2.84	487.11
Pant T-7	46.54	4.13	4.52	28.28	4.37	2.34	381.59
EC-521056	36.99	4.16	4.97	29.60	4.12	3.34	361.48
EC-520059	55.82	4.33	3.85	38.92	3.69	2.84	403.26
JTP-02-05	54.42	4.11	4.50	29.14	3.80	3.17	277.84
EC-521086	45.56	4.18	4.40	23.93	4.44	2.34	525.82
EC-521067	35.79	4.21	4.42	26.75	5.27	3.00	278.00
EC-251581	50.91	4.13	4.25	30.69	4.39	3.17	357.42
EC-521059	68.11	4.28	4.45	35.29	3.07	2.17	313.09
EC-521044	48.27	4.26	4.17	29.40	4.02	2.83	325.49
EC-27995	52.53	4.04	4.82	25.32	3.85	2.00	243.78
EC-521041	49.61	4.06	5.04	32.18	4.17	2.50	295.97
EC-538151/3	51.85	4.05	4.87	25.20	3.84	2.67	465.06
EC-3526	53.32	4.10	4.67	30.27	3.75	3.34	328.46
EC-9046	46.79	3.96	4.90	30.54	4.25	3.00	398.77
DT-2	55.05	3.94	4.04	31.50	4.14	2.50	315.11
Punjab Chhuhara	36.86	4.14	4.55	36.10	4.70	3.17	358.68
Pant T-8	47.61	4.17	4.19	29.07	4.42	2.50	274.26
CO-3	45.31	4.16	4.35	34.69	4.43	2.33	238.13
EC-521045	44.85	4.11	4.52	34.29	4.54	2.84	286.66
CTS-02	45.10	4.23	3.67	30.50	4.42	2.33	224.48
CTS-06-19	51.35	4.37	4.15	28.52	3.92	2.00	327.48
EC-521079	45.77	4.38	4.24	32.17	4.42	2.50	361.55
EC-35293	55.37	4.11	4.52	25.75	3.64	3.67	342.80
EC-5888	38.66	4.23	4.92	35.35	4.82	2.84	348.66
PAU-2371	38.53	4.48	4.37	31.64	5.20	2.33	330.97
PAU-2372	47.01	3.75	4.62	35.43	4.37	2.34	277.66
EC-3668	60.61	4.20	4.70	29.60	3.30	2.34	253.80
EC-529081	47.38	3.90	4.12	29.62	4.24	2.00	307.50
EC-2798	45.07	4.10	4.35	23.78	4.35	2.33	224.98
PAU-1374	52.40	3.56	4.50	30.07	3.89	3.17	284.08
EC-528374	55.69	4.12	4.29	34.90	3.48	3.17	291.64
NDT-9	48.26	4.12	4.34	35.62	4.19	2.50	325.97
EC-29914	52.67	3.96	4.54	32.50	3.85	2.67	292.48
Local-2707	48.48	3.44	5.00	31.37	4.25	2.33	342.40
VTG-85	55.34	3.81	4.67	36.34	4.05	3.00	284.33
VTG-86	60.19	4.59	4.49	39.14	3.33	3.00	260.97
VR-415	45.53	4.20	4.45	36.67	4.27	3.34	436.68
Pant T-10	50.16	4.16	4.47	26.44	3.89	2.67	318.83
EC-521054	46.64	3.41	4.45	35.42	4.37	2.83	212.27
EC-381213	44.55	4.21	4.42	29.27	4.47	2.67	221.75
KS-227	44.62	4.24	4.47	33.70	4.49	2.84	154.19
KS-229	37.77	4.10	4.29	30.22	4.84	2.84	265.66
CO-2	44.27	4.04	4.32	35.39	4.07	3.34	311.67
EC-52077	40.29	4.10	4.68	31.30	5.02	3.34	327.75
EC-135580	43.16	3.42	4.25	27.57	4.92	2.50	187.31
EC-2517	38.59	4.17	4.50	34.17	4.93	3.17	293.04

Table 3. Contd.

Improved shalimar	41.05	4.12	4.60	30.18	4.40	3.34	556.76
CGNT-1	47.34	4.22	4.40	30.49	4.34	2.67	336.45
CGNT-2	60.12	3.99	3.97	29.54	3.45	2.17	219.86
CGNT-3	64.43	4.32	4.05	33.04	2.85	2.50	299.41
CGNT-5	64.56	3.79	4.35	38.05	2.58	2.50	315.06
CGNT-6	61.10	3.36	4.50	34.02	2.93	2.50	220.42
CGNT-10	62.11	4.12	4.04	28.02	3.14	2.17	280.71
CGNT-11	65.15	4.15	4.22	32.15	3.02	3.00	277.82
CGNT-12	58.86	4.05	3.85	31.74	3.39	2.67	213.67
CGNT-13	63.36	4.27	4.32	33.13	2.89	2.67	261.91
CGNT-14	63.71	3.97	4.60	28.94	3.07	2.50	260.79
C.D 5%	**4.05**	**0.18**	**0.14**	**1.89**	**0.25**	**0.64**	**92.26**
CV	**5.07**	**2.73**	**1.91**	**3.73**	**3.74**	**14.65**	**18.52**

Table 4. Estimate of range, mean, genotypic and phenotypic coefficient of variation (GCV and PCV), heritability and genetic advance for different traits of tomato genotypes.

Character	Range	Grand mean	SEM ±	Coefficient of variation		Hertaibility (%)	Genetic advance (%)	
				GCV	PCV	Heritibility	GA	GA % of mean
Polygalacturonase activity	28.48 - 68.11	49.46	1.45	18.47	19.75	87	17.57	35.52
Fruit pH	3.36 - 4.59	4.08	0.06	6.04	6.83	78	0.45	11.02
Tota soluble solids (%)	3.67 - 5.04	4.41	0.05	6.48	7.06	84	0.54	12.24
Alcohol insoluble solids	23.78 - 39.14	31.39	0.68	12.12	13.11	86	14.5	46.19
Pericarp thickness (mm)	2.58 - 5.27	4.06	0.09	15.96	16.78	90	2.54	62.56
Number of locules per fruit	2.00 - 3.67	2.70	0.23	14.73	24.66	36	0.98	36.29
Yield (q /ha)	122.17 - 556.76	308.10	32.94	24.21	32.29	59	119.41	38.75

these genotypes should be utilized for the improvement of yield and yield contributing traits in tomato. The minimum fruit yield was recorded in EC-164660 (122.17 q/ha). The grand mean value of population was 308.10 q/ha.

An enormous genetic variability is available in the genotypes of tomato (*Solanum lycopersicum* L) for the evaluated traits. However, the lack of systematic breeding work or major wealth of its variability remains unexploited with respect to subtropical conditions. It is necessary to gather basic information on the nature of genetic variability among the germplasm lines, heritability of various important traits to facilitate identification of parents and characters for use in future breeding programme. Yield is a complex metric trait and is the end product of number of quantitative and qualitative factors often interrelated with each other. The relative value of these traits determines the yield in a crop species and is of paramount importance in selection of superior

Improved Shalimar had highest yield quintals per hectare (556.76 q/ha) followed by EC-521086 (525.82 q/ha), EC-538151 (487.10 q/ha), EC-538151/3 (465.06 q/ha), VR-415 (436.68 q/ha) and EC-520059 (403.26 q/ha). Whereas the genotype EC-164660 registered the lowest (122.17 q/ha). This suggested that these genotypes should be utilized for the improvement of yield and yield contributing traits in tomato. The yield results of present investigation agree with those of Sharma et al. (2009), Singh et al. (2005), and Satesh et al. (2007), who have also reported variation in yield ranging from 125.40 to 414.33 q/ha. Other reseachers have also found that the yield of tomato is associated with various yield attributing characters, such as number of fruiting bunch per plant, average fruit weight, fruit per plant etc. The product of those components determines the fruit yield per plant, as well as yield per hectare.

Estimation of genetic variability

The genotypic and phenotypic coefficient of variation of the seven characters is presented in Table 4. The data depicted in the table indicated that in general phenotypic coefficients of variation were higher in magnitude than the genotypic ones for all the characters studied. Similar observation were made by Singh (2005).

It was clear from the pooled data depicted in Table 4 that the higher phenotypic coefficient of variation was

recorded for yield in quintals per hectare (32.29%) which was significantly higher than all other characters. This was closely followed by fruit yield per plant (32.15%). Moderate phenotypic variability was recorded for number of locules per fruit (24.66%), polygalacturonase activity (19.75%), pericarp thickness (16.78%), and alcohol insoluble solids (13.11%). However,low phenotypic coefficient of variation was observed for total soluble solids (7.06%) and fruit pH (6.83%). Table 4 indicated that the high coefficient of genotypic variability was recorded for, yield(24.21%) and polygalacturonase activity (18.47%), whereas a moderate genotypic coefficient of variation was observed in pericarp thickness (15.96%), number of locules per fruit (14.73%), and alcohol insoluble solids (12.12%). The lowest coefficient values were recorded for total soluble solids (6.48%) and fruit pH (6.04%). The estimate of heritability in broad sense genetic advance in percent of mean is presented in Table 4. The heritability ranged from 36 to 90%. It was observed that most of the characters under study had high heritability. It was (90%) for pericarp thickness followed by polygalacturonase activity (87%), alcohol insoluble solids (86%), total soluble solids (84%) and fruit pH (78%). However at low heritability was recorded for yield per hectare (59%), fruit yield per plant (55%) and number of locules per fruit (36%).The estimate of expected genetic gain (genetic advance expressed as percent of mean) from pooled data is presented in Table 4 and ranged from 11.02 to 62.56%. The highest value of expected genetic advance in percent of mean was recorded for pericarp thickness (62.56%) and, alcohol insoluble solids (46.19%). A moderate estimate was obtained for yield per hectare (38.75%), number of locules per fruit (36.29%), polygalacturonase activity (35.52%). However a low estimates of genetic advance per cent of mean was observed for total soluble solids (12.24%) and fruit pH (11.02%). These results corroborate the views of Singh et al. (2002) and Ara et al. (2009).

Conclusion

The findings of the research article are that the genotypes EC-251581, CGNT-5, EC-363942, CGNT-14, EC-521041, EC-521067, EC-35293, CGNT-3, Improved Shalimar, VTG-86 and EC-521026 are promising as they showed an overall good performance for most of the characters. These genotypes may be recommended for commercial cultivation after testing them over years and locations.

REFERENCES

A.O.A.C. (1975). Official method of analysis. Association of Analytical Chemist, Washington D.C. and Madison, Wisconsin, U.S.A. pp. 54-72.

Anonymous (1936). *Proceeding of the ninth Session of the* International Commission for uniform Methods of Sugar Analysis, London.

Anonymous (2008-09). Annual report of area and production of vegetables. Department of Agric. J. (J & K). pp. 41-42.

Ara A, Raj N, Nazeer A, Khan SH (2009) Genetic variability and selection parameters for yield and quality attributes in tomato. Ind. J. Hort. 66:30-35

Burton GM, Devane EW (1953). Estimating heritability in tall fescue (*Festuca araadinancea*) from replicated clonal material. Agron. J. 45:478-481.

Bushan B (2004). Evaluation of tomato genotypes for horticultural and biochemical traits. M.Sc thesis submitted to College of Horticulture Dr Y.S.P.U of Horticulture and Forestry, Solon H.P.

Durvesh K, Singh DK (2006). Performance of commercial hybrids of tomato. Progressive Hortic. 38(1):100-104.

FAO, Rome (2007). *FAOSTAT* Database. Food and Agriculture Organisation, Rome, Italy.

Gomez KV, Gomez AA (1983). Statistical Procedure for Agricultural Research. 2nd Edn., John Wiley and Sons Inc., New York. pp. 357-427.

Hanson CH, Robinson HF, Comstock RE (1956). Biometrical studies of yield in segregating population of Korean. Lespedeza Agron. J. 48:268-272.

Jackson ML (1973). Soil Chemical Analysis. *Prentice* Hall of India, Pvt, Ltd, New Delhi. pp. 183-184.

Jackson ML (1967). Soil Chemical Analysis Prentice Hall Inc. New York, *U.S.A.* pp. 375.

Koutsos TV. Portas CAM, Paroussis E (1994). Changes in pH, titrable acidity, and soluble solids of Processing Tomato varieties in relation to fruit storage until processing. ISHS Acta Horticulture V International Symposium on the Processing Tomato. p. 376:

Lush JL (1949). Animal Breeding Plans. 3rd Edn., College Press, Iowa State. p. 443.

Mazumdar BC, Majumder K (2001). In Methods of Physico-Chemical Analysis of Fruits. pp. 147-150.

NHB (2008). Indian Horticulture Database. Gurgaon Haryana.

Olsen SR, Cole CW, Watenable, PS, Dean LA (1954). Estimation of available phosphorus in soil by extraction with $NAHCO_3$. *United States* Department of Agriculture Circular 939:19.

Peterson RG. Calvin LD (1965). Sampling method for soil analysis, part-1 (ed). *C.A. Black*

Piper CS (1944). Soil and plant analysis. Interscience publishers, Inc. New Delhi.p.368

Ravinder K, Cheema DS (2004). Department of Vegetable Crops, Punjab Agricultural University, Ludhiana, India. J. Res. Punjab Agric. Univ.. 41(2):223-226.

Satesh, K, Sharma JP, Singh AK, Tiwari SP, Neerja S (2007). Harvest index, quality and morpho-meterical evaluation for identification of superior types in tomato. Environ. Ecol. 25:399-402.

Sekhar L, Prakash BG, Salimath, PM, Sridevi O, Patil, AA (2008). Genetic diversity among some productive hybrids of tomato (*Lycopersicon esculentum* Mill). Karnataka J. Agric. Sci. 21(2):264-265.

Sharma JP, Singh AK, Satesh K. Sanjeev K (2009). Identification of traits for ideotype selection in tomato. Mysore J. Agric. Sci. 43:222-226.

Singh AK (2005). Genetic variability correlation and path co-efficient studies in tomato under cold arid region of Ladkh. Prog. Hortic. 37:437-443.

Singh, JK,, Singh, JP. Jain SK. Joshi A (2002). Studies on genetic variability and its importance in tomato. Progressive Hortic. 34(1):77-79.

Singh T, Shravan K, Singh B, Singh, JP (2005). Studies on genetic variability of tomato genotypes for different quantitative and qualitative characters. Advan. Plant Sci. 18(1):355-359.

Subbiah BV, Asija GL (1956). A rapid procedure for the estimation of available nitrogen in soil. Curr. Sci. 25:259-260.

Walkley A, Black TA (1934). An experiment of the vegetative modification of chromic acid filtration method. Soil Sci. 37:38-39.