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Research Article

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Evaluation of Open Tomato Cultivars for Adaptation and Yield Attributes in Central Mid-hills of Nepal

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Abstract

Tomato seedlings of nine tomato cultivars with Pusa Ruby as check were transplanted on March first to second week, 2018 and 2019 at Khumaltar. Crop geometry was maintained with the 60X60 cm in three replications and fertilized with 150:120:100 NPK kg + 20-ton FYM per hectare. The main objective of this study was to evaluate and select high yielding, insect pest and disease tolerant cultivars with preferred characters at open field conditions for central mid-hills. The observation was recorded on vegetative, insect pest and disease, yield attributing parameters and response of consumers & farmers. Among the tested cultivars, HRD109 showed superior performance onseptoria leafspottolerant (3.5), early days to flowering (21.8), higher number of fruits per plant (121), yield (58.80 t/ha) and 2289 gm per plant, consumers (4.5) and farmers preferred (4.1), and small fruit size (32.6 g). The next superior cultivar was HRD7 which has late blight (4.1), days to flowering (22), the higher number of fruits per cluster (7.4) and per plant (119), superior yield (54.00 t/ha) and 2158 gm per plant, consumers (4.1) and farmers preferred (4.3), small fruit size (30.3 g). These two cultivars are recommended for cultivation in the central mid-hills of Bagmati Pradesh underopen field conditions.

Keywords: Cultivar, disease, high yielding, open-pollinated, open field

Introduction:

Tomato is the most popular home garden and the world's second most consumed vegetable after potato (Ebert and Chau, 2015). It is knownas the world's most widely grown and processed vegetable (FAOSTAT, 2017). Tomato is the third largest vegetable crop in Nepal in terms of production. The area under tomato cultivation is around 21,981 ha with a total production of 410,721mt andan average yield of 19mt/ha (MoALD, 2019). In the Bhaktapur district, tomato production is 4908mt in 239ha land, and productivity is 21mt/ha. In the Kathmandu district, tomato production is 5656mt in 352ha land, and productivity is 16mt/ha. In the Lalitpur district, tomato production is 7141mt in the area of 623ha land with the productivity of 11mt/ha (MoALD, 2019). The productivity of tomatoes in Nepal is very low due to the lack of high yielding, insect pest and disease-resistant varieties. Tomato has been accepted as remunerative crops by the farmers of Nepal; however, the availability of reliable varieties is limited (Shrestha & Sah, 2014). Various biotic and abiotic stresses greatly influence the productivity of tomatoes. However, tomato varieties grown in Nepal are vulnerable to specific pests and disease. Due to the lack of abiotic and biotic stress tolerant tomato cultivars in Nepal, productivity is low. For example, in India, the productivity of tomatoes in open field conditions is 25 t/ha, in China, it is 48 t/ha, and the world average is 37.6 t/ha, which is not comparable with Nepal's national productivity (19.0 t/ha) (FAOSTAT, 2018).

It has been observed that many promising local selections and introduced genotypes of tomato are popular in small areas. Hybrid varieties useincreasing every year, even in remote areas (Rawal et al. 2017). The officially released open-pollinated varieties of tomato, namely Pusa Ruby, Monoprecos, Roma and NCL-1 are not successful to meet the various changing needs of growers and consumers on the one hand, and on the other, it seems that the released varieties are likely to break down their performance due to many biotic and abiotic stresses. So, continuous varietal evaluation is needed for providing sufficient varietal options for the farmers (Chapagain et al. 2014).Various factors such as the use of improved varieties, proper management, quality of seed, and awareness about improved production technologies affect the production of tomatoes.

Rawal et al., (2017b) evaluated AVRDC lines for mid-western Terai conditions and found that CLN3552B produced the highest fruit weight (102 g fruit-^{1}), while the highest fruit yield was obtained in CLN3669A (41 t/ha) along with resistance to late blight and tomato yellow leaf curl virus. Similarly, Shrestha et al., (2017) evaluated OP genotypes and found that STM03 (34.74 t/ha) and STM08 were superior in both the Terai and mid-hill conditions with a vigorous growth, higher yield, less pest and disease susceptibility and therefore recommended for these areas.

The main objective of this study was to evaluate and select high yielding insect pests and disease tolerant having preferred characters tomato cultivars at open field in central mid-hills condition of Nepal.

Materials and Methods:

Site characteristics

The experiments were conducted at National Horticulture Research Station (NHRC), Khumaltar, Lalitpur, Nepal in spring and summer from March to August 2019 and 2020. The research field of the National Horticulture Research Centre is located at an altitude of 1275 m, latitude of 27º40'N and longitude of 085º20'E (NHRC, 2019). The soil type of the experimental plot was black and sandy loam in texture, slightly acidic and medium in organic matter (NHRC, 2019).

Experimental details and Data record

Twenty days oldtomato seedlings of nine tomato genotypes; HRD7, CLN2545B, HRD109, V5, HRDTOM099, STMO2, STM03, HRDTOM06 with Pusa Ruby as check were transplanted in March first to second week, 2018 and 2019 at open field of NHRC, Khumaltar, Lalitpur where seed sowing was done on second week of February. Four genotypes (HRD109, HRDTOM099, HRDTOM06 and Pusa Ruby) were collected from Nepal, three genotypes (V5, STM02 and STM03) from SAARC countries and one (HRD7) from India, respectively. Crop geometry was maintained with the row and plant spacing of 60X60 cm. The plot size was 3m x 1.2m with 3.6 m2 area. There were 5 plants per row and 2 rows per plot, total of 10 plants per plot. The standard recommended dose of fertilizers (150:120:100 NPK kg/ha + 15-ton (FYM/ha) was applied, and fungicide was sprayed only two times during the cropping period.

The observation was recorded on vegetative, insect pest, disease, and yield attributing parameters. Its growth habit was recorded in determinate, semi-determinate and indeterminate. Plant height was measured on five plants each in each plot from ground level to tip of the main shoot. Plant uniformity and vigour were recorded visually after six weeks of transplanting with 1: unacceptable to 5: excellent scale. Insect pest was recorded on major pests ; leaf minor and helicoverpa incidence on 1:none to 9: dead scale according to IPBGR tomato descriptor 1996. Among diseases,late blight, early blight, powdery mildew and septoria leaf spot was recorded after the second harvest in 1: none to 9: dead stage according to IPBGR tomato descriptor 1981.Virus infected plant (%) was recorded in the last stage of plants; it was counted virus-infected plants and converted in percent. Days to flowering and fruit set was recorded on 50 percent plants with flower and 50% plant in fruit setting stage after transplanting. The number of flowers per cluster and number of fruits per cluster was recorded on the second truss of the 5 plants per plot. Fruit set in percent was calculated by using formula = (number of fruit set per cluster/number of flowers per cluster)*100. Days to harvest were recorded based on its physiological maturity when it becameready for harvest. Multiple manual harvesting of fruit was done at 5 to 6 days intervals. The number of fruits per plant was calculated with the total number of fruits harvested per plot by number of plants harvested per plot. Likewise, fruit yield per plant was calculated with total fruits (weight) harvested per plant by the number of plants harvested per plot. Yield ton per hectare was calculated by total weight per plot converting into 10000 m^{2}.

All the collected data were subjected to analysis of

variance and Duncan's Multiple Range Test (DMRT) for mean separation using MSTAT-C (version 1.2).

Results and Discussion:

Vegetative parameter

P*lant uniformity and Plant vigour:* Average plant uniformity among the genotypes is not significant. It was not significant in both the years also. However, HRDTOM099 had more uniform plants. In addition, mean plant vigour was significant among the genotypes where HRDTOM099 was significantly vigorous (4.7) compared to the other tested genotypes (Table 1).

Plant height: Mean plant height of HRDTOM099 (135 cm) and HRD109 (128.5 cm) was significantly taller than the rest of the genotypes. The shortest plants were measured on CLN2545B (59 cm) followed by V5 (69.5 cm). In both the years (2018 and 2019), tallest plants were measured on HRDTOM099 and HRD109, and the shortest plants on CLN2545B and V5 (Table 1). It supports the findings of Ahmad et al., (2007) who has reported the variation on plant height OP tomato cultivars where Local round variety had attained 110.5 cm plant height in Pakistan.

Table 1: Vegetative growth of nine tomato cultivars at NHRC, Khumaltar in 2018 and 2019

Cultivars	Plant uniformity (1-5)[x]			Plant vigor(1-5)[y]			Plant height (cm)		
	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
HRD-7	3.0	3.7	3.35±0.35	3.3	3.4	3.35±0.05d	97.4	111	104.2±6.8b
CLN2545B	3.0	4.0	3.5±0.5	3.0	3.7	3.35±0.35d	61.0	57	59±2.0e
HRD109	4.0	3.7	3.85±0.15	3.6	4.2	3.9±0.3bc	124	133	128.5±4.5a
V5	3.6	3.3	3.45±0.15	3.3	3.7	3.5±0.2cd	81	58	69.5±11.5de
HRDTOM099	4.0	4.8	4.40±0.4	4.6	4.8	4.7±0.1a	130	141	135±5.51cde
STM02	3.3	3.0	3.15±0.15	3.6	3.7	3.65±0.05cd	94.6	99	96.8±2.2bc
STM03	3.0	3.7	3.35±0.35	3.3	4.0	3.65±0.35cd	90.8	112	101.4±10.6b
HRDTOM086	3.0	3.7	3.35±0.35	3.6	4.0	3.8±0.2c	98.8	86	92.4±6.4bc
Pusa ruby	3.6	3.3	3.45±0.15	4.0	4.0	4.0±0.0b	81	90	85.5±4.5bcd
GM	3.38	3.68	3.54±0.15	3.58	3.94	3.77±0.15	95.4	98.5	96.97±1.55
F-test	ns	ns	ns	ns	ns	*	**	ns	**
LSD (0.05)						0.437	25.3		22.74
CV%	19.8	15.54	11.52	16.4	13.94	5.06	15.29	20.43	10.17

[x]1:poor, 5: excellent [y]1:poor, 5: Vigorous

Reproductive characters

Days to flowering: The effect of genotypes on days to flowering was not significant. However, days to flowering mean was earliest in CLN2545B and HRDTOM086 (21.6 days), followed by HRD109 and V5 (21.8 days). STM03 had the late days to flowering (24.9). In the first year, it ranged from 21.6 days (HRDTOM086) to 27.3 days (STM03). Similarly, it was ranged from 20.7 days (HRDTOM099) to 22.6 days (STM03) in second year (Table 2). It is little bit earlier than the result of Gautam et al., (2013) who had found earliest flowering variety Kashi Vishes (44 days) in Madhya Pradesh, India.

Days to fruit setand maturity

Days to fruit set difference among the cultivars were not significant in both the years. However, the combined mean of days to fruit set was ranged from 33.6 days (HRD7, HRDTOM099 and Pusa Ruby) to 34.9 days (STM03) (Table 2). Days to fruit maturity or harvest was significantly earliest in CLN2545B (63.3 days), followed by HRDTOM099 (65.4 days) and HRDTOM086 (66 days), respectively (Table 2). Similar result was obtained by Parmao et al. (2018) who had reported the Heemsohna variety was the earliest (67.2 days) days to fruit maturity or harvest at Kullu district, Himanchal Pradesh, India.

Table 2: Vegetative growth of nine tomato cultivars at NHRC, Khumaltar in 2018 and 2019

Cultivars	Days to flowering			Days to fruit set			Days to maturity
	2018	2019	Mean	2018	2019	Mean	2018
HRD-7	22.6	21.6	22.1±0.5	31.3	36	33.6±2.35b	66.6±2.31
CLN2545B	22.3	21.0	21.6±0.68	33.3	36	34.6±1.35ab	63.3±0.58
HRD109	22.3	21.3	21.8±0.15	32.0	35.7	33.8±1.85ab	66.6±2.31
V5	22.3	21.3	21.8±0.5	31.3	36.3	33.8±2.5ab	68.6±1.53
HRDTOM099	22.0	20.7	21.3±0.65	31.3	36	33.6±2.35b	65.4±1.8
STM02	26.3	21.3	23.8±2.5	34.3	37.3	35.8±1.5a	67.6±1.15
STM03	27.3	22.6	24.9±2.35	33.6	36.3	34.9±1.35ab	69.0±1.73
HRDTOM086	21.6	21.7	21.6±.06	31.3	37.7	34.5±3.2ab	66±2.64
Pusa ruby	24.0	21.0	22.5±1.5	31.6	35.7	33.6±2.05b	69.6±0.58
Mean	23.41	22.45	22.93±0.48	32.2	36.3	34.27±2.05	66.9±1.15
F-test	ns	ns	ns	ns	ns	ns	**
LSD (0.05)							2.794
CV%	12.67	5.27	12.01	7.62	4.4	2.54	2.41

Insect pest and disease

Insect pest

Insect damage among the cultivars was not significant in both the years. However, it was ranged from HRDT, V5 and STM02 (2.6) to CLN2545B, HRDTOM099 and STM03 (3.0) (Table 3).

Disease

The late blight mean was not significant among the genotypes. However, V5 was least affected by late blight disease (4.0) followed by HRD-7 (4.1), and the most severe infection was seen in HRDTOM099 (5.1). In 2018, STM02 was least infected (3.0), followed by V5 and Pusa Ruby (4.0), whereas in 2019, HRD7 (3.3) was least infected, followed by V5 (4.0) (Table 3). This result is supported by Rawal (2017) who reported STM010 genotype was found to be tolerant to late blight (2.67 scores out of 1-5 scale) in their varietal performance study at mid-western terai condition. Similarly, varietal response with septoria leaf spot disease was not significant. However, the least septoria leaf spot infection (3.5) mean was noticed on HRD109, Pusa Ruby and HRDTOM099, whereas the highest infection was seen in HRD-7 (4.5) (Table 4).This result supports the study of Gotame et al., (2021) who had mentioned that HRD109 had higher resistant and HRDTOM035 was highly susceptiblewith septorial leaf spot as compared to other genotypes. Powdery mildew infection was noticed in all the cultivars ranged from a 3.6 score in Pusa Ruby to a 4.6 score in STM03 and HRDTOM086 (Table 3). Similarly, early blight disease was seen in all the cultivars' early growth stage but not significantly different. Virus-infected plants were seen in all the cultivars except in HRDTOM099 and STM02 (Table 3).

Table 3: Insect pest and disease of nine tomato cultivars at NHRC, Khumaltar in 2018 and 2019

Cultivars	Insect (1-9) [x]			Powdery mildew (1-9)[x]	Late Blight (1-9)[x]		
	2018	2019	Mean	2018	2018	2019	Mean
HRD-7	3.0	2.3	2.6±0.35	4	5.0	3.3	4.1±0.85
CLN2545B	3.3	2.7	3.0±0.3	4	4.3	5.0	4.6±0.35
HRD109	3.6	2.0	2.8±0.8	4	5.3	4.2	4.7±0.55
V5	3.0	2.3	2.6±0.35	4	4.0	4.0	4.0±0.0
HRDTOM099	3.3	2.7	3.0±0.3	4.3	4.6	5.7	5.1±0.55

Cultivars	Insect (1-9) [x]			Powdery mildew (1-9)[x]	Late Blight (1-9)[x]		
	2018	2019	Mean	2018	2018	2019	Mean
STM02	3.0	2.3	2.6±0.35	4	3.0	5.7	4.3±1.35
STM03	3.3	2.7	3.0±0.3	4.6	5.0	4.7	4.8±0.15
HRDTOM086	3.6	2.3	2.9±0.65	4.6	4.6	4.7	4.8±0.1
Pusa ruby	3.6	2.3	2.9±0.65	3.6	4.0	5.0	4.6±0.5
Mean	3.3	2.4	2.85±0.45	4.12	4.42	4.7	4.56±0.14
F-test	ns	ns	ns	ns	ns	ns	ns
CV%	13.69	14.21	9.61	14.95	16.36	20.80	16.51

[x] 1:resistant, 9:highly damaged

Table 4 : Insect pest and disease of nine tomato cultivars at NHRC, Khumaltar in 2018 and 2019

Cultivars	Septoria (1-9)[x]			Virus plants (%)	Early Blight [x]
	2018	2019	Mean	2018	2019
HRD-7	5.3	3.7	4.5±0.8	4.2	3.0
CLN2545B	4.0	4.3	4.1±0.15	25.0	2.7
HRD109	4.0	3.0	3.5±0.5	8.3	3.0
V5	4.3	3.0	3.6±0.65	4.2	2.0
HRDTOM099	4.3	2.7	3.5±0.8	0	2.3
STM02	4.0	4.0	4.0±0.0	0	2.7
STM03	4.6	3.0	3.8±0.8	8.3	3.0
HRDTOM086	5.0	3.0	4.0±1.0	8.3	2.0
Pusa ruby	4.0	3.0	3.5±0.5	8.3	2.3
Mean	4.38	3.3	3.84±0.54	7.41	2.5
F-test	ns	ns	ns	*	ns
LSD (0.05)				12.66	
CV%	19.4	23.71	14.23		26.09

Yield and yield attributing parameter

Flowers and fruits per inflorescence

The number of flowers per inflorescence among the cultivars was significantly different in both years. All the tested cultivars had a significantly higher number of flowers than check Pusa Ruby (4.9). The combined mean was the highest (8.5) in HRD7 followed by HRDTOM099 ((8.4) and HRD109 (8.2), respectively (Table 5). Khan et al., (2021) also supports this result that they have reported maximum number of flowers 11.4 on Surkhali F1 and least number of flowers (6.4) in Sahil and Saandal. The trend was also similar in the number of fruit set per cluster. The varietal difference was significant in both years. The combined mean of the number of fruits per cluster was the highest (7.7) in HRD109 followed by HRD7 (7.4) and HRDTOM099 (7.1), respectively, whereas the lowest was in local check Pusa Ruby variety (4.6) (Table 5). As this is one of the factors attributing to tomato fruit yield, these higher number of fruits per cluster cultivars had also higher yield.

Table 5: Reproductive characteristics of nine tomato cultivars at NHRC, Khumaltar in 2018 and 2019

Cultivars	Flowers/inflorescence (no.)			Fruits/cluster (no.)		
	2018	2019	Mean	2018	2019	Mean
HRD-7	8.2	8.9	8.5±0.35a	7.0	7.8	7.4±0.4ab
CLN2545B	6.6	7.4	7.0±0.4bcd	6.9	6.1	6.2±0.43bcd
HRD109	8.0	8.5	8.2±0.25a	7.1	8.4	7.7±0.65a
V5	5.8	6.1	5.9±0.15de	5.5	5.3	5.4±0.1de
HRDTOM099	7.6	9.3	8.4±0.85a	6.5	7.7	7.1±0.6ab
STM02	7.6	7.9	7.7±0.15ab	6.4	7.6	7.0±0.6abc
STM03	7.0	7.7	7.3±0.35abc	5.9	7.1	6.15±0.63abcd
HRDTOM086	6.5	6.1	6.3±0.2cd	5.9	5.3	5.6±0.3cde
Pusa ruby	5.4	4.5	4.9±0.45e	5.1	4.1	4.6±0.5e
Mean	6.96	7.37	7.17±0.2	6.25	6.66	6.39±0.21
F-test	**	**	**	*	**	*
LSD (0.05)	1.301	1.18	1.207	1.02	1.32	1.478
CV%	10.76	8.77	7.3	9.87	11.55	10.02

Fruit set (%)

Fruit set in percentage was not significant; however, it was ranged from 84.1 % (HRDTOM099) to HRD109 (93.7%) (Fig. 1). Similar result was obtained by Pandey et al., (2006) at Lumle, Kiski, Nepal where fruit set percent was ranged from 83.1% (Avinash-2) to 93.9% (NSITH-162).

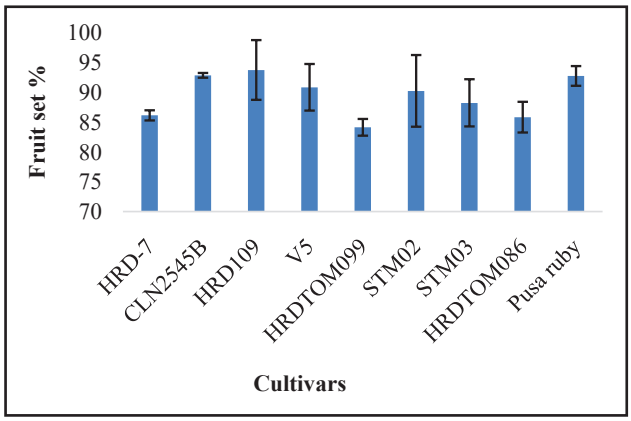

Fig. 1. The combined mean of fruit set (%) in nine different cultivars

Fruits yield in number and weight: HRDTOM099 gave a significantly higher number of fruits/plant (166.5) followed by HRD109 (121) and HRD-7 (119.5) with the least in STM03 (42.5) and was found statistically significant at 1% level. The number of fruits per plant was the highest (134 and 172) in HRDTOM099 in both the tested years (2018 and 2019) followed by HRD109 (109 and 133), respectively. Ahmad et al. (2007) had also mentioned the variation in number of fruits harvested among the tested cultivars in his study at Pakistan where the highest number harvested was 98.3 on Local round variety. This might have resulted due to different climate at Pakistan. The highest fruit yield per plant mean was recorded in HRD109 (2289g) followed by HRD7 (2157.5g) and HRDTOM099 (2116g) respectively. It was significant in the first year where the highest yield (g/plant) was obtained from HRD109 (2100 g) followed by HRDTOM099 (1993 g) and V5 (1822g), respectively. Hence, HRD109 and HRDTOM099 gave consistent yields in both years (Table 6). Ahmad et al. (2007) had also reported cultivar Shalkot with 3.03 kg fresh fruit weight per plant was significantly higher yielder than other cultivars. Other cultivars i.e. Peto-mech-II, Rio grande, Red blast and Roma also gave remarkably good fruit weight per plant of 2.84,2.73, 2.63 and 2.57 kg respectively at Kullu, Pakistan.

As far as yield in ton per hectare is concerned, the response of genotypes is significant. All the tested genotypes gave significantly higher yield as compared to cv. Pusa Ruby (39.71 t/ha). HRD109 had produced the highest yield (59.52 t/ha), followed by HRD7 (54.00 t/ha) and HRDTOM099 (53.48 t/ha), respectively(Table 6). The result of these open tomato cultivars is also supported by Rawal et al., (2017), who evaluated open-pollinated tomato genotypes in mid-western Terai region and found that the highest yield produced by STM010 (45.47 t/ha). But Gotame et al., (2021) reported the highest yield (39.63 mt ha-1) was produced by the genotype HRA43 and it was followed by HRA33 (26.40 mt ha-1). It is quite lower than our study may be due to the heavy rain

occurred during his crop growing season as mentioned by them. Same trend was obtained by Bhurtyal et al., (2007) in the summer of the year 2000, evaluated 14 heat toleranttomato genotypes at Rampur, Chitwan and reported that there was a lot of variations withrespect to yield attributing traits; yield ranged from 40.53 ton/ha to 9.83 ton/ha. The better performing genotypes were Bari-5 (40.53 ton/ha), followed by Bari-4 (39.83 ton/ha), CLN-1621-L (31.33 ton/ha) and Lapsigede (29.84 ton/ha).

Table 6: Yield parameter of nine tomato cultivars at NHRC, Khumaltar in 2018 and 2019

Cultivars	Fruit /plant (#)			Fruit/ plant (g)			Yield (t/ha)		
	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
HRD-7	92	147	119.5±27.5b	1510	2805	2157.5±647.5	39.29	68.72	54.00±14.71a
CLN2545B	31	63	47±16e	1490	2182	1836±346	34.46	65.48	49.97±15.51ab
HRD109	109	133	121±12b	2100	2478	2289±189	51.30	67.74	59.52±8.22a
V5	42	60	51±9e	1822	2231	2026.5±204.5	41.76	65.20	53.48±11.72a
HRDTOM099	134	199	166.5±32.5a	1993	2239	2116±123	45.39	58.71	52.05±6.66a
STM02	35	64	49.5±14.5e	1639	2432	2035.5±396.5	36.39	66.15	51.27±14.88ab
STM03	32	53	42.5±10.5e	1465	1991	1728±263	35.97	63.75	49.86±13.89ab
HRDTOM086	60	123	91.5±31.5c	1437	2237	1837±399	34.13	51.75	42.94±8.81bc
Pusa ruby	53	81	67±14d	1196	2342	1769±573	28.13	51.30	39.71±11.58c
Mean	65.3	102.5	83.94±18.6	1605.7	2326.3	1979.2±360.7	38.53	62.09	50.31±11.78
F-test	**	**	**	*	ns	ns	*	*	*
LSD (0.05)	25.5	48.39	9.569	632			16.36		9.74
CV%	22.5	28.12	15.59	25.29	25.59	11.84	24.53	21.92	8.37

Fruit characteristics

Mean fruit weight was ranged from small size (15.6 g) to big size (76.7 g) (Fig. 2). Two cultivars were small-sized, one medium, and the other three were big. Similar type of result was shown by Shrestha and Sah (2014) in varietal evaluation trial at Parwanipur, Bara, Nepal in 2014 where Manisha gave bigger sized fruits (58 g) followed by Makis (40 g) and Pusa Ruby (36 g) respectively, whereas the smallest size fruits were obtained in Bari-5 (18.8 g) followed by Bari-4 (19.8g) respectively. As far as fruit shape is concerned, two cultivars had round shapes, four cultivars oval shape, two cultivars oblong shape and one flat shape fruits (Table 7). Mean fruit length was ranged from 33.1 mm (HRDTOM099) to 52.9 mm (V5) (Fig. 3). Similar result was obtained by Rangnamei et al., (2017) in their study at NEH region of India where the fruit length was varied from 38.4 mm (Pusa Ruby) to 46.7 mm (MT-2) in varital evaluation trial. Likewise, fruit width was ranged from 26.6 mm (HRDTOM099) to 50.1 mm (STM03) (Fig. 4). Pericarp thickness was ranged from 2.2 mm (HRDTOM099) to STM02 and STM03 (6.3 mm) (Fig. 5). In nature, most of the cultivars had the watery type of fruits except CLN2545B and V5, which had a medium fleshy type of fruits (Table 7). Likewise, number of seeds contained in the fruits was ranged from CLN2545B (53.5) to V5 (86.9) (Fig. 6). This result is also supported by the study of Animasaun et al., (2015) who had reported number of seed per fruit 47.8 (Tima) to 82.8 (Tropimech) cultivr at Negeria.

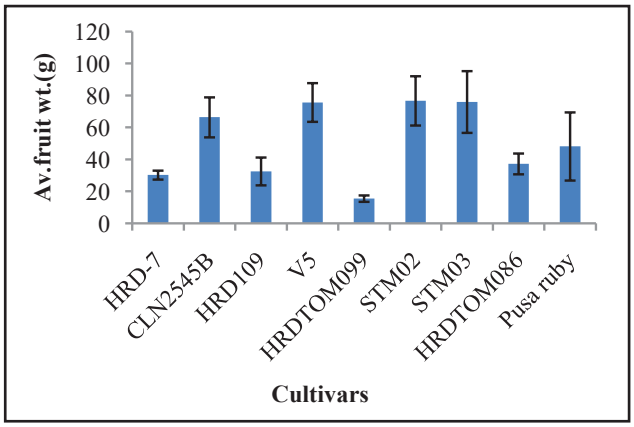

Fig. 2. Average fruit weight of nine tomato cultivars

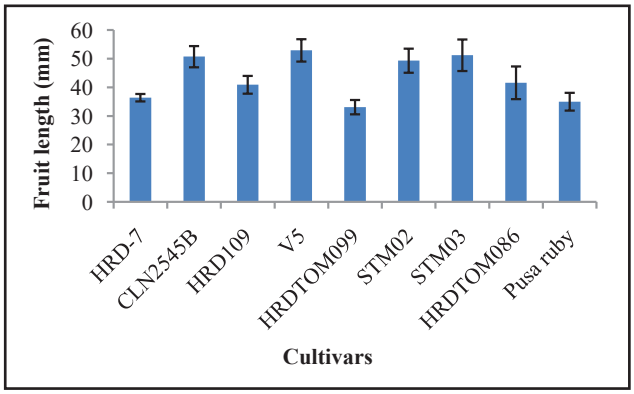

Fig. 3. Average fruit length of nine tomato cultivars

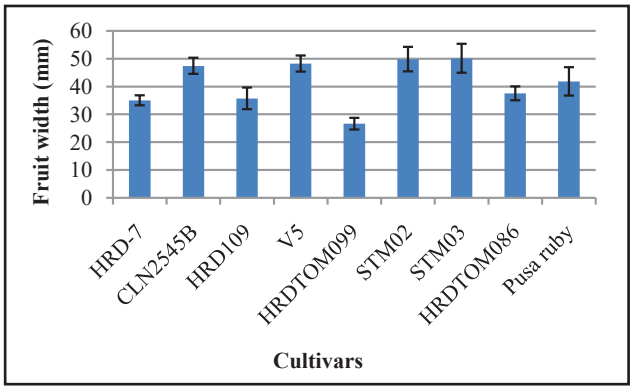

Fig. 4. Average fruit width of nine tomato cultivars

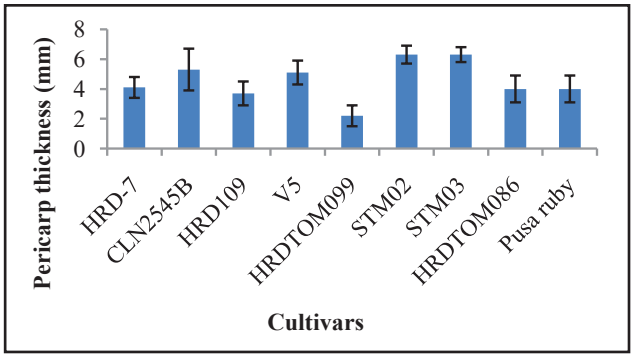

Fig. 5. Average pericarp thickness of nine tomato cultivars

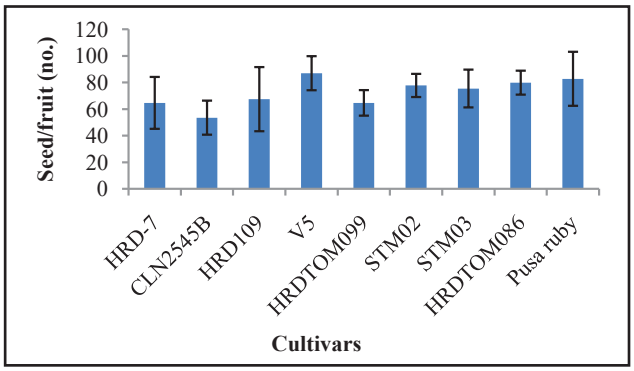

Fig. 6. Average seed number in the fruits of nine tomato cultivars

Table 7: Fruit characteristics of nine tomato cultivars at NHRC, Khumaltar

Cultivars	Fruit shape	Fruit size	Fruit nature
HRD-7	Oval	Small	Watery
CLN2545B	Oblong	Big	Medium
HRD109	Oblong	Small	Watery
V5	Oval	Big	Medium
HRDTOM099	Oval	Small	watery
STM02	Round	Big	watery
STM03	Round	Big	watery
HRDTOM086	Oval	Medium	watery
Pusa ruby	Flat	Big	watery

Consumer and Farmer response

Based on the size, consumers preferred V5 and STM02 (4.3) cultivars the most.According to the shape, farmers preferred HRD109, V5, HRDTOM099 and HRDTOM086 (5.0). Based on the colour, the farmers most preferred cultivar is HRDTOM099 followed by HRDTOM086. Consumer response was the highest (4.7) for HRD109 followed by HRDTOM099 and Pusa Ruby (4.3) for the freshness of the tomato. Farmer preferred HRD7, HRD109 and HRDTOM099 (5.0) the most according to the plant appearance. Based on the marketability, HRD7, HRDTOM099,and STM02 had more responses (4.3). Cultivars V5(4) and HRD109 & HRDTOM099 (3.7) were found to be more disease resistant according to farmer's response, and CLN2545B, STM02, HRDTOM086 and Pusa Rubywereleast preferred (3.0) by the farmers (Table 8).

Table 8 : Consumer and farmersresponse of nine tomato cultivars

Cultivars	Consumer response[x]					Farmers response[x]				
	Size	Shape	Color	Freshness	Mean	Plant appearance	Marketability	Insect	Disease	Mean
HRD-7	3.7	4.7	4.0	4	4.1	5	4.3	4.3	3.5	4.3
CLN2545B	4.0	4.3	3.3	4	3.9	2.7	3.7	4	3	3.3
HRD109	4.0	5.0	4.3	4.7	4.5	5	3.7	4	3.7	4.1
V5	4.3	5.0	3.3	3.7	4.1	3.3	4	4	4	3.6
HRDTOM099	3.7	5.0	5.0	4.3	4.5	5	4.3	4	3.7	4.2
STM02	4.3	4.3	3.7	3.7	4.0	4.7	4.3	4	3.0	4.0
STM03	4.0	4.7	4.3	4.0	1.2	4.7	3.3	4.3	3.3	3.9
HRDTOM086	4.0	5.0	4.7	4.0	4.4	4	3.3	4	3.0	3.6
Pusa ruby	4.0	4.0	4.3	4.3	4.1	3.3	3.7	4	3.0	3.5
Mean	4.01	4.67	4.11	4.07		4.18	3.85	4.07	3.3	
CV%	23.11	8.18	14.9	13.77		13.11	20.45	6.89	8.28	
F-test	ns	ns	*	ns		**	ns	ns	ns	
$LSD_{0.05}$			1.06			.949				

[x] 1: unacceptable, 5: excellent

Conclusion:

Among the tested cultivars, HRD109 showed superior performance that was septoria leaf spot tolerant, early days to flowering, the higher number of fruits per plant, superior yield, consumers and farmers preferred, and small fruit size. The next superior cultivar is HRD7 which hadlate blight filed tolerant, early days to flowering, the higher number of fruits per cluster and per plant, superior yield, consumers and farmers preferred small fruit size. Therefore, these two cultivars are recommended for cultivation in the central mid-hills of Bagmati Pradesh underopen field conditions.

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Declaration of conflict of interest and ethical approval:

S.L. Shrestha involved in designing, conducting experiment, analyzing and interpreting the resultis and preparing the research paper. Y.K. Shrestha involved in conducting the field experiments.

References:

Ahmad, F., Khan, O., Sarwar, S., Hussain, A. & Ahmad, S. (2007). Performance evaluation of tomato cultivars at high altitudes. Pakistan. Sarhad J. Agri. Vol. 23 (3): 581-595.

Animasaun, D., Oyedeji, S., Onyegwukwn, F., & Azeez, M. A. (2015). Evaluation of growth and pollen viabiality in relation to fruit set amaong five varieties of tomato grown in Nigeria. Agronomy Journal. 76(4-5):201-217.

Bhurtyal, P.R., Shakya, S.M., Dhakal, D.D., & Upreti, G. (2007). Evaluation of heat-tolerant tomato (Solanum lycopersicon) genotypes during summer in Chitwan, Nepal. IAAS Res. Advances, 2: 47-51.

Chapagain, T.R., Tiwari, D.N., Adhikari, R.C. & Shrestha, M.B. (2014). Physicochemical properties and yield of tomato varieties under plastic house condition. Nepal J. Sci. Tech. 15(2): 17-22. doi.org/10.3126/njst.v15i2.12106.

Ebert A.W., Chou Y.Y. (2015) The tomato collection maintained by AVRDC –The World Vegetable Center: composition, germplasm dissemination and use in breeding. Acta Hortic. 1101:169–176

FAOSTAT. (2018). Food and Agricultural Organization (FAO). Food and Agricultural Organization. http://www.fao.org/faostat/en/No. of data/QC.

Gautam, US., Negi, R.S., Singh, R., Kaushik, S.S. & Singh, A. (2013). Participator evaluation of tomato varieties for commercial cultivation durig rainy season under Kaymore plateau and Satpura hills- agro-climatic zone of Madhya Pradesh. Journal of Agricultural Science; Vol. 5, No. 4; 2013. ISSN 1916-9752 E-ISSN 1916-9760. Published by Canadian Center of Science and Education

Gomez, K.A., & Gomez. A.A. (1984). Statistical procedures for agricultural research. 2nd Edition. International Rice Research Institute, College, Laguna.

Gotame, T.P., Gautam, I.P., Shrestha S.L. & Pradhan, N.G. (2019). A field guide for vegetable germplasm testing and variety registration/ release. Nepal Agricultural Research Council (NARC), National Agriculture Research Institute (NARI), Horticulture Research Division (HRD), Khumalta, Lalitpur. NARC Publication Serial No. 00669-683 (2019/20).

Gotame, T.P., Gautam, I.P., Ghimire D. & Shrestha, S.L. (2021). Performance evaluation of exotic and local landraces of tomatoes for the mid-hill conditions of Nepal.

Gotame, T.P., Poudel, S., Shrestha, S.L. & Shrestha, J. (2021). Growth and yield performance of different open pollinated tomato genotypes in terai region of Nepal. Journal of Agriculture and Natural Resources. 4(1):256-264.

IPGRI. (1996). Descriptors for tomato (Lycoperrsicon spp.). International Plant Genetic Resource Institute (IPGRI), Rome (Italy). ISBN 10: 92-9043-294-2. https://www.bioversityinternational.org/fileadmin/_migrated/uploads/tx_news/Descriptors_for_tomato_Lucopersicon_spp._286.pdf.

Khan, B.A., Muhammad, A., Ali, A. & Hussain, U.L. (2021). Evaluation different varieties of tomato for growth and seed quality in district Sargodha climate. Plant Cell Biotechnology and Molecular Biology. 22(33&34):533-545.

MoALD. (2019). Statistical Information on Nepalese Agriculture, 2018/19. Agribusiness, Promotion

and Market Development Directorate, DOA, Kathmandu, Lalitpur, Nepal.

NHRC. (2019). Annual Report 2018/19. National Horticulture Research Center, NARC, Khumaltar, Lalitpur, Nepal

Parmao, D.K., Thakur, D.R., Jamwal, R.S. & Singh, G. (2018). International Journal of current microbiology and applied sciencies. ISSN: 2319-7706. Vol.7(1).

Pandey, Y.R., Pun, A.B. & Upadhya, K.P. (2006). Nepal Agriculture Research Journal. Vol. 7, pp. 11-15.

Rawal, R., Khadka, R.B., Gautam, D.M., Gautam, I.P., Mishra, K., Acedo, A.L., Hanson, P., Easdown, W., Hughes, J.A. & Keatinge, J.D.H. (2017b). Evaluation of AVRDC advanced lines of processing tomato in the mid-western plain of Nepal. Acta. Hortic., 1179, 305-310. DOI: org/10.17660/ActaHortic.2017.1179.47.

Rawal, R., Shrestha, S.L., Gautam, I.P. & Khadka, R.B. (2017a). Evaluation of open pollinated and hybrid tomato (*Solanum lycopersicum*) genotypes for quality and yield in mid-western Terai of Nepal. In: I.P. Gautam, S.L. Shrestha, G.D. Subedi, D.R. Bhattarai, T.P. Gotame and K.P. Upadhya (eds), Proc. Of 9thNational Horticulture Workshop, May 31-June 1, 2017, NARC, HRD, Khumaltar, Lalitpur. P.229.

Rangnamei, K.L., Kumar, M., Meena, K.L. & Rajkhowa, D.Y. (2017). Indian Journal of Hill Farming. Vol. 30(2):256-258.

Shrestha, S.L. & Sah, R.L. (2014). Evaluation of tomato cultivars for central Terai of Nepal. *Nepal J.Sci. and Tech., 15*(2), 11-16.