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Comparative Evaluation of Tomato Hybrids and Parental Lines For Fruit Quality Traits

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ABSTRACT

The present study was conducted to assess the variability and performance of tomato (*Solanum lycopersicum* L.) parental lines and their hybrids for key quality traits. Eleven genetically diverse parental lines were crossed and the resulting hybrids were evaluated along with their parents for seven traits: total soluble solids (TSS), total sugars, titratable acidity, ascorbic acid, lycopene, total carotenoids, and total phenolic content. Significant variability was observed among genotypes for all traits, indicating ample scope for genetic improvement. Hybrids such as P8×P10 showed superior performance in lycopene (6.10 mg/100g), total carotenoids (0.59 mg/100g), and phenolic content (3.68 mg/100g), surpassing their respective parents and suggesting strong heterotic effects. In contrast, traits like TSS and total sugars exhibited more additive inheritance, with mean values of parents generally higher than hybrids. The study provides valuable insights for breeding programs aimed at improving tomato fruit quality, contributing to both consumer health and market value.

Introduction

Tomato (*Solanum lycopersicum* L.) is a widely cultivated fruit vegetable known for its adaptability, high yield potential, and versatility in fresh and processed forms. Belonging to the Solanaceae family (2n = 24), it is primarily self-pollinated, with up to 5% natural cross-pollination reported (Muthukumar et al., 2017). Globally, tomato is grown on 5.41 million hectares with a production of 192.31 million metric tons and an average productivity of 35.53 t/ha (Anonymous, 2023). In India, it occupies 854 thousand hectares, producing 21.32 million metric tons at 24.97 t/ha (Anonymous, 2024), with major contributions from states like Andhra Pradesh, Madhya Pradesh, and Karnataka. Uttar Pradesh ranks sixth in production, with 23.5 thousand hectares yielding 940.12 thousand metric tons and a productivity of 40.0 t/ha (Anonymous, 2024).

Tomato is considered a "protective food" due to its rich nutritional profile and is consumed both raw and cooked. It is widely used in the preparation of processed products such as paste, puree, ketchup, juice, and pickles. Tomatoes are an excellent source of vitamins, minerals, and organic acids, containing 94% moisture, 3.6 g carbohydrates, 0.9 g protein, and significant amounts of vitamin A (585 IU), vitamin C (26 mg), calcium (48 mg), thiamine (0.12 mg), and riboflavin (0.06 mg) per 100 g of fresh fruit (Choudhary et al., 2018). The red color is attributed to lycopene, a carotenoid with potent antioxidant and anti-cancer properties (Bose et al., 2002). Red tomato varieties contain up to 50 mg/kg of lycopene, substantially higher than yellow varieties (Clinton, 1998). Its nutritional and functional qualities contribute to its increasing global demand in both fresh and processed forms.

The increasing consumption of tomato makes it, a high value crop for generating income to the farmers. Since tomato is an important crop both from production and industry point of view there is a necessity to improve the productivity per unit area to achieve the increased production from a limited land. Improving the productivity through traditional plant breeding method means, it is sustainable, affordable and ecofriendly. Generally, diverse parents are expected to give high hybrid vigour and it is also often possible to combine desired alleles in regular fashion without waiting for longer term as in case of development of an open pollinated cultivars. Usually, the hybrids show better fitness and breeding value as compared to parents from which they are made. Higher yield and better fruit quality are universally desired.

The objectives of this study were to characterize tomato parents and hybrids on fruit quality traits and to develop improved tomato varieties with superior fruit quality and higher yield potential, supporting breeding programs and commercial production.

Materials and Methods

The experiment was conducted at main Experimental Station, Department of Vegetable Science, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya. Geographically, experimental site falls under humid sub-tropical climate and is located in between 24.47º and 26.56º N latitude, 82.12º and 83.58 º E longitudes at an altitude of 113 m above the mean sea level. The soil type of experimental site was sandy-loam with average fertility level and Ph in the range of 7.5-8.5. The experimental materials for the present study comprised of eleven promising and diverse inbreds and varieties of tomato selected on the basis of genetic variability from the germplasm stock maintained in the Department of Vegetable Science, A.N.D.U.A.T., Kumarganj, Ayodhya (U.P.) India. The selected parental lines i.e.; NDT-2019-01 (P_1), Punjab Chhuhara (P_2), NDT-2019-02 (P_3), NDT-2 (P_4), NDT-4 (P_5), NDT-7 (P_6), NDT-6 (P_7), NDT-2019-03 (P_8), NDT-2019-04 (P_9), NDT-2020-01(P_{10}) and NDT-2020-02(P_{11}) with commercial check variety Kashi Aman were crossed in all possible cross combinations (excluding reciprocals) during year, 2022-23 to get 55 F_1's hybrid for the study of the mean performance of parental line and their resultant F1. All Sixty-Seven genotypes (eleven parental lines and fifty five F1 as well as one check variety) were evaluated in Randomized Complete Block Design (RBD) with three replications. The row to row spacing was kept 0.6 m and plant to plant spacing 0.5 m in both the season (Y1, Y2) and pooled. To raise a good crop, all agronomic techniques were followed.

Biochemical traits were analyzed using standard protocols are as follows:

Total Soluble Solids (°Brix)

TSS of fresh fruit juice was measured at 20°C using a hand refractometer (Erma, Japan, 0–32% range) and expressed as % TSS. The refractometer was rinsed with distilled water and wiped with blotting paper after each use.

Total Sugars (%)

Twenty grams of fresh pulp were homogenized in distilled water and volume adjusted to 250 ml. To this, 5 ml of 10% sodium oxalate was added and filtered. Fifty ml of filtrate were hydrolyzed with concentrated HCl overnight and neutralized with saturated NaOH. The sample was titrated with Fehling's solution using methylene blue as an indicator. Total sugars (glucose equivalent) were calculated per 100 g fresh weight (AOAC, 1980).

Titratable Acidity (%)

Five ml of juice were titrated with N/10 NaOH using phenolphthalein. Results were expressed as anhydrous citric acid using the formula:

Titratable acidity (%) = (ml of NaOH × 0.14878 × Normality of NaOH) / (Weight of aliquot) × 100

Ascorbic Acid (mg/100g)

Juice was diluted with 3% metaphosphoric acid and titrated with 2,6-dichlorophenol indophenol dye (Dahuja & Madaan, 2004). Dye was standardized using 100 mg ascorbic acid in 3% metaphosphoric acid. Ascorbic acid content was calculated as:

Ascorbic acid (mg/100g) = (X × V2 × Z) / (V1 × Y × Weight of sample) × 100

Where:

X : mg of standard ascorbic acid
V1: titre value of standard ascorbic acid against dye
V2: titre value of sample against dye
Y : volume of aliquot taken (ml)
Z : total volume of extracted sample (ml)

Total Phenols (mg/100g)

Half gram of sample was extracted in 80% ethanol, centrifuged at 10,000 rpm for 20 min, and re-extracted. Pooled extract was dried and re-dissolved in 5 ml distilled water. Aliquots (0.2–2.0 ml) were reacted with Folin–Ciocalteu reagent and 20% Na_2CO_3, heated for 1 min, cooled, and absorbance recorded at 650 nm. Phenol content was calculated using a standard curve (catechol equivalent).

Total Carotenoids (mg/100g)

Two grams of fruit were extracted with 10 ml acetone until colorless. Extract was dried and diluted to 25 ml with petroleum ether. OD was recorded at 450 nm and total carotenoids were calculated as:

Total carotenoids = (Final volume in ml) / (2 × Weight of sample in g) × Optical Density at 450 nm

Lycopene (mg/100g)

Two grams of fruit were extracted with acetone, dried, and diluted to 25 ml with petroleum ether. OD was measured at 505 nm. Lycopene was calculated as:

Lycopene = (Final volume in ml) / (2 × Weight of sample in g) × Optical Density at 505 nm

Results and Discussion

The evaluation of tomato genotypes (parents and hybrids) revealed significant variations across all the seven biochemical traits assessed, namely total soluble solids (TSS), total sugars, titratable acidity, ascorbic acid content, lycopene content, total carotenoids content, and total phenolic content.

Total Soluble Solids (TSS)

The TSS ranged from 4.14°Brix to 5.59°Brix among the parental lines, with genotype NDT-2019-02 exhibiting the highest mean TSS (5.59°Brix). Among the hybrids, TSS values ranged from 2.83°Brix (P9×P11) to 5.74°Brix (P5×P9). The mean TSS for parents (4.67°Brix) was higher than that of hybrids (4.40°Brix), indicating some hybrids failed to surpass the parental performance. Similar findings were reported by Shankar et al. (2014) and Basavaraj et al. (2016), who also observed variations due to genetic factors influencing TSS.

Total Sugars

Total sugars ranged from 3.69% to 4.18% among parents and from 3.27% to 4.41% among hybrids. The highest sugar content was observed in the hybrid P2×P9 (4.41%), exceeding all parental lines, indicating positive heterosis for sugars in this particular cross combination. These observations align with those reported by Ravindra Kumar et al. (2012) and Sunil et al. (2013), highlighting the additive and dominant genetic effects contributing to sugar content.

Titratable Acidity

The titratable acidity exhibited variability between 0.30% and 0.56% in parental lines and 0.30% to 0.58% in hybrids. The hybrid P1×P10 recorded the highest acidity (0.58%), demonstrating significant heterosis over parent lines. This trait is crucial for consumer acceptance, particularly in fresh-market tomatoes, balancing sweetness and flavor, as supported by findings of Gul et al. (2010) and Vilas et al. (2015).

Ascorbic Acid

Parental lines showed ascorbic acid content ranging from 18.5 mg/100g to 25.81 mg/100g, with genotype NDT-2 having the highest mean. Hybrids varied between 16.29 mg/100g and 26.76 mg/100g, with the standard check Kashi Aman recording the highest mean (26.76 mg/100g). Several hybrids performed comparably or better than their respective parents, similar to findings reported by Shankar et al. (2014) and Basavaraj et al. (2016), suggesting potential for improved vitamin C content through specific hybrid combinations.

Lycopene Content

Lycopene content varied widely, with parents ranging from 2.55 mg/100g to 5.83 mg/100g. The hybrid P8×P10 showed the highest mean lycopene content (6.10 mg/100g), surpassing all parental lines, indicating substantial positive heterosis. High lycopene content is a desirable trait due to its antioxidant properties, enhancing the nutritional quality of tomato fruits. These results are consistent with the observations of Sujeet Kumar and Ramanjini Gowda (2016) and Ravindra Kumar et al. (2012).

Total Carotenoids Content

Total carotenoid content in parental lines ranged from 0.30 mg/100g to 0.58 mg/100g, while hybrids ranged from 0.30 mg/100g to 0.59 mg/100g. The hybrid P8×P10 exhibited the maximum carotenoid content (0.59 mg/100g), suggesting the possibility of carotenoid enhancement through targeted hybridization. Similar trends were noted by Gul et al. (2010) and Sunil et al. (2013).

Total Phenolic Content

Total phenolic content showed substantial variability, ranging from 1.09 mg/100g to 3.52 mg/100g in parents, whereas hybrids ranged from 1.35 mg/100g to 3.68 mg/100g. The hybrid P8×P10 had the highest phenolic content (3.68 mg/100g), exceeding all parental lines, indicating strong positive heterosis. High phenolic content is associated with enhanced antioxidant capacity, providing both nutritional and shelf-life benefits. These findings align with results obtained by Vilas et al. (2015) and Sujeet Kumar and Ramanjini Gowda (2016).

Conclusion

The present investigation highlights significant genetic variability among tomato parental lines and hybrids for essential biochemical quality traits. Hybrids such as P8×P10 demonstrated superior performance across multiple parameters, including lycopene content, carotenoids, and phenolics, underscoring the effectiveness of hybrid breeding for nutritional quality enhancement. However, traits like total soluble solids and sugars appeared predominantly additive in inheritance, requiring careful parental selection for hybrid development. Thus, strategically chosen hybrids can substantially enhance tomato quality, benefiting both producers and consumers.

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Table 1. Mean performance, general mean, range, coefficient of variation and critical difference for seven characters of diallel set of 55 F_1's and their 11 parents in Y_1 (2023-24), Y_2 (2024-25) and pooled.

SN.	Parent/Hybrids	Total soluble solids (^{0} Brix)			Total sugars (%)			Titrable acidity (%)			Ascorbic acid (mg/100 g fruit)			Lycopene content (mg/100 g fruit)			Total carotenoids content (mg/100 g fruit)			Total phenol content (mg/100 g fruit)		
		Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P
	Parents																					
1	**NDT-2019-01**	4	4.44	4.22	3.6	3.85	3.73	0.3	0.33	0.32	20.1	21.51	20.8	3.28	3.5	3.39	0.45	0.55	0.5	1.23	1.25	1.24
2	**Punjab chhuhara**	4.3	4.6	4.45	3.97	4.39	4.18	0.47	0.53	0.5	17.53	19.46	18.5	2.43	2.66	2.55	0.47	0.38	0.43	1.12	1.06	1.09
3	**NDT-2019-02**	5.3	5.88	5.59	3.8	4.17	3.99	0.47	0.55	0.51	20.1	21.5	20.8	3.94	3.97	3.96	0.47	0.55	0.51	1.75	1.9	1.83
4	**NDT-2**	4.8	5.14	4.97	3.6	3.94	3.77	0.4	0.44	0.42	24.5	27.11	25.81	3.82	3.9	3.86	0.4	0.44	0.42	1.89	1.92	1.91
5	**NDT-4**	4.9	5.44	5.17	3.5	3.89	3.69	0.4	0.44	0.42	21.83	23.94	22.89	3.16	3.36	3.26	0.35	0.45	0.4	1.35	1.38	1.37
6	**NDT-7**	4	4.28	4.14	3.7	3.96	3.83	0.27	0.33	0.3	23.77	25.98	24.88	3.05	3.25	3.15	0.27	0.33	0.3	1.95	1.99	1.97
7	**NDT-6**	4	4.43	4.22	3.9	4.32	4.11	0.33	0.32	0.33	21	23.31	22.15	3	3.15	3.08	0.33	0.32	0.33	1.92	1.97	1.95
8	**NDT-2019-03**	4	4.39	4.2	3.8	4.07	3.93	0.43	0.48	0.45	19.5	20.86	20.18	5.75	5.9	5.83	0.55	0.58	0.57	2.55	2.75	2.65
9	**NDT-2019-04**	4.2	4.59	4.4	3.83	4.26	4.04	0.47	0.51	0.49	20.5	22.69	21.59	3.15	3.5	3.3	0.47	0.51	0.49	2.05	2.15	2.1
10	**NDT-2020-01**	4.5	5	4.75	3.67	3.92	3.8	0.47	0.55	0.51	19.7	21.6	20.65	3.1	3.43	3.27	0.57	0.58	0.58	3.65	3.7	3.52
11	**NDT-2020-02**	5.03	5.38	5.21	3.57	3.95	3.76	0.53	0.58	0.56	20.5	22.41	21.45	2.74	2.98	2.86	0.27	0.35	0.31	1.98	1.99	1.99
	Mean	**4.46**	**4.87**	**4.67**	**3.72**	**4.07**	**3.89**	**0.41**	**0.46**	**0.44**	**20.82**	**22.76**	**21.79**	**3.4**	**3.6**	**3.5**	**0.42**	**0.46**	**0.44**	**1.95**	**2.01**	**1.97**
	Min	**4**	**4.28**	**4.14**	**3.5**	**3.85**	**3.69**	**0.27**	**0.32**	**0.3**	**17.53**	**19.46**	**18.5**	**2.43**	**2.66**	**2.55**	**0.27**	**0.32**	**0.3**	**1.12**	**1.06**	**1.09**
	Max	**5.3**	**5.88**	**5.59**	**3.97**	**4.39**	**4.18**	**0.53**	**0.58**	**0.56**	**24.5**	**27.11**	**25.81**	**5.75**	**5.9**	**5.83**	**0.57**	**0.58**	**0.58**	**3.65**	**3.7**	**3.52**
	Hybrids																					
12	$P_1 \times P_2$	4	4.43	4.21	3.73	4.09	3.92	0.37	0.44	0.4	20.1	21.78	20.94	3.4	3.58	3.49	0.53	0.55	0.54	1.55	1.78	1.67
13	$P_1 \times P_3$	4.4	4.83	4.62	3.8	4.16	3.98	0.47	0.53	0.5	20	22.19	21.1	3.7	3.92	3.81	0.47	0.53	0.5	1.37	1.39	1.38
14	$P_1 \times P_4$	4	4.37	4.19	3.4	3.77	3.59	0.43	0.45	0.44	19.9	21.29	20.59	3.87	3.96	3.92	0.43	0.45	0.44	1.88	1.9	1.89
15	$P_1 \times P_5$	3.7	4.01	3.85	3.3	3.53	3.42	0.37	0.44	0.4	20.1	22.25	21.18	3.67	3.85	3.76	0.57	0.54	0.56	1.48	1.5	1.49
16	$P_1 \times P_6$	3.1	3.44	3.27	3.6	3.99	3.79	0.3	0.33	0.31	19.8	21.71	20.76	3.2	3.43	3.32	0.5	0.53	0.52	1.39	1.47	1.43
17	$P_1 \times P_7$	3.9	4.17	4.04	3.97	4.35	4.16	0.37	0.44	0.4	24.97	27.29	26.13	3.4	3.63	3.52	0.55	0.54	0.55	1.78	1.65	1.72
18	$P_1 \times P_8$	5.03	5.57	5.3	3.73	4.08	3.91	0.37	0.43	0.4	20.5	22.75	21.62	3.63	3.79	3.79	0.55	0.57	0.56	1.92	1.97	1.95
19	$P_1 \times P_9$	4.1	4.5	4.3	3.97	4.3	4.13	0.5	0.56	0.53	20.17	21.58	20.87	3.6	3.89	3.75	0.5	0.56	0.53	1.48	1.57	1.53
20	$P_1 \times P_{10}$	4.2	4.59	4.39	3.7	4.11	3.9	0.55	0.61	0.58	20.4	22.58	21.49	3.3	3.35	3.33	0.53	0.54	0.54	2.06	2.15	2.11
21	$P_1 \times P_{11}$	4.4	4.88	4.64	3.73	4	3.86	0.47	0.51	0.49	19.9	21.83	20.86	3.15	3.35	3.25	0.47	0.51	0.49	1.92	1.95	1.94
22	$P_2 \times P_3$	5.03	5.39	5.21	4.07	4.5	4.28	0.53	0.57	0.55	18.17	19.86	19.02	2.9	3.08	2.99	0.48	0.5	0.49	1.78	1.88	1.83
23	$P_2 \times P_4$	4.1	4.54	4.32	3.67	4.02	3.85	0.38	0.42	0.4	20.07	21.75	20.9	3.8	3.55	3.68	0.38	0.42	0.4	1.8	1.85	1.83
24	$P_2 \times P_5$	4	4.39	4.2	3.73	4.08	3.91	0.43	0.46	0.45	21.33	23.33	22.33	3.53	3.74	3.64	0.5	0.53	0.52	1.45	1.47	1.46
25	$P_2 \times P_6$	3.9	4.26	4.08	3.8	4.22	4.01	0.37	0.44	0.4	15.73	16.84	16.29	2.87	2.99	2.93	0.39	0.44	0.42	1.33	1.37	1.35
26	$P_2 \times P_7$	3.97	4.3	4.13	3.83	4.1	3.97	0.43	0.44	0.44	16.07	17.78	16.92	3.43	3.53	3.48	0.43	0.44	0.44	1.9	1.98	1.94
27	$P_2 \times P_8$	5.03	5.5	5.27	3.97	4.39	4.18	0.37	0.44	0.41	19.5	21.39	20.45	3.93	3.98	3.96	0.52	0.54	0.53	1.99	1.97	1.98
28	$P_2 \times P_9$	4.2	4.49	4.35	4.2	4.61	4.41	0.48	0.54	0.51	19.8	21.65	20.72	3.13	3.24	3.19	0.48	0.54	0.51	1.8	1.77	1.79
29	$P_2 \times P_{10}$	4.2	4.65	4.42	3.87	4.23	4.05	0.45	0.48	0.46	19.43	21.56	20.5	3.03	3.32	3.18	0.53	0.56	0.55	2.05	2.23	2.14

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30	$P_2 \times P_{11}$	3.7	4.06	3.88	3.73	4.04	3.89	0.53	0.56	0.55	20.53	21.97	21.25	3.13	3.26	3.2	0.45	0.48	0.47	1.57	1.65	1.61
31	$P_3 \times P_4$	4	4.37	4.19	4.07	4.45	4.26	0.33	0.37	0.35	20.03	22.17	21.11	3.98	4.05	4.02	0.53	0.57	0.55	1.89	1.9	1.9
32	$P_3 \times P_5$	4.2	4.66	4.43	3.73	3.99	3.86	0.47	0.55	0.51	23.67	25.96	24.81	4.4	4.87	4.64	0.47	0.55	0.51	1.93	1.98	1.96
Table 1 Continue..																						
33	$P_3 \times P_6$	4.9	5.24	5.07	3.8	4.21	4	0.33	0.36	0.35	20.07	21.94	21	4.8	4.88	4.84	0.5	0.53	0.52	1.97	1.98	1.98
34	$P_3 \times P_7$	4.3	4.76	4.53	3.97	4.35	4.16	0.47	0.55	0.51	19.9	21.56	20.73	4.2	4.4	4.3	0.47	0.55	0.51	1.85	1.89	1.87
35	$P_3 \times P_8$	3.8	4.17	3.99	3.97	4.34	4.15	0.37	0.39	0.38	19.77	21.61	20.69	4	4.25	4.13	0.55	0.56	0.56	1.99	2.05	2.02
36	$P_3 \times P_9$	4.1	4.48	4.29	3.8	4.22	4.01	0.43	0.45	0.44	20.87	22.33	21.6	3.98	3.99	3.99	0.53	0.55	0.54	1.92	1.95	1.94
37	$P_3 \times P_{10}$	3.9	4.22	4.06	3.73	3.99	3.86	0.43	0.44	0.44	19.4	21.47	20.44	3.32	3.52	3.42	0.53	0.54	0.54	2.3	2.55	2.43
38	$P_3 \times P_{11}$	4.3	4.7	4.5	3.73	4.13	3.93	0.4	0.47	0.44	19.9	21.82	20.86	3.5	3.4	3.45	0.4	0.47	0.44	1.89	1.95	1.92
39	$P_4 \times P_5$	3.8	4.07	3.93	3.73	4.09	3.92	0.43	0.54	0.49	20.4	22.17	21.29	3.6	3.85	3.73	0.43	0.54	0.49	1.94	1.99	1.97
40	$P_4 \times P_6$	4	4.43	4.21	3.83	4.19	4.01	0.4	0.51	0.45	21.5	23.37	22.43	3.87	3.94	3.91	0.45	0.51	0.48	1.97	1.98	1.98
41	$P_4 \times P_7$	4.2	4.61	4.4	3.67	3.97	3.82	0.33	0.36	0.35	20.93	22.53	21.73	3.97	3.96	3.97	0.33	0.36	0.35	1.99	1.98	1.99
42	$P_4 \times P_8$	4.8	5.22	5.01	3.33	3.64	3.49	0.43	0.48	0.46	18.77	20.64	19.71	3.94	3.97	3.96	0.43	0.48	0.46	2.15	2.2	2.18
43	$P_4 \times P_9$	3.9	4.24	4.07	3.23	3.46	3.35	0.4	0.44	0.42	23.87	26.18	25.02	3.99	4.05	4.02	0.4	0.44	0.42	1.92	1.97	1.95
44	$P_4 \times P_{10}$	3.5	3.77	3.63	3.47	3.84	3.65	0.4	0.47	0.44	17.8	19.52	18.66	3.68	3.8	3.74	0.5	0.57	0.54	2.55	2.58	2.57
45	$P_4 \times P_{11}$	4	4.4	4.2	3.43	3.77	3.6	0.53	0.58	0.56	20.8	22.67	21.74	3.9	3.92	3.91	0.45	0.48	0.47	1.95	1.97	1.96
46	$P_5 \times P_6$	3.3	3.62	3.46	3.8	4.13	3.97	0.4	0.46	0.43	19.9	21.62	20.76	3.67	3.82	3.75	0.4	0.46	0.43	1.45	1.55	1.5
47	$P_5 \times P_7$	4.2	4.61	4.4	3.73	4.06	3.89	0.4	0.49	0.45	17.9	19.15	18.53	3.8	3.96	3.88	0.4	0.49	0.45	1.78	1.83	1.81
48	$P_5 \times P_8$	4.2	4.58	4.39	3.73	4.02	3.88	0.4	0.44	0.42	20.07	22.08	21.07	3.87	3.9	3.89	0.4	0.44	0.42	1.98	1.99	1.99
49	$P_5 \times P_9$	5.5	5.98	5.74	3.67	4.04	3.85	0.4	0.47	0.44	20.3	22.27	21.29	3.4	3.54	3.47	0.4	0.47	0.44	1.75	1.8	1.78
50	$P_5 \times P_{10}$	5.03	5.38	5.21	3.33	3.66	3.5	0.47	0.53	0.5	20.1	22.04	21.07	3.78	3.8	3.79	0.47	0.53	0.5	2.08	2.13	2.11
51	$P_5 \times P_{11}$	3.9	4.29	4.09	3.67	4.02	3.84	0.43	0.45	0.44	20.5	22.41	21.46	3.73	3.9	3.82	0.43	0.45	0.44	1.53	1.55	1.54
52	$P_6 \times P_7$	4.2	4.61	4.4	4.1	4.47	4.28	0.33	0.34	0.34	21.13	23.02	22.08	3.56	3.68	3.62	0.33	0.34	0.34	1.97	1.99	1.98
53	$P_6 \times P_8$	4.8	5.26	5.03	3.53	3.84	3.68	0.47	0.55	0.51	20.5	22.56	21.53	3.63	3.88	3.76	0.47	0.55	0.51	1.99	2.05	2.02
54	$P_6 \times P_9$	4.1	4.48	4.29	3.57	3.82	3.69	0.37	0.4	0.38	21.33	23.39	22.37	3.4	3.54	3.47	0.37	0.4	0.39	1.78	1.85	1.82
55	$P_6 \times P_{10}$	5.03	5.48	5.26	3.57	3.93	3.75	0.43	0.44	0.44	20.1	22.05	21.08	3.25	3.32	3.29	0.53	0.54	0.54	3.53	3.65	3.59
56	$P_6 \times P_{11}$	4.1	4.51	4.31	3.73	4.09	3.92	0.3	0.36	0.33	21.2	23.11	22.16	3.9	3.98	3.94	0.3	0.36	0.33	1.98	1.99	1.99
57	$P_7 \times P_8$	3.9	4.28	4.09	3.33	3.66	3.49	0.4	0.46	0.43	20.6	22.39	21.49	3.67	3.91	3.79	0.4	0.46	0.43	2.65	2.75	2.7
58	$P_7 \times P_9$	4	4.39	4.2	3.53	3.87	3.7	0.37	0.42	0.4	20	21.47	20.73	3.4	3.61	3.51	0.37	0.42	0.4	1.99	1.98	1.99
59	$P_7 \times P_{10}$	4	4.36	4.18	3.13	3.41	3.27	0.43	0.48	0.46	19.5	21.46	20.48	3.4	3.5	3.45	0.43	0.48	0.46	3.53	3.75	3.64
60	$P_7 \times P_{11}$	3.9	4.24	4.07	4.1	4.51	4.31	0.33	0.33	0.33	20.67	22.66	21.67	3.3	3.37	3.34	0.33	0.33	0.33	1.95	1.98	1.97
61	$P_8 \times P_9$	3.7	3.97	3.83	3.27	3.58	3.43	0.43	0.47	0.45	19.63	21.54	20.59	5.93	6.08	6.01	0.56	0.58	0.57	2.78	2.85	2.82
62	$P_8 \times P_{10}$	4.3	4.73	4.52	3.53	3.88	3.7	0.47	0.54	0.51	19.93	21.79	20.86	5.98	6.22	6.1	0.58	0.59	0.59	3.58	3.78	3.68
63	$P_8 \times P_{11}$	4.5	4.94	4.72	3.37	3.67	3.52	0.4	0.47	0.43	21.73	23.33	22.53	4.7	4.95	4.83	0.5	0.57	0.54	2.45	2.55	2.5
64	$P_9 \times P_{10}$	4	4.39	4.2	3.67	3.99	3.83	0.37	0.46	0.42	21.93	24.13	23.03	3.5	3.69	3.6	0.47	0.5	0.49	2.78	2.75	2.77
65	$P_9 \times P_{11}$	2.7	2.95	2.83	3.73	4.01	3.87	0.53	0.56	0.55	20.5	22.48	21.49	3.45	3.39	3.42	0.53	0.56	0.55	2.13	2.25	2.19
66	$P_{10} \times P_{11}$	4.3	4.73	4.51	3.23	3.56	3.4	0.43	0.48	0.46	20.03	21.97	21	3.35	3.15	3.25	0.57	0.58	0.58	3.05	3.15	3.1
67	**Kashi Aman (Check)**	4.1	4.5	4.3	3.73	4.09	3.92	0.27	0.33	0.3	25.57	27.95	26.76	3.97	4.35	4.16	0.56	0.58	0.57	1.99	2.05	2.02
	Mean	**4.2**	**4.59**	**4.4**	**3.69**	**4.03**	**3.86**	**0.41**	**0.46**	**0.44**	**20.39**	**22.28**	**21.34**	**3.67**	**3.81**	**3.74**	**0.46**	**0.5**	**0.48**	**2.01**	**2.07**	**2.04**
	Min	**2.7**	**2.95**	**2.83**	**3.13**	**3.41**	**3.27**	**0.27**	**0.32**	**0.3**	**15.73**	**16.84**	**16.29**	**2.43**	**2.66**	**2.55**	**0.27**	**0.32**	**0.3**	**1.12**	**1.06**	**1.09**
	Max	**5.5**	**5.98**	**5.74**	**4.2**	**4.61**	**4.41**	**0.55**	**0.61**	**0.58**	**25.57**	**27.95**	**26.76**	**5.98**	**6.22**	**6.1**	**0.58**	**0.59**	**0.59**	**3.65**	**3.78**	**3.68**
	SE(d) ±	**0.09**	**0.12**	**0.1**	**0.15**	**0.17**	**0.16**	**0.05**	**0.03**	**0.04**	**0.46**	**0.54**	**0.48**	**0.09**	**0.09**	**0.08**	**0.01**	**0.01**	**0.01**	**0.05**	**0.04**	**0.04**
	C.D.at 5%	**0.18**	**0.23**	**0.2**	**0.3**	**0.34**	**0.32**	**0.1**	**0.07**	**0.08**	**0.91**	**1.06**	**0.96**	**0.17**	**0.17**	**0.16**	**0.02**	**0.02**	**0.02**	**0.1**	**0.09**	**0.08**
	C.V. (%)	**2.68**	**3.08**	**2.8**	**4.98**	**5.26**	**5.09**	**15.56**	**9.1**	**11.41**	**2.76**	**2.93**	**2.76**	**2.87**	**2.74**	**2.7**	**2.89**	**2.7**	**2.82**	**2.96**	**2.55**	**2.5**