Performance Evaluation and Path Analysis Studies in Tomato (*Solanumlycopersicon*l.) Genotpes under Humera, Northern Ethiopia Condition

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Abstract In order to evaluate performance of genotypes and study the direct and indirect effects of characters on fruit yield, thirty six tomato genotypes introduced from different countries were grown at Humera Agricultural Research Center during 2010/11 cropping season under irrigation condition. The trial was laid out in 6 x 6 simple lattice design in two replications. The maximum marketable yield was obtained from the genotype CLN-2037-A (49.20 tons ha^{-1}) and the minimum with H-1350 (3.00 tons ha^{-1}). Estimates of genotypic direct and indirect effects of various characters on fruit yield showed that number of matured fruits plant-1 (0.798) and average weight of fruits plant^{-1} (0.644) had highest positive direct contribution to fruit yield. This indicated direct selection based on these characters will improve fruit yield. On the contrary, fruit set percentage (-0.447) and fruit polar diameter (-0.392) exerted highest negative direct effect on fruit yield ha^{-1}.

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1. Introduction

Tomato (Solanum*lycopersicon* L.) is one of popular vegetables grown in the world. It requires warm and dry climate (MoARD, 2009). However, it is adapted to a wide range of climatic conditions from temperate to hot and humid tropics. The plant can survive a range of temperatures, but grow best under temperatures of 20–27°C (Naika *et al.*, 2005).

In Ethiopia cultivation of tomato is increased in area coverage and volume of production from time to time. It showed an increment in total cultivated area from 5,342 ha with a production of 41,815 tons (FAOSTAT, 2011) to 7,237 ha with a volume of production 55,514 tons (FAOSTAT, 2012). This is because many domestic and foreign investors are attracted to the horticulture sector in Ethiopia. Moreover, the government contributing a lot to have farmers' alternative water source (exploit ground water or constructing common dams) besides, small scale farmers increased their awareness about the profitability of cultivation of vegetables and fruits through irrigation.

However, growing of tomato is constrained by many factors i.e. shortage of improved varieties, disease and pest infestation (*Tutaabsoluta*), poor agronomic practices and poor postharvest handling are some of the major production challenges.

Tomato fruit yield is a quantitative character, which is influenced by a number of yield contributing characters. Path coefficient analysis specifies the cause and measures the relative importance of the characters, while correlation measures only mutual association without considering causation (Dewey and Lu, 1959). Moreover, path coefficient analysis partitions the genotypic correlation into direct and indirect effects via alternative characters and assists plant breeders in identifying traits that are useful as selection criteria to improve crop yield (Dewey and Lu, 1959; Samonte *et al.*, 1998).

Many authors Hidayatullah *et al.* (2008); Mehta and Asati (2008); Ghosh *et al.* (2010); Tiwari and Upadhyay, 2011; Tanuja *et al.* (2012); Reddy *et al.* (2013) have been made study on path coefficient analysis and evaluation studies in tomato. However, little information is available with respect to path coefficient analysis studies on tomato genotypes under Ethiopian conditions. Therefore, a study was carried out to evaluate performance of genotypes and study the direct and indirect effect of characters on fruit yield.

2. Materials and Methods

Thirty sixtomato genotypes introduced from different sources i.e. Asian Vegetable Research and Development Center (AVRDC) (17), Israel (4), Italy (7) USA (1),

Guadaloupe (1), France (1) and information not available (5) were grown in Humera Agricultural research Center experimental site during 2010/11 under irrigation condition. Humera is located 14°06' N latitude and 38°31' E longitude at an altitude of 604 meter above sea level. The maximum temperature varies from 33°C to 42°C and the minimum 17.5°C to 22.2°C (EARO, 2002). The experiment was laid out in 6 x 6 simple lattice design in two replications. The trial had gross plot size of 4 m*5.1 m with a net plot size of 2 x 5.1 m spaced at 100x30 cm between rows and plants respectively. DAP @ 200 kg ha^{-1} and Urea @ 100 kg ha^{-1} were applied at time of planting and two weeks after transplanting as of recommended for the crop (Lemma, 2002).

Ten plants and 10 fruits were randomly sampled from middle two rows leaving the two rows as borders. Data's on plant height (cm), primary branches, number of flowers plant^{-1}, number of fruit clusters plant^{-1}, number of fruits cluster^{-1}, number of fruits plant^{-1}, fruit set percentage (%), weight of fruit plant^{-1} (kg), single fruit weight (g), fruit polar diameter (mm), equatorial diameter (mm), Fruit shape index, number of locules fruit^{-1}, Pericarp thickness (mm), number of seeds fruit^{-1} and total soluble solids (TSS) (°Brix) were recorded per plant and fruit basis. Measurements such as days to 50% flowering, days to maturity, number of Pickings and fruit yield ha^{-1} (t) were taken on plot basis.

Statistical analysis were done according to Montogomery (2005) using statistical analysis software (SAS) package and treatment means were compared using least significant difference (LSD) at 1% probability level. Path coefficient analysis was computed according the method given by Dewey and Lu (1959) using the genotypic correlation coefficients to determine the direct and indirect effects of yield components on fruit yield (tons ha^{-1}).

Table 1. Growth and yield components of tomato genotypes grown in Humera

No	Name of genotype	50FL	DM	PHT (cm)	PBR	NFLO	NFCL	FRPC	FRPP	FSPER (%)	WFPP (kg)
1	Fetan	40	132	68.9	9.2	123	3.87	1.14	15	12.4	0.504
2	5915-206-d4-2-2-0	52	103	102.8	5.8	127	7.50	1.60	30	23.9	1.400
3	Beaf steak	55	153	71.8	6.2	49	3.45	1.28	6	13.0	0.392
4	CLN-2037-H	46	105	120.1	6.4	91	10.20	1.82	42	45.6	1.020
5	CLN-2366-C	40	93	88.2	1.8	91	9.35	1.40	31	33.8	0.409
6	Chali	37	99	62.3	7.3	117	7.59	1.65	32	27.8	0.660
7	CLN-2498	41	107	120.2	7.7	186	1.72	1.00	7	3.58	0.125
8	CLN-2037-C	35	106	120.8	8.4	184	4.50	1.20	31	16.8	1.219
9	Miya	30	79	67.1	6.8	91	10.75	2.15	42	46.0	1.633
10	Roma-VF	38	120	73.1	6.9	130	7.26	1.56	25	18.9	0.665
11	CLN-2037-A	30	79	106.1	6.4	116.	15.25	2.36	94	80.5	1.717
12	PT-4719B	36	80	92.5	5.8	100	13.88	2.25	59	59.3	1.168
13	Fire ball	35	100	60.5	5.0	91	8.59	1.38	28	31.5	1.119
14	Supper Roma-VF	37	105	72.1	7.1	158	10.25	1.86	29	18.3	0.933
15	CLN-2037-E	42	90	117.8	8.7	135	5.09	1.41	25	18.1	1.198
16	Bishola	42	112	101.8	6.6	119	5.02	1.88	10	8.5	0.591
17	CLN-2037-I	38	96	102.5	4.4	86	5.50	1.72	28	33.1	1.024
18	Tomato 1358/95	45	154	61.5	5.5	38	1.0	0.75	3	9.2	0.249
19	CLN-1621-F	38	83	91.2	5.3	64	7.58	1.63	51	82.9	1.616
20	Eshet	42	99	129.0	6.5	118	8.29	1.59	24	20.3	0.720
21	Marglobe	43	93	67.1	5.7	93	6.40	1.86	22	24.3	0.565
22	CL 5915-93-D4	28	69	59.5	6.1	126	18.08	4.55	97	77.0	2.10
23	5915-206-d4-2-5-0	37	82	112.9	6.1	93	9.82	2.34	31	34.2	1.447
24	Metadel	36	149	59.0	6.2	40	1.65	1.35	6	14.8	0.380
25	ARP Tomato No 367-2	41	153	108.5	6.2	64	3.50	1.60	8	12.7	0.465
26	Cathrine	50	156	116.5	8.1	99	1.75	1.05	5	5.1	0.325
27	Tomato 1365/95	34	78	72.3	6.4	80	19.40	1.78	22	28.2	1.426
28	Electra	38	97	106.6	6.4	86	5.02	1.47	18	21.3	1.292
29	CLN-13114-G	44	141	126.4	6.9	92	1.74	1.55	7	7.2	0.539
30	H-1350	51	155	93.0	5.4	44	3.95	1.30	8	17.4	0.374
31	Cochora	34	81	73.7	6.0	109	14.17	2.27	36	33.0	0.870
32	CLN-2366-A	38	82	84.5	6.3	111	6.05	1.60	14	12.3	0.605
33	Melka salsa	35	90	87.3	7.0	106	9.49	2.01	19	18.0	0.783
35	CLN-2070-A	31	77	108.8	7.8	120	15.42	2.84	55	47.5	1.090
36	Melka Shola	33	78	94.4	6.2	112	10.33	1.59	24	21.8	0.650
	Mean	39	104	91.07	6.40	103	7.80	1.71	28	27.6	0.887
	SEM(±)	0.220	0.440	0.570	0.080	0.870	0.112	0.021	0.218	0.303	0.012
	CV (%)	7.27	5.53	8.21	15.87	10.99	18.73	16.45	10.22	14.36	17.50
	LSD at 1%	7.27	14.92	18.19	2.83	31.61	4.15	0.78	7.97	10.48	0.443
	Significant level	**	**	**	**	**	**	**	**	**	**

50FL=days to 50 percent flowering, DM= days to maturity, PHT= plant height, PBR= number of primary branches, NFLO= number of flowers per plant, NFCL= number of fruit clusters per plant, FRPC= number of fruits per fruit cluster, FRPP= number of matured fruits per plant, FSPE= fruit set percentage, WFPP= average weight of fruits per plant, SEM=standard of the mean, CV= coefficient of variation and LSD= least significant difference and **= highly significant difference

Table 2. fruit characteristic and yield of tomato genotypes grown in Humera

No	Name of genotype	SFW(g)	NPIC	FPD (mm)	FED (mm)	SHIN	NSEE	NLOC	PETI (mm)	TSS (°Brix)	MYLD (t/ha)
1	FETAN	73	3.0	49.2	47.6	1.03	38	3.95	6.65	5.42	8.49
2	5915-206-D4-2-2-0	60	5.0	42.9	45.8	0.94	40	4.50	4.33	4.83	25.67
3	Beaf steak	95	3.0	41.5	40.2	1.03	15	3.00	5.03	4.50	5.35
4	CLN-2037-H	30	4.5	36.3	39.0	0.93	17	4.45	3.37	4.98	18.94
5	CLN-2366-C	18	4.0	36.1	27.5	1.32	32	2.47	3.17	6.12	13.18
6	Chali	49	4.0	54.3	44.8	1.21	37	3.65	5.93	3.78	12.76
7	CLN-2498	43	4.0	57.9	35.8	1.62	28	2.55	5.15	4.52	5.89
8	CLN-2037-C	60	4.5	41.5	45.0	0.92	68	3.25	4.83	5.64	15.96
9	Miya	67	5.0	52.0	47.0	1.11	30	2.50	7.48	4.83	35.28
10	Roma-VF	57	4.0	60.6	34.2	1.92	60	2.60	5.70	5.26	20.74
11	CLN-2037-A	26	5.0	34.2	36.7	0.93	45	5.00	3.03	6.71	49.20
12	PT-4719B	42	5.0	37.1	39.0	0.95	78	2.75	4.75	5.39	28.65
13	Fire ball	54	4.5	50.1	43.6	1.15	23	3.00	6.35	3.80	19.06
14	Supper Roma-VF	46	4.5	60.6	33.1	1.83	38	2.00	5.38	5.38	17.47
15	CLN-2037-E	62	4.5	46.2	42.1	1.11	51	3.25	5.10	4.79	20.13
16	Bishola	147	3.0	41.1	50.7	0.81	43	2.95	4.81	4.93	5.58
17	CLN-2037-I	46	5.0	42.0	41.2	1.02	44	3.50	4.05	5.81	19.00
18	Tomato 1358/95	40	2.5	34.0	33.8	1.01	31	2.75	2.55	5.63	3.02
19	CLN-1621-F	69	5.0	46.5	44.5	1.05	35	3.75	4.65	4.70	22.81
20	Eshet	29	4.0	40.9	37.9	1.08	40	2.75	4.08	5.37	9.77
21	Marglobe	58	4.5	37.2	40.0	0.96	51	4.25	4.28	5.28	15.78
22	CLN 5915-93-D4	31	6.0	39.3	36.3	1.08	64	2.50	4.95	5.45	43.27
23	5915-206-d4-2-5-0	75	5.0	49.6	46.6	1.07	33	3.90	4.06	4.88	26.78
24	Metadel	58	2.5	38.0	36.8	1.03	30	2.85	3.15	5.46	3.01
25	ARP Tomato No 367-2	77	3.0	44.1	52.3	0.85	53	5.00	5.65	5.05	4.84
26	Cathrine	58	2.0	41.4	39.6	1.05	102	2.95	2.75	5.68	3.14
27	Tomato 1365/95	106	5.0	46.6	64.4	0.73	94	6.05	5.15	5.56	25.82
28	Electra	76	3.5	55.6	41.8	1.33	103	5.25	5.75	5.53	14.67
29	CLN-13114-G	45	3.5	46.2	38.3	1.21	39	4.55	3.49	5.75	4.85
30	H-1350	26	2.0	40.5	31.0	1.31	44	2.00	3.47	3.58	3.00
31	Cochora	36	5.0	54.1	37.1	1.48	32	1.95	6.85	5.10	18.00
32	CLN-2366-A	41	3.5	38.8	35.2	1.10	35	2.60	3.15	5.81	8.45
33	Melka salsa	56	4.5	59.0	38.3	1.54	46	2.60	5.65	4.68	16.90
34	CLN-2366-B	45	5.0	44.3	41.6	1.07	50	2.75	5.05	5.72	13.02
35	CLN-2070-A	34	5.0	38.8	39.1	0.99	124	4.25	3.65	5.75	16.25
36	Melka Shola	40	5.5	58.6	39.9	1.47	37	2.75	5.73	4.70	10.67
	Mean	55	4.15	45.6	40.8	1.14	48	3.36	4.70	5.18	16.26
	SEM(±)	0.587	0.034	0.180	0.196	0.007	0.274	0.018	0.043	0.009	1.930
	CV (%)	13.96	10.68	5.16	6.27	7.49	7.47	6.80	12.06	2.34	14.98
	LSD at 1%	20.437	1.24	6.31	7.48	0.246	10.43	0.66	1.49	0.32	6.64
	Significant level	**	**	**	**	**	**	**	**	**	**

SFW= single fruit weight per plant, FPD= fruit polar diameter, FED= fruit equatorial diameter, SHIN= shape index, NPIC= number of fruit pickings, NSEE= number of seeds per fruit, NLOC= number of locules per fruit, PETI= pericarp thickness, TSS= total soluble solids, MYLD=marketable yield per hectare SEM=standard of the mean, CV= coefficient of variation and LSD= least significant difference and **= highly significant difference

3. Results and Discussion

All the 36 tomato genotypes studied showed highly significant differences (p<0.01) for all the characters studied (Table 1). Days to 50% flowering ranged from 28 to 55 with a mean of 39 days. Similarly Ghosh *et al*., 2010 reported a wide range of variation for days to initial flowering in tomato. Days to maturity ranged from 69 to 156 days. CLN 5915-93-D4 genotype, the second high yielder genotype, was the earliest to mature (69 days) whereas Cathrine was the late matured (156 days). This is in line with the finding of Meseret *et al*., 2012 who reported a wide range of difference in days to first harvest (70 to 120 days) in tomato varieties evaluated in Jimma.

A wide range of difference was observed for plant height (59 to 129 cm). Similarly Meseret *et al*. (2012) reported a wide range of difference in tomato varieties (40.2 to 107 cm). Pradeepkumar *et al.* (2001) also found a wide range of differences in plant height. Total number of matured fruits plant[-1] ranged from 4 to 96 with an average of 28 fruits plant[-1]. This is in agreement with the finding of Muhamed *et al*., 2013 who reported a wide range of difference in number of fruits plant[-1] (11-85) and Jiregna,

2013 (8 to 59 fruits plant[-1]). Similarly, Pradeepkumar *et al.* (2001) obtained a wide range of variation for number of fruits plant[-1]. The maximum number of fruits was scored by CLN 5915-93-D4 genotype (96) while tomato- 1358 scored the least number of matured fruits plant[-1] (4).

Average weight of fruits plant[-1] ranged from 0.13 to 2.10 kg with an average weight of 0.887 kg. Similarly, Jiregna (2013) (0.22 – 1.61 kg plant[-1]) and Muhamed *et al*., 2013 (0.25-2.48 kg) found a wide range of difference. The highest yield plant[-1] were recorded by CLN 5915-93-D4 genotype (2.102 kg) and CLN-2037-A (1.716 kg). Single fruit weight ranged from 18 to 147 gram. This is in agreement with the finding of Muhamed *et al.* (2013) who reported a wide range of difference (6.18 -74.91 gram). Similarly, Pradeepkumar *et al.* (2001), reported wide range of variability for single fruit weight.

Total fruit yield per hectare ranged from 3.00 to 49.20 tons ha^{-1} which showed wide difference with a mean of 16.26 tons ha^{-1}. The maximum yield was obtained from CLN-2037-A (49.20 tons ha^{-1}) followed by CLN 5915-93-D4 (43.27 tons ha^{-1}) and Miya (35.28 tons ha^{-1}).Generally, the genotypes which scored the highest number of fruits and fruit yield per plant had the highest fruit yield per hectare (Table 2).

Fruit polar and equatorial diameter ranged from 34.0 to 65.3 mm and 27.5 to 64.4 mm. This is in line with the finding of Syed *et al.* (2001) who reported wide range in fruit width and length (3.2-5.2 cm) and (5.6-8.5 cm). Number of locules per fruit ranged from 2 to 5. Pericarp thickness varied from 2.55 to 7.48 mm. Number of seeds per fruit ranged from 18 to 118 with an average of 48 and total soluble solids (TSS) varied from 3.33 to 6.71 °Brix (Table 2). Similar results on pericarp thickness, TSS, and number of locules were also reported by Shashikanth *et al.* (2010).

Path coefficient analysis involves partitioning of the correlation coefficients into direct and indirect effects via alternative characters. Fruit yield is the final products of various characters and here it was considered to be the resultant variable while the rest of the variables were casual variables. Each character influence fruit yield by its direct and indirect contributions with other characters. An aggregate residual factor that includes all other factors affecting fruit yield and not yet accounted for was treated as independent of the rest of factors considered. The residual factor 0.235 (Table 3.) implied that characters included in the path analysis explained 76.5% of the total variation in fruit yield per hectare while the remaining 23.5% was contributed by other factors not included in the path analysis.

Table 3. Path coefficients of direct (main diagonal) and indirect effects of the characters studied

	50FL	DM	PHT	PBR	NFLO	NFCL	FRPC	FRPP	FSPE	WFPP
50FL	**0.066**	0.022	0.009	0.001	0.046	-0.089	0.120	-0.477	0.227	-0.348
DM	0.049	**0.030**	0.001	-0.001	0.061	-0.103	0.120	-0.528	0.268	-0.441
PHT	0.019	0.001	**0.030**	-0.002	-0.042	-0.026	0.024	-0.045	0.042	-0.002
PBR	-0.005	0.003	0.008	**-0.008**	-0.082	-0.024	0.031	-0.094	0.137	0.001
NFLO	-0.021	-0.013	0.009	-0.005	**-0.142**	0.020	-0.029	0.182	0.015	0.104
NFCL	-0.045	-0.024	-0.006	0.001	-0.022	**0.131**	-0.160	0.621	-0.325	0.453
FRPC	-0.038	-0.017	-0.004	0.001	-0.020	0.102	**-0.208**	0.647	-0.318	0.442
FRPP	-0.040	-0.020	-0.002	0.001	-0.032	0.102	-0.169	**0.798**	-0.416	0.521
FSPE	-0.034	-0.018	-0.003	0.002	0.005	0.096	-0.148	0.744	**-0.447**	0.512
WFPP	-0.036	-0.021	0.000	0.000	-0.023	0.093	-0.143	0.646	-0.355	**0.644**
SFW	0.011	0.005	-0.002	-0.003	0.016	-0.023	0.031	-0.284	0.126	0.011
FPD	-0.017	-0.004	-0.004	0.003	-0.053	0.002	0.017	-0.160	0.111	-0.013
FED	-0.008	-0.004	0.000	-0.003	0.008	0.023	-0.004	-0.061	0.004	0.219
SHIN	-0.008	-0.001	-0.004	-0.001	-0.050	-0.007	0.018	-0.110	0.100	-0.162
NPIC	-0.044	-0.027	0.000	0.000	-0.064	0.105	-0.133	0.590	-0.297	0.493
NSEE	-0.015	-0.005	0.007	-0.003	-0.020	0.037	-0.052	0.134	-0.041	0.153
NLOC	0.003	-0.002	0.008	-0.001	0.023	0.021	-0.010	0.087	-0.073	0.209
PETI	-0.025	-0.009	-0.012	-0.003	-0.042	0.027	-0.025	0.029	0.001	0.142
TSS	-0.019	-0.005	0.005	0.001	-0.017	0.023	-0.028	0.207	-0.072	0.085
	SFW	**FPD**	**FED**	**SHIN**	**NPIC**	**NSEE**	**NLOC**	**PETI**	**TSS**	**r$_g$**
50FL	0.019	0.098	-0.016	-0.064	0.003	0.037	0.004	-0.039	-0.019	**-0.581****
DM	0.018	0.058	-0.020	-0.010	0.004	0.026	-0.005	-0.030	-0.010	**-0.710****
PHT	-0.007	0.050	0.000	-0.066	0.000	-0.038	0.025	-0.041	0.012	**-0.110**
PBR	0.037	-0.160	0.046	0.039	0.000	-0.061	0.010	0.032	-0.007	**-0.093**
NFLO	-0.013	-0.147	-0.008	0.195	-0.002	-0.023	-0.014	0.030	0.008	**0.218**
NFCL	-0.019	-0.005	0.024	-0.029	-0.004	-0.047	0.014	0.021	0.012	**0.785****
FRPC	-0.017	0.033	0.003	-0.048	-0.003	-0.041	0.004	0.012	0.009	**0.703****
FRPP	-0.040	0.078	-0.010	-0.076	-0.003	-0.028	0.010	0.004	0.017	**0.870****
FSPE	-0.032	0.097	-0.001	-0.123	-0.003	-0.015	0.015	0.000	0.011	**0.814****
WFPP	0.002	0.008	0.047	-0.138	-0.004	-0.039	0.029	0.022	0.009	**0.910****
SFW	**0.112**	-0.056	0.104	-0.180	0.001	-0.016	0.028	0.038	-0.012	**-0.127**
FPD	0.016	**-0.392**	0.010	0.428	-0.001	0.009	-0.017	0.076	-0.027	**-0.003**
FED	0.085	-0.029	**0.137**	-0.300	-0.001	-0.036	0.056	0.043	-0.010	**0.163**
SHIN	-0.037	-0.305	-0.075	**0.549**	0.000	0.026	-0.048	0.034	-0.014	**-0.103**
NPIC	-0.025	-0.074	0.027	0.013	**-0.005**	-0.010	0.010	0.037	0.008	**0.803****
NSEE	0.011	0.022	0.030	-0.087	0.000	**-0.165**	0.032	-0.009	0.024	**0.114**
NLOC	0.035	0.072	0.086	-0.296	-0.001	-0.059	**0.089**	-0.010	0.017	**0.216**
PETI	0.042	-0.297	0.058	0.185	-0.002	0.015	-0.009	**0.101**	-0.031	**0.206**
TSS	-0.020	0.157	-0.020	-0.113	-0.001	-0.060	0.022	-0.046	**0.067**	**0.211**

Residual effect= 0.235 * and ** indicate significance at 0.05 and 0.01 probability levels, respectively. 50FL=days to 50 percent flowering, DM= days to maturity, PHT= plant height, PBR=number of primary branches, NFLO= number of flowers per plant, NFCL= number of fruit clusters per plant, FRPC= number of fruits per fruit cluster, FRPP= number of matured fruits per plant, FSPE= fruit set percentage, WFPP= average weight of fruits per plant, SFW= average single fruit weight per plant, FPD= fruit polar diameter, FED= fruit equatorial diameter, SHIN= shape index, NPICK= number of fruit pickings, NSEE= number of seeds per fruit, NLOC= number of locules per fruit, PETI= pericarp thickness, TSS= total soluble solids, and r$_g$= genotypic coefficient of correlation

Estimates of direct and indirect effects of various characters on fruit yield tons ha^{-1} are indicated in Table 3. Number of matured fruits plant[-1] had the highest direct positive contribution to fruit yield tons ha^{-1} (0.798) followed by weight of fruits plant[-1] (0.644) and shape index (0.549) indicating that direct selection based on these characters will improve the total fruit yield at this particular location for the particular crop. Similarly, Islam *et al.* (2010) reported number of fruits plant[-1] had highest (0.980) positive direct effect on fruit yield plant[-1] in 39 tomato genotypes studied in Bangladesh.

Characters that had negative direct effects for total fruit yield ha^{-1} (Table 3) were fruit set percentage (-0.447), fruit polar diameter (-0.392) and number of fruits cluster[-1] (-0.208). However, the negative direct effect of fruit set percentage (-0.447) was compensated by its indirect positive effect via number of matured fruits plant[-1] (0.744), weight of fruits plant[-1] (0.512) and days to 50% fruiting (0.160) and resulted in positive effect (0.814). Similarly the negative direct effect of number of fruits per cluster (-0.208) was compensated by its indirect positive effect via number of matured fruits plant[-1] (0.647), weight of fruits

plant[-1] (0.442), days to 50% fruiting (0.159) and number of fruit clusters plant[-1] (0.102), which resulted in positive effect (0.218).

The positive direct effect of days to maturity on total fruit yield hectare[-1] (0.030) was nullified by its indirect negative effects on number of matured fruits plant[-1] (-0.528), weight of fruits plant[-1] (-0.441), days to 50% fruiting (-0.201) and number of fruit clusters plant[-1] (-0.103) and resulted in negative effect (-0.710). Similarly the positive direct effect of average single fruit weight plant[-1] (0.112) was nullified by its indirect negative effects via on number of matured fruits plant[-1] (-0.284) and resulted in negative effect (-0.127). In line with this, Ghosh *et al*. (2010) reported that number of fruits per plant showed highest positive direct effect on fruit yield plant[-1] and number of flowers cluster[-1] showed negative direct effect on fruit yield plant[-1]. Similarly Hidayatullah *et al*., 2008; Mehta and Asati, 2008; Tiwari and Upadhyay (2011) reported that weight of fruits per plant had the highest positive direct effect on fruit yield per plot.

Generally, the path analysis revealed that highest positive direct effect of number of fruits plant[-1] and weight of fruits plant[-1] on total fruit yield hectare[-1] in conjunction with the highest positive indirect effect of fruit set percentage and number of fruits cluster[-1] via number of fruits per plant and weight of fruits plant[-1] on total fruit yield hectare[-1] indicating these traits could be considered simultaneously as selection criterion for improving total fruit yield of tomato.

4. Conclusion

Of the studied 36 tomato genotypes CLN-2037-A (49.20 tons ha^{-1}) scored the highest fruit yield followed by CLN 5915-93-D4 (43.27 tons ha^{-1}) and Miya (35.28 tons ha^{-1}). Results of the path coefficient analysis showed that number of fruits plant[-1] and weight of fruits plant[-1] had highest positive direct effect on fruit yield hectare[-1]. Hence direct selection based on those traits will be rewarding. Fruit set percentage and number of fruits per cluster had the highest positive indirect effect via number of fruits per plant and weight of fruits per plant. Therefore, the above traits could be considered as selection criterion in tomato improvement program.

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