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AUGMENTED ANALYSIS FOR YIELD AND SOME YIELD COMPONENTS IN TOMATO (*LYCOPERSICON ESCULENTUM* Mill.)

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Abstract

A preliminary yield trial involving 30 exotic selections in comparison to three check varieties viz. Nagina, Riogrande and Roma of tomato was conducted according to augmented design at Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, Pakistan during 2009-10. The analysis of variance indicated non-significant differences among blocks for yield per plant, days to maturity, number of fruit per plant and single fruit weight whereas significant differences were among all checks for yield per plant, single fruit weight and number of fruit per plant except days to maturity. None of the selections except 'Mission 102' had significantly higher yield (2.48 kg plant^{-1}) than that of high yielding check, Riogrande (2.00 kg plant^{-1}). Most of the selections proved to be low performer for yield and its components in prevailing environmental conditions.

Introduction

Tomato (*Lycopesicon esculentum* Mill.) is used as an essential ingredient in preparation of various dishes, sauces and drinks. During 2009, tomato was grown on an area of 53.4 thousand hectares giving fruit production of 561.9 thousand tonnes and average yield of 10.5 thousand tonnes per hectare in Pakistan (Anon., 2009). The quantity of tomato produced during 2009 was lower than that of demand of 602 thousand tonnes in the country (Anon., 1999). Although the area under tomato cultivation over the last eight years has been increased from 29.4 to 53.4 thousand hectares, yet the average yield has been stagnated (9.6 to 10.7 thousand tonnes per hectare) and could not be significantly improved as compared to average yield of 23-77 thousand tonnes per hectare of modern agricultural areas (Anon., 2009). Among yield limiting constraints, susceptibility of extensively grown tomato varieties to biotic stresses (early blight, late blight, cucumber mosaic virus, aphid, fruit borer etc), abiotic stresses (frost, heat, drought etc.,) and lack of quality seed (hybrids varieties) are major factors in Pakistan (Saleem *et al*., 2009; Saleem *et al*., 2011; Akhtar *et al*., 2010; Akhtar *et al*., 2012; Hameed *et al*., 2010). On account of limited progress on commercial production of tomato hybrid seed in Pakistan, a quantity of 56.52 tonnes of seed was imported at the cost of 184.66 million rupees in 2009 (Anon., 2009). Issues of adaptability to environments, risks of genetic vulnerability to diseases and insect pest are serious threats owing to imported tomato seed. It is therefore, necessary to screen the exotic varieties following an efficient and cost effective breeding design prior to conducting massive yield trials for the release of either hybrids or cultivars.

In early stages of plant breeding programme, expected genetic gains may be increased by screening a larger number of genotypes in contrast to having more precise comparisons of a fewer genotype (Bos, 1983; Gauch & Zobel, 1996). This consideration will likely make it necessary to evaluate entries where there may not be the sufficient seed to replicate each (Kent, 2009). Federer (1956, 2002, 2005) proposed augmented designs where a set of check entries are replicated with an equal number of times in a specified field design and additional set of new or test entries are included in the experiment only once. Any type of block design can be used for the check treatments with the test entries being added or 'augmented' to the blocks and the standard error for the difference between test entries or checks may simply be computed. Performance of new selection being greater than mean performance of check + least significant increase (LSI) can be rated as significantly greater than that of check mean. This is what a breeder needs either before the release of variety or making choice of parental genotypes to be used in hybridization. Efforts were therefore, made in current study to compare and isolate the performance of some new exotic selections with those of extensively grown cultivars through an augmented field trial at Faisalabad, Pakistan.

Materials and Methods

A preliminary yield trial involving 30 new selections of tomato listed in Table 1 was conducted on tomato breeding field area at Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, Pakistan during 2010. Nursery seedlings were grown on beds enriched with farm yard manure and canal silt (2:5) in November, 2009. Healthy seedlings were transplanted in February, 2010 on beds at a distance of 50 cm apart. The beds were spaced 1.5 m from each other. The experimental area was divided into six blocks in such a way that beds in each block were treated as single rows. There were eight rows in each block. Three check varieties viz., Nagina, Riogrande and Roma were planted at random on rows within blocks in a way that same check varieties appeared in every block. The remaining five rows in each block were assigned to new selections, with a different set of selections in each block. Eight plants per genotype in each row were successfully grown till maturity following standard agronomic and plant protection practices.

The data recorded on yield per plant (kg), days to maturity, number of fruits per plant and single fruit weight in gram (g) were analyzed following augmented techniques (Federer, 1956; Federer & Ragavarao, 1975).

Table 1. List of selections and checks for augmented analysis.

S. No.	Selections	S. No.	Selections
1.	Caldera F_1	18.	Canada 25
2.	Summer king	19.	CLN2413R
3.	TMA 604 F_1	20.	Munna
4.	Eden F_1	21.	Peto -86
5.	BSS-082 F_1	22.	BGR 1906
6.	BSS-5067	23.	Jessica hybrid
7.	SAM F_1	24.	CDK 1088
8.	CM Selection	25.	Peto
9.	AVRDC-19291	26.	Madona F_1
10.	Commander	27.	Malka F_1
11.	Samrudhi	28.	V Yaqi
12.	BL1176	29.	Syngenta hybrid
13.	Riogrande (China)	30.	Riogrande (Tarnab seed)
14.	AVRDC-106587	31.	Nagina (check)
15.	Tol 8TDI	32.	Riogrande (check)
16.	Canada Ac-1	33.	Roma (check)
17.	Mission 102		

Results and Discussion

Mean squares for analysis of variance indicated significant differences among all checks for yield per plant, single fruit weight and number of fruit per plant, however it was non-significant for days to maturity (Table 2). The result showed that the checks were extremes of the characters for as long as three important traits are concerned except days to maturity where all the checks matured within same duration. Therefore, the efficacy of checks to make different comparisons against new selections could not be ruled out. Saleem *et al*., (2009) reported the worth of genetic variability for days to fruiting, number of fruit per plant and single fruit weight for checks.

Table 2. Mean squares for analysis of variance of check genotypes.

Source	d.f.	Yield per plant (kg)	Days to maturity	No. of fruit per plant	Single fruit weight (g)
Total	17				
Blocks	5	0.06	9.52	82.93	18.66
Checks	2	0.13*	4.39	266.00*	72.49**
Error	10	0.03	3.99	69.33	6.36

*, ** = Significant at 0.05 and 0.01 level of probability, respectively

In routine evaluation of germplasm, two disadvantages have been recorded. Firstly, the checks are systematically placed and secondly no provision is made to adjust the mean performance of the traits due to soil or other differences from one part of experiment to another. To overcome these difficulties, three checks were assigned at random to rows with in the blocks, with same check genotype appearing in every block. The present study also provides estimates of standard errors of four different comparisons (Table 3) to compute least significant differences. However, the most useful comparison was the difference between adjusted means of selections and a check mean therefore, LSI at 0.05 level of probability using one tailed t-test at 10 degree of freedom (d.f) for each trait was worked out.

Table 3. Standard errors (SE) for various comparisons.

Differences	Yield per plant (kg)	Days to maturity	Fruit per plant	Single fruit weight (g)
Difference between means of check varieties (Sc)	0.10	1.15	1.49	1.46
Difference between adjusted means of two selections in the same block (Sb)	0.24	2.82	3.65	3.57
Difference between adjusted means of two selections in different blocks (Sv)	0.27	3.26	4.21	4.12
Difference between adjusted means of a selection and a check (Svc)	0.21	2.49	3.21	3.15
LSI = t_{α}.Svc	0.38	4.51	5.82	5.70

The means of checks and the adjusted means of block differences of new selections for various traits are given in Table 4. Any adjusted mean performance of new selection greater than overall performance (observed mean + LSI) helped to obtain various comparisons of each check and new selection. None of the new selections except 'Mission 102' had significantly higher yield than that of highest yielding check Riogrande. Early maturity of tomato fruit is a desirable character to fetch high profit in markets. Days to maturity indicated a wide range of mean differences among new selections. Twenty-one new selections possessed significantly early maturity ranging from 165-179 days, against top most early maturing check 'Nagina' whose fruits matured within 181 days. For judicious use of new selections except hybrids in cross breeding programme, it is suggested that new selections can be opted having 10 days early maturity than Nagina. Higher number of fruits per plant and single fruit weight are major yield components in tomato. Two exotic new selections viz., AVRDC-106587 and AVRDC-19291 had significantly higher number of fruit per plant against high fruit bearing check, Riogrande. As far as single fruit weight is concerned, new selections viz., Mission 102, TMA604 F_1, Riogrande (China), Malka F_1 hybrid, Madona F_1 and Riogrande (Tarnab seed) had significantly higher single fruit weight than that of top most check 'Riogrande'. It is evident from these results that exotic new selections; particularly F_1 hybrids have come up with low yield performance contrary to checks which of course, is due to their less adaptation to local environments. Similar results on yield and yield components in tomato were reported by Barten *et al*., (2010) are in line to our results.

Table 4. Mean performance of checks and adjusted performance of genotypes of tomato.

Yield per plant (kg)		Days to maturity (DM)		No. of fruit per plant (Fr/Pl)		Single fruit weight (SFrW) in (g)	
Selections	**Yield**	**Selections**	**DM**	**Selections**	**Fr/Pl**	**Selections**	**SFrW**
Mission 102	2.48	CLN2413R	182	AVRDC-106587	85	Mission 102	74.91
Riogrande	**2.00**	BL1176	179	AVRDC-19291	62	TMA 604 F_1	73.41
Malka F_1	1.89	**Riogrande**	**178**	Mission 102	43	Riogrande (China)	67.18
Nagina	**1.86**	Canada Ac-1	178	Munna	43	Malka F_1	65.74
Peto	1.75	Jessica F_2	178	**Riogrande**	**39**	Madona F_1	65.51
Roma	**1.71**	**Roma**	**178**	**Nagina**	**39**	Riogrande (Tarnab seed)	65.08
Madona F_1	1.68	SAM F_1	177	**Roma**	**36**	Eden F_1	62.08
Munna	1.6	Syngenta hybrid	177	Canada 25	36	Summer king	61.96
Summer king	1.50	**Nagina**	**177**	Malka F_1	34	CM Selection	61.62
Riogrande (China)	1.50	Summer king	176	Peto	33	Peto	60.74
Canada 25	1.48	Tol 8TDI	175	Madona F_1	32	CDK 1088	58.75
Riogrande (Tarnab seed)	1.37	BGR 1906	175	BSS-5067	30	**Riogrande**	**57.83**
TMA 604 F_1	1.34	Caldera F_1	174	SAM F_1	28	Commander	55.29
CDK 1088	1.28	AVRDC-19291	174	Summer king	27	**Nagina**	**54.50**
Commander	1.27	Eden F_1	173	Commander	26	Canada 25	51.07
BSS-082 F_1	1.23	CM Selection	173	Riogrande (China)	26	**Roma**	**50.88**
Eden F_1	1.15	Riogrande (Tarnab seed)	173	BSS-082 F_1	26	BSS-082 F_1	50.74
SAM F_1	1.11	BSS-5067	173	Peto-86	25	V Yaqi	49.74
Peto-86	1.03	Samrudhi	173	Canada Ac-1	24	Peto-86	47.29
Jessica hybrid	0.96	Munna	173	Jessica F_2	24	BGR 1906	47.18
BSS-5067	0.94	BSS-082 F_1	173	CDK 1088	24	Tol 8TDI	46.75
V Yaqi	0.94	V Yaqi	173	Riogrande (Tarnab seed)	24	Samrudhi	46.18
Caldera F_1	0.92	TMA 604 F_1	172	Caldera F_1	24	Caldera F_1	45.86
CM selection	0.92	CDK 1088	172	Eden F_1	22	Jessica F_2	42.84
Tol 8TDI	0.79	Peto-86	171	TMA 604	20	Syngenta hybrid	42.52
Samrudhi	0.75	Riogrande (China)	171	V Yaqi	19	SAM F_1	41.52
Canada Ac-1	0.69	Commander	170	Syngenta hybrid	19	BL1176	38.19
AVRDC-19291	0.65	Canada 25	169	CM Selection	18	Munna	37.18
Syngenta hybrid	0.65	Malka F_1	169	Tol 8TDI	18	BSS-5067	31.84
BGR 1906	0.51	AVRDC-106587	168	Samrudhi	17	Canada Ac-1	31.62
AVRDC-106587	0.40	Peto	168	CLN2413R	12	CLN2413R	29.86
Bl1176	0.30	Mission 102	166	BGR 1906	11	AVRDC-19291	10.51
CLN 2413R	0.25	Madona F_1	165	BL1176	11	AVRDC-106587	6.18
LSI (0.05)	0.38	LSI (0.05)	4.51	LSI (0.05)	5.82	LSI (0.05)	5.70
Mean + LSI (Riogrande)	2.38	Mean + LSI (Nagina)	181	Mean + LSI (Riogrande)	45	Mean + LSI (Riogrande)	63.53
Mean + LSI (Nagina)	2.24	Mean + LSI (Roma)	182	Mean + LSI (Nagina)	44	Mean + LSI (Nagina)	60.19
Mean + LSI (Roma)	2.09	Mean + LSI (Riogrande)	183	Mean + LSI (Roma)	42	Mean + LSI (Roma)	56.58

Conclusion

Except Mission 102 neither of the new selections was at par with the checks for yield and its other related traits. This was the result of first year study; however, data for another year is suggested to be analyzed by augmented evaluation to judge interaction between genotype × environment. The new selections have limited scope to be released as cultivars, however; the segregating generations of F_1 hybrids may give better segregates for the development of pure lines of tomato.

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