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Appraisement of heritability in narrow sense and genetic advance in per cent of mean for different characters in tomato (*Solanum lycopersicon* L.)

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Abstract
An investigation was carried out to evaluate the 36 genotypes (28 F_1 and parental lines) of tomato (*Solanum lycopersicon* L.) at Main Experimental Station, Department of Vegetable Science, A.N.D. University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) during season 2019-20 and 2020-2021. The experiment was laid out in a Randomized Complete Block Design with three replications. The data were recorded for 17 characters including total fruit yield per plant. The findings of the present investigation revealed that high heritability (h^2ns) coupled with high genetic advance as per cent of mean were observed for plant height, average fruit weight and total fruit yield per plant in both the seasons and pooled. High estimates of heritability with high genetic advance as per cent of mean provides a clear picture to the breeders for improvement during the process of selection.

Keywords: Tomato, *Solanum lycopersicon* L., heritability and genetic advance

Introduction
A significant impact of globalization on horticulture has been an increasing demand for quality improvement and the wider adoption of quality standards for fruit, vegetable and salad commodities. Tomato (*Solanum lycopersicum*) (2n = 2x = 24) is one of the most important Solanaceous vegetable crops grown worldwide under outdoor and indoor conditions. It has become an important commercial crop so far as the area, production, industrial values and its contribution to human nutrition is concerned. Tomato belongs to the family Solanaceae.
Tomato is one of the most popular and widely grown vegetable crops of the world next to potato. The genus Solanum consists of annual or short lived perennial herbaceous, typical day neutral plant and warm season crops. Tomato is reasonably susceptible to frost as well as high temperature but it is grown in a variety of climatic conditions. Tomato probably originated in Peru-Ecuador region (Rick and Holle, 1990) [17] and was introduced into Italy at the beginning of the sixteenth century as an ornamental plant. It did not begin to be grown for food until the middle of that century. Its cultivation has become widespread over the subsequent centuries and is now one of the world's major food crops (Frusciante *et al.*, 2000) [6].
Tomato fruit are eaten raw or cooked called as "Protective Food" is being extensively grown as annual plant all over the world. Tomato in large quantities is used to produce several items like paste, syrup, juice, ketchup, puree and drinks etc. Green Tomato are also used for pickles and preserves. It is a rich source of vitamins, minerals and organic acid. There are various types of flavoring compounds found in the fruits, which enrich the taste.
India ranks third in terms of production of tomato after China and USA. In India the leading tomato growing states are, Karnataka, West Bengal, Maharashtra, U.P., Haryana, Punjab, Gujarat and Bihar. These states are account for 90% of the total production of the country in India. The total area covered under tomato cultivation is 0.781 Mha with production of 19.007 MT and its productivity is 24.34 tonnes per ha (NHB database, 2019).
The estimate of narrow sense heritability provides the index of transmissibility of characters and serves as a useful guide to the breeders for practicing selection. Genetic advance give more clear view about overall efficiency of the selection for improvement of the characters.

Material and Methods
The experimental materials consisted of 36 genotypes comprised of a set of 8x8 diallel cross (excluding reciprocals) and their 8 parents of tomato *viz*: NDT-2-2, NDT-7, Kashi Aman, NDT-4, NDT-5, Arka Vikas, S_5 × NDT-3-2-1-1 and 2013/TODVAR-2-1-1. Eight parents and

their 28 hybrids were grown in a Randomized Block Design (RBD) with three replications during *Rabi* 2019-20 and 2020-2021 at the Main Experiment Station (MES) of the Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Ayodhya (U.P.) India. Thirty days old seedlings were transplanted to the main field and irrigated just after transplanting. Each hybrids and parents were grown in rows spaced at 0.60 meters apart with a plant to plant spacing of 0.50 meter. Thus, there were 12 plants in each entry per replication in both the years and all the cultural practices regarding tomatoes were followed as recommended. The data were recorded on 5 randomly selected healthy plants from each plot on seventeen characters, *viz.*, days to 50% flowering, days to first fruit harvest, plant height (cm), number of primary branches per plant, number of fruits per cluster, number of fruits per plant, average fruit weight (g), pericarp thickness (mm), number of locules per fruit, polar diameter (cm), equitorial diameter (cm), total fruit yield per plant (kg), marketable fruit yield per plant (kg), total soluble solids (TSS), titrable acidity (%), ascorbic acid content (mg/100g) and total sugar (mg/100g). The data were recorded from 28 F_1's and 8 parental lines on seventeen characters were subjected to estimate nature and magnitude of heritability in narrow sense (Crumpacker and Allard, 1962) and genetic advance in per cent of mean (Johnson *et al.*, 1955) [9].

Result and Discussion

The knowledge of heritability of a character is important to the breeder since it indicates the possibilities and extent to which, improvement is possible through selection (Robinson *et al.*, 1949) [18]. Heritability, which showed the proportion of additive genetic variance to the total variability, is a measure of genetic relationship between parents and progeny and has been widely used in determining the degree to which characters may be transmitted from parent to offspring. Singh *et al.* (2005) [20] pointed out that the heritability in combination with intensity of selection and amount of variability present in the population

Table 1: Heritability (ns & bs) and genetic advance as tomato over two seasons (Y_1, Y_2) and pooled.

Characters	Seasons	Heritability in narrow sense (%)	Heritability in broad sense (%)	Genetic advance as per cent of mean
Days to 50% flowering	Y_1	3.39	90.68	18.85
	Y_2	14.55	82.19	12.32
	Pooled	2.97	31.40	7.05
Days to first fruit harvest	Y_1	16.12	97.96	19.44
	Y_2	17.32	98.11	19.53
	Pooled	10.19	26.67	5.42
Plant height (cm)	Y_1	60.47	96.39	32.80
	Y_2	54.79	97.45	33.37
	Pooled	57.84	55.92	20.26
Primary branches per plant	Y_1	16.28	65.05	8.29
	Y_2	25.18	81.04	12.84
	Pooled	2.50	14.72	3.28
Fruits per cluster plant	Y_1	19.71	87.78	17.21
	Y_2	45.91	87.68	18.57
	Pooled	13.41	30.85	7.94
Fruits per p Lant	Y_1	15.04	83.28	18.44
	Y_2	23.64	87.94	22.08
	Pooled	3.31	25.56	7.97
Average fruit weight (g)	Y_1	51.77	96.79	29.64
	Y_2	17.93	93.56	26.45
	Pooled	13.44	39.80	12.80
Pericarp thickness(mm)	Y_1	16.97	84.64	12.48
	Y_2	16.93	83.11	11.59
	Pooled	14.82	9.65	1.83
Locules per fruit	Y_1	76.75	92.14	17.88
	Y_2	14.40	93.31	19.41
	Pooled	8.10	27.07	6.25
Characters	**Seasons**	**Heritability in narrow sense (%)**	**Heritability in broad sense (%)**	**Genetic advance as per cent of mean**
Polar diameter (cm)	Y_1	22.05	82.90	9.93
	Y_2	20.28	81.28	7.31
	Pooled	24.23	17.20	2.56
Equitorial diameter (cm)	Y_1	27.61	70.45	4.47
	Y_2	33.94	72.05	4.72
	Pooled	30.51	12.94	1.40
Marketable fruit yield per plant (kg)	Y_1	17.60	80.29	24.48
	Y_2	22.40	85.86	27.51
	Pooled	17.22	47.40	19.80
Total soluble solids (%)	Y_1	29.74	60.69	4.48
	Y_2	27.08	59.86	4.50
	Pooled	28.34	15.55	2.15
Titrable acidity (%)	Y_1	15.55	93.23	21.98
	Y_2	62.90	90.90	18.34
	Pooled	4.27	31.15	7.98
Ascorbic acid content (mg/100g)	Y_1	19.04	85.29	10.63
	Y_2	25.47	81.08	8.63
	Pooled	23.57	21.22	3.26

Total sugar(mg/100g)	Y_1	10.68	90.97	14.78
	Y_2	65.98	87.78	12.56
	Pooled	5.10	21.57	4.01
Total fruit yield per plant(kg)	Y_1	29.82	90.60	33.70
	Y_2	85.44	92.91	35.09
	Pooled	5.84	50.92	22.26

Influence the gains to be obtained from selection. Since the genetic gain is yet another important selection parameter which is although dependent and represents the expected genetic gain under selection. It measures the differences between the mean genotypic values of the selected lines and means genotypic value of base population from which these lines were selected. Thus, it is necessary to utilize the heritability in conjunction with selection differential, which would indicate the expected genetic gain. The estimate of heritability with genetic advance as per cent of mean provides a better picture to the breeders during the process of selection.

The estimates of heritability in narrow-sense (h^2ns) have been classified according to Crumpacker and Allard, (1962) as (i) High (> 30%), (ii) Moderate (10% to 30%) and (iii) low (< 10%). In this study high estimate of heritability in narrow-sense was recorded for plant height in both the years and pooled, fruits per cluster in Y_2, average fruit weight in Y_1, equatorial diameter Y_2 and pooled, titrable acidity, total fruit yield in Y_2 and total sugar in Y_1, (Table-1), Similar finding for high estimate of narrow sense heritability for different tomato traits have been also reported by Rani *et al.*(2011) [15], Singh *et al.* (2011, Islam *et al.* (2012) [8], Mohamed *et al.* (2012) [11], Hasanuzzaman *et al.* (2012) [7], Reddy *et al.* (2013) [16], Shalaby (2013) [19], Patel *et al.* (2013) [14], E l-Gabry *et al.* (2014) [5], Meitei *et al.* (2014) [10], Doddamaniv *et al.* (2017) [4], Barragan *et al.* (2019) [2].

The findings of the present investigation revealed that high heritability (h^2ns) coupled with high genetic advance as per cent of mean were observed for plant height in Y_1,Y_2 and pooled, average fruit weight in Y_1 and total fruit yield per plant in Y_2. Similar results had also been reported by Patel *et al.* (2013) [14], Meitei *et al.* (2014) [10], Bhandari *et al.* (2017) [3] and Doddamani *et al.*(2017) [4].

Moderate estimate of heritability in narrow sense was observed for days to first fruit harvest, primary branch per plant, fruits per cluster, fruits per plant, pericarp thickness, polar diameter, equatorial diameter, marketable fruit yield per plant, total soluble solids ascorbic acid, titrable acidity and total sugar in Y1, days to 50% flowering in plant in Y_2, days to first fruit harvest in Y_2 and pooled, primary branch and locules per fruit in Y_2, fruits per plant in pooled, pericarp thickness, polar diameter, marketable fruit yield, total soluble solid, ascorbic acid, average fruit weight in Y_2 and pooled. Similar finding for moderate estimate of narrow sense heritability for different tomato traits have been also previously reported by Hasanuzzaman *et al.* (2012) [7], Reddy *et al.* (2013) [16], Shalaby (2013) [19], Doddamaniv *et al.* (2017) [4].

High heritability's (h^2ns) coupled with moderate to low genetic advance were observed for fruits per cluster in Y_2, locules per fruit in Y_1, titrable acidity in Y_2 and total sugar in Y_2. Similar results had also been reported by Reddy *et al.* (2013) [16] Shalaby (2013) [19], Barragan *et al.* (2019) [2].

The estimate of high genetic advance in per cent of mean was observed for plant height and total fruit yield in Y_1, Y_2 and pooled, average fruit weight and marketable fruit yield per plant in Y_1, Y_2, fruits per plant in pooled, titrable acidity in Y_1, while, moderate estimate of genetic advance in per cent of mean was observed for days to 50% flowering, days to first fruit harvest primary branch, fruits per cluster, pericarp thickness, locules per fruit and total sugar in Y_1, Y_2, fruits per plant, marketable fruit yield per plant in Y_2, titrable acidity in Y_2,similar results had also been reported by earlier workers Ghobary and Ibrahim (2010), Rani *et al.* (2011) [15], Reddy *et al.* (2012), Panthee *et al.* (2015) [13], Panchbhaiya *et al.* (2018) [12].

Conclusion

The findings of the present investigations high heritability (h^2ns) coupled with high genetic advance as per cent of mean for the traits plant height, average fruit weight and total fruit yield per plant revealed that these traits governed by additive gene action and selection may be effective for those traits.

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