

Selection Of Elite Vegetable Varieties Through On-Station And On-Farm Experiments For The Central Terai Condition Of Nepal

Tek Prasad Gotame^{1*}, Sujata Poudel¹, Surendra Lal Shrestha¹, Ishwori Prasad Gautam¹,
Suresh Kumar Sah², Janga Bahadur Prasad and Jeet Narayan Chaudhary²

¹National Horticulture Research Centre, Khumaltar, Lalitpur

²Directorate of Agricultural Research (DoAR), Province 2, Parwanipur, Bara

*Corresponding authors' email: gotame@gmail.com

*Orcid ID: <https://orcid.org/0000-0003-0041-1363>

Abstract

Directorate of Agricultural Research (DoAR), Parwanipur, Bara is only one research station mandated to carry out research in vegetables for the Province 2 of Nepal. A series of on-station experiments under initial varietal trial (IET), coordinated varietal trial (CVT) and advance varietal trial (AVT), and on-farm experiments (farmers field trials, FFT) were conducted to select elite tomato, brinjal, broad leaf mustard, radish, hot pepper, ginger and turmeric genotypes for the central Terai conditions. The results from the IET revealed that open pollinated (OP) tomato genotype 'AVTO 1422' produced the highest yield (38.58 t/ha) followed by 'AVTO 1350' (36.6 t/ha). Results from the CVT showed that OP tomato genotype 'HRDTOM084' produced the highest yield (28.5 t/ha) followed by 'HRDTOM085' (19.9t/ha). Results from the FFT in OP tomato also revealed that 'HRDTOM084' produced the highest yield (25.6t/ha) followed by 'HRDTOM085' (21.1t/ha). Results from FFT on hybrid tomato recorded that 'HRA13 x HRD7' produced the highest yield (37.4t/ha) followed by 'HRA14 x HRD7' (33.8 t/ha). Similarly, AVT on brinjal showed that 'Parwanipur Selection-1' was the highest yielding genotype (25.8 t/ha). FFT on broad leaf mustard recorded the highest leaf yield (19.8 t/ha) in 'HRDBLM004' followed by 'Marpha Chauda Pat' (15.2 t/ha). CVT on radish recorded the highest root yield (28.6 t/ha) in 'HRDRAD004' followed by 'HRDRAD003' (28.0 t/ha). FFT on hot pepper recorded that 'HRDCHI012' genotype produced the highest yield (17.0 t/ha) followed by 'HRDCHI009'(12.5 t/ha). From these results, the promising variety of brinjal 'Parwanipur Selection-1' and tomato 'HRA14 x HRD7' hybrid genotype have been recommended for notification in the national seed system.

Keywords: CVT, FFT, IET, On-farm, On-station technology

Introduction

Director of Agricultural Research (DoAR), Province 2 (former RARS) Parwanipur is the oldest agriculture station of Nepal which was

established in 1947 AD (2004 BS) with the name of "Parwanipur Agriculture Farm". It was renamed as DoAR, Province 2, Parwanipur in March 2019. Horticulture units was established

in 1959 AD (2016 BS) with a mandate to conduct the basic, adaptive, and applied research on horticulture for developing technologies to increase production and yield of horticultural crops including vegetables for the central Terai region of Nepal (Gotame, 2018). In this context, Horticulture Research Unit of DoAR, Parwanipur has been continuously carried out initial varietal trial (IET), coordinated varietal trials (CVT), farmers field trial (FFT), farmers acceptance test (FAT) and advance varietal trials (AVT) to select elite genotypes of numerous vegetable species and to generate technologies on

vegetables aiming to increase yield in nutshell.

The area, production and yield of vegetable in the central Terai region (Province 2) is 85,074 ha, 126,6366 tonnes and 14.89 t/ha respectively while the national yield is 14.37 t/ha (MoALD, 2020). Tomato, brinjal, radish, broad leaf mustard, hot pepper is one of the major vegetables for central Terai region. In Province 2, the yield of tomato is 14.59 t/ha, brinjal is 13.21 t/ha, radish is 16.88 t/ha, broad leaf mustard is 15.93 t/ha and hot pepper is 8.79 t/ha (MoALD, 2020) (Table 1).

Table 1. Area, production and yield of major vegetables in Province 2 and comparison with national yield

Vegetables	Area ha	Production tonne	Yield t/ha	National yield t/ha
Cauliflower	12937	216698	16.75	16.07
Cabbage	7787	132607	17.03	17.11
Onion	11013	168270	15.28	13.94
Tomato	3704	54047	14.59	18.01
Radish	3096	52249	16.88	15.74
Brinjal	3339	44115	13.21	14.48
Bitter Gourd	3913	64,990	16.61	14.86
Pointed Gourd	2878	40877	14.2	13.8
Sponge Gourd	2197	33143	15.09	13.65
Okra	2,544	27714	10.9	11.58
Broad Leaf Mustard	1374	21882	15.93	14.38
Hot Pepper	2055	18071	8.79	10.35
Vegetable total	85074	1266366	14.89	14.37
Potato total	24400	377128	15.46	16.05

Source: MoALD, 2020

There is higher yield in cauliflower, onion, radish, bitter melon, sponge melon, broad leaf mustard and total average yield of vegetable crops in the province 2 as compared to national average vegetable yield. Nevertheless, other vegetables have low yield than the national average (MoALD, 2020). Therefore, it needs to increase the yield since this region is very fertile along with high access to the most of the agricultural inputs such as irrigation, fertilizer, improved seeds and plant protection measures (RARS, 2019).

The low yield of vegetables in the central Terai region is due to lack of suitable cultivars of field tolerance with many insects pests and fungal diseases. For example, fruit borer (*Leucinodes orbonalis*) is one of the major destructive pests of brinjal (Thapa et al., 2009) while late blight, *Tuta absoluta* and fruit borer are the major problems in tomato (Shrestha and Sah, 2014). The yield of tomato is greatly influenced by various biotic and abiotic stresses (Panthee and Gotame, 2020). Due to the lack of abiotic and biotic stress tolerant tomato and brinjal cultivars in Nepal, the productivity is low (Gurung et al., 2020, Gotame et al., 2021c). Shrestha et al. (2014) evaluated commercial hybrid and OP cultivars of tomato for central Terai region and found that hybrid HRDTOM005 x HRDTOM010 produced the highest yield (30.64 t/ha) followed by Makis (28.90 t/ha) and Srijana (28.87 t/ha). Gurung et al. (2020) evaluated tomato hybrids developed by Horticulture Research Division, Khumaltar at RARS, Parwanipur conditions and found that Srijana produced the highest yield (50.54 t/ha) which was statistically at par with HRA13 x HRD7. Gotame et al. (2020) found that the local genotype Parwanipur Selection-1 was the highest yielding brinjal variety in the central Terai conditions. Selection of elite vegetable genotypes is continuous process of research from DoAR, Province 2, Parwanipur. Therefore varietal evaluation research in tomato, brinjal, radish, hot pepper and broad leaf mustard

under IET, CVT, FFT and AVT were carried out in the FY 2015/16 to 2019/20. This manuscript highlights the overall finding and insights the promising genotypes.

Materials and Methods

Tomato:

On-station trial:

IET on tomato in 2018/19:

An initial evaluation trial of twelve genotypes of OP tomato (AVTO 0102, AVTO 1422, AVTO 1219, AVTO 1350, AVTO 1424, AVTO 9802, 1455, 9331, 9708, Pusa Ruby and CL1131) (Table 2) was conducted in the farm of DoAR, Parwanipur to screen superior tomato lines. The 4 weeks old seedlings were transplanted in the field with the spacing of 60 cm x 60 cm with two replications. The plot size was 3 m x 1.2 m = 3.6 m². There were 5 plants per row and 2 rows were maintained per plot.

CVT on OP tomato in 2015/16 and 2017/18:

CVT on ten OP genotypes (HRDTOM011, HRDTOM109, HRDTOM135, HRDTOM078, HRDTOM080, HRDTOM083, HRDTOM084, HRDTOM-085, HRDTOM086, Pusa Ruby) (Table 2) was carried out at RARS, Parwanipur to find out the appropriate germplasm for central Terai region of Nepal. The experiment was carried out in RCBD design in 3 replications. Seedlings were planted at 60 x 60 cm geometry and the plot size was 3 m x 1.2 m = 3.6 m². There were 5 plants per row and 2 rows were maintained per plot.

On-farm trial:

FFT on OP tomato in 2017/18:

Seven open pollinated tomato germplasm (HRDTOM011, HRDTOM035, HRDTOM083, HRDTOM084, HRDTOM085, HRDTOM086 and Pusa Ruby) (Table 2) were evaluated for their performance. The experiment was carried

out in RCBD design in 3 replications (farmer as replication). Seedlings were planted at 60 x 60 cm and the plot size was 3 m x 2.4 m =7.2 m². There were 5 plants per row and 3 rows were maintained per plot. Therefore the total plants were 15 per plot.

FFT on hybrid tomato in 2018/19 and 2019/20:

FFT on six hybrids (HRA13x HRD7, HRA14x HRD7, HRA20x HRD1, HRA20x HRD2, HRA20

x HRD6, Srijana and Dalila)(Table 2) were carried out to find out the appropriate F1 for central Terai region. The experiment was carried out in RCBD design in 3 replications (farmer as replication). Seedlings were planted at 70 x 60 cm geometry and the plot size was 3 m x 2.1 m =6.3 m². There were 5 plants per row and 3 rows were maintained per plot. Therefore the total plants were 15 per plot.

Table 2. List of tomato genotypes and hybrids evaluated at on-station and on-farm experiments, DoAR, Parwanipur

S.N.	On-station, 2015/16	On-station, 2017/18	On-farm, 2017/18 and 2018/19	On-farm, 2018/19 and 2019/20	On-station 2018/19
1	HRDTOM011	HRDTOM011	HRDTOM011	HRA 13x HRD 7	AVTO 0102
2	HRD109	HRD109	HRDTOM035	HRA 14x HRD 7	AVTO 1422
3	HRDTOM035	HRDTOM035	HRDTOM083	HRA 20x HRD 1	AVTO 1219
4	HRDTOM078	HRDTOM078	HRDTOM084	HRA 20x HRD 2	AVTO 1350
5	HRDTOM080	HRDTOM080	HRDTOM085	HRA 20x HRD 6	AVTO 1424
6	HRDTOM083	HRDTOM083	HRDTOM086	Srijana (check)	AVTO 9802
7	HRDTOM084	HRDTOM084	Pusa Ruby (check)	Dalila (check)	1455
8	STOM 05	HRDTOM085			9331
9	STOM 06	HRDTOM086			9708
10	Pusa Ruby (ch)	Pusa Ruby (ch)			Pusa Ruby (ch)
11					CL1131 (ch)

Brinjal:

On-station trial:

Advance varietal trial in brinjal in 2018/19:

Advance varietal trial was carried in eight brinjal genotypes (Parwanipur Selection-1, Pusa Purple Long (PPL), Pokhara Lurki, Lalgulab, Pusa Kranti, Arka Keshav, HRDBRI-012 and HRDBRI-013)using a randomized complete block design (RCBD) with three replications. The plot size was 6 m x 1.5 m (9 m²), with planting distance of 75 cm x 60 cm. There were 10 plants per row and two rows per treatment. Therefore, in total there were 20 plants per plot (Gotame et al., 2020).

On-farm trial

FFT in brinjal in 2018/19:

FFT was carried out in six brinjal genotypes (Parwanipur Selection -1, Pusa Purple Long (PPL), Pokhara Lurki, Lalgulab, Pusa Kranti, and Arka Keshav) in randomized complete block design (RCBD) with three districts, Bara, Parsa and Rautahot. There were 4 replications (farmers as replication). The plot size was 6 m x 2.25 m (13.5 m²), with planting distance of 75 cm x 60 cm. There were 10 plants per row and three rows per treatment (Gotame et al., 2020). Therefore, in total there were 30 plants per plot.

Broad Leaf Mustard:*On-farm trial:**FFT on broad leaf mustard in 2017/18:*

Six broad leaf mustard lines (HRDBLM001, HRDBLM003, HRDBLM004, HRDBLM007, HRDBLM009, Marpha Chauda Pat) were evaluated. The experiment was carried out in RCBD design in 4 replications (farmer as replication). Seedlings were transplanted in the field with a spacing of 45 x 30 cm. The plot size was 1.5 m x 3.0 m = 5.4 m². There were 10 plants per row and 3 rows were maintained per plot. Therefore the total plants were 30 per plot.

Radish:*On-station trial:**CVT on radish in 2017/18 and 2018/19:*

Five radish genotypes (HRDRAD001, HRDRAD002, HRDRAD003, HRDRAD004, HRDRAD005) were evaluated in 2017/18 while six genotypes (Pusa Chetki as check variety was included) were evaluated in 2018/19 (Gotame et al, 2021a). The experiment was carried out in RCBD design in 4 replications. Seeding was done in the spacing of 30 x 15 cm. The plot size was 2.1 m x 1.5 m = 3.15 m². There were 7 rows in 30 cm apart in a bed and plant to plant 15 cm with 10 plants per row, counting a total of 70 plants per plot.

Hot Pepper:*On-farm trial:**FFT on hot pepper in 2017/18 and 2019/20:*

Five hot pepper lines namely HRDCHI010, HRDCHI011, HRDCHI012, HRDCHI014 in 2017/18 and HRDCHI009, HRDCHI010, HRDCHI012, HRDCHI014 along with Jwala as check variety were evaluated. The experiment was carried out in RCBD design in 4 replications (farmer as replication). Seedlings were transplanted in the spacing of 60 x 30 cm (Gotame et al., 2021b). The plot size was 3 m x 1.8 m = 5.4 m². There were 10 plants per row

and 3 rows were maintained per plot. Therefore the total plants were 30 per plot.

Experimental locations:

The DoAR, Parwanipur, Bara is situated between 84° 15' to 86° 15' east longitude and 26° 15' to 26° 45' north latitude with the elevation of 115 m asl having subtropical climate (RARS, 2020). The average maximum and minimum mean daily temperature was 29.8°C and 19.6°C, respectively. Similarly, average relative humidity was 50.4% and mean rainfall was 35.5 mm during the growing period. The soil structure was angular blocky, dark grayish brown (10YR 4/2) in color, silt loam in texture. The soil was moderately acidic in pH (5.67±0.09), low in organic matter (0.74±0.04%) (Khadka et al., 2018). Farmer's field trials were carried out in Bara, Parsa and Rautahot districts.

Statistical analysis:

The collected data were entered and compiled by using the MS-excel program, 2016 and subjected to analysis of variance as per the procedure given in R- STAT software (Version 1.2.1335) for the randomized complete block design (R Core Team, 2013).

Result and Discussion**Tomato:**

The results from IET on OP tomato revealed that number of fruits per plot was highest in AVTO1350 (712) followed by CL1131 (620) and the lowest number was in AVTO1429 (78). Fruit yield per plot was highest (13.17 kg) in AVTO1350 followed by 9331(12.26 kg) and AVTO0102 (12.14 kg), respectively. The highest marketable fruit yield was obtained from 9331 (11.39 kg/plot) followed by AVTO1350 (11 kg/plot)(Table 3).

Table 3. Evaluation of tomato genotypes under IET at DoAR, Parwanipur

Genotypes	No of fruit per plot	Fruit yield per plot kg	Marketable fruit yield per plot kg	Number of plant harvested	Yield t/ha
AVTO0102	536	12.14	9.33	10	33.72
AVTO1422	211	9.25	7.19	7	38.58
AVTO1219	173	4.2	2.57	5	23.33
AVTO1350	712	13.17	11	10	36.6
AVTO1424	221	6.73	4.32	9	21.34
AVTO9802	230	10.5	6	10	29.16
1455	382	9.24	8.56	10	25.68
9331	452	12.26	11.39	10	34.05
9708	146	6.04	5.1	10	16.79
Pusa Ruby	364	7.76	7.53	10	21.56
CL1131	620	8.46	7.98	10	23.51
F-test	***	ns	**	***	ns
CV%	22.08	29.3	28.9	9.2	70.94

** highly significant at $P < 0.01$; * Significant at $P < 0.05$, ns= non significant

The results of the CVT on OP tomato showed that HRDTOM084 produced the highest yield (28.5 t/ha) followed by HRDTOM085 (19.9 t/ha). The results of the FFT carried out in 2017/18 showed that the highest yield was from HRDTOM084 (25.5 t/ha) followed by HRDTOM85 (21.1 t/ha). These genotypes showed moderate resistance to late blight and septoria leaf spot with a score value of 2.3 in 1-5 rating scale (Gotame et al., 2021).

The results of the FFT on hybrid tomato revealed that the highest number of fruit was recorded in HRD13 × HRD7 (553.6) followed by cv Srijana (549). The cv. Srijana recorded highest total fruit yield per plot (16.88 kg) and marketable fruit yield per plot (15.52 kg). Similarly, the highest fruit yield per hectare (37.38 kg) was measured in HRD13 × HRD7 followed by HRD14 × HRD7 (33.8 kg) and HRD20 × HRD1 (32.22 kg) (Table 4).

Table 4. Evaluation of hybrid tomato varieties in farmer's field trial (FFT), DoAR, Parwanipur

Hybrids	No of fruit per plot	Fruit yield per plot kg	Non-marketable fruit yield per plot kg	Marketable fruit yield per plot kg	plant harvested per plot
HRA13 × HRD7	553.6	15.7	1.0	14.79	9.3
HRA14 × HRD7	342.6	14.19	1.47	12.86	10
HRA20 × HRD1	374.6	13.53	0.69	12.82	10
HRA20 × HRD2	358.0	11.5	0.58	11.15	10
HRA20 × HRD6	312.3	9.18	0.79	8.44	7
Srijana (check)	549.0	16.88	1.49	15.52	10

Hybrids	No of fruit per plot	Fruit yield per plot kg	Non-marketable fruit yield per plot kg	Marketable fruit yield per plot kg	plant harvested per plot
Dalila (check)	276.0	7.02	1.09	5.93	6
F-test	*	*	ns	*	***
CV	26.8	26.48	43.05	26.68	2.45

** highly significant at $P < 0.01$; * Significant at $P < 0.05$, ns= non significant

The mean of 2 years results on hybrid tomato revealed that Srijana hybrid produced the highest yield (35.86 t/ha) followed by HRA14 x HRD7 (32.36 t/ha) (Table 5).

Table 5. Yield and yield traits of hybrid tomato, DoAR, Province 2, Parwanipur

Hybrids	No of fruits per plant			Fruit yield per plant kg			Yield t/ha		
	2018/19	2019/20	Mean	2018/19	2018/19	Mean	2018/19	2019/20	Mean
HRA13× HRD7	37	18	27	1.047	0.703	0.875	37.38	19.54	28.46
HRA14 × HRD7	23	23	23	0.946	1.113	1.0295	33.8	30.93	32.36
HRA20 × HRD1	25	26	25	0.902	0.847	0.8745	32.22	23.52	27.87
HRA20 × HRD2	24	25	24	0.767	1.150	0.9585	27.39	31.95	29.67
HRA20 × HRD6	21	21	21	0.612	0.927	0.7695	21.85	25.75	23.8
Srijana (check)	37	48	42	1.125	1.795	1.46	21.85	49.87	35.86
Dalila (check)	18	15	17	0.468	0.464	0.466	16.71	12.88	14.79
F-test	**	**		*	**		**	*	
LSD	10	15		0.256	0.321		11.1	9.6	
CV%	9.08	8.63		10.5	14.1		12.2	10.5	

** highly significant at $P < 0.01$; * Significant at $P < 0.05$, ns= non significant

Brinjal:

Gotame et al. (2020) performed advance varietal trial (AVT) in brinjal at RARS, Parwanipur and reported that Parwanipur Selection-1 (PS-1) produced the highest yield (28.8 t/ha). The results from the farmer's field trial (FFT) revealed that the largest fruit size was found in Parwanipur Selection-1 (130 g per fruit) followed by Pusa Kranti (121 g) and Pusa Purple Long (108 g). The highest yield, marketable yield and adjusted yield was also found the highest (33.1 t/ha) in Parwanipur Selection-1 followed by Pusa Kranti (31.7 t/ha) (Gotame et al.,

2020). Therefore, Parwanipur Selection-1 is recommended for the commercial production and a registration process is underway in the National Seed Board.

Broad leaf mustard:

FFT on broad leaf mustard genotypes carried out in 2017/18 revealed that the highest leaf yield (19.8 t/ha) was found in 'HRDBLM004' followed by 'Marpha Chauda Pat' (15.2 t/ha) (Table 6).

Table 6. Performance of broad leaf mustard genotypes at farmer's fields, DoAR, Parwanipur

Genotypes	No. of plant per plot	Plant vigor (1-5 scale)	Plant spreading cm	No. of leaf per plot	Leaf yield kg/plot	Leaf length cm	Leaf breadth cm	Yield t/ha
HRDBLM001	22.0	3.3	2.3	309.0	7.9	24.4	20.2	14.7
HRDBLM003	24.0	4.0	3.0	251.7	7.5	40.9	19.2	14.0
HRDBLM004	29.0	4.0	3.0	770.7	10.7	39.5	18.7	19.8
HRDBLM007	27.0	4.3	3.3	325.7	5.6	31.9	17.1	10.3
HRDBLM009	30.0	3.7	2.7	333.0	6.6	27.5	16.3	12.1
Marpha Chauda-Pat (check)	24.0	3.7	3.0	369.7	8.2	30.2	16.2	15.2
Mean	26.0	3.8	2.9	393.3	7.8	32.4	18.0	14.4
SEM±	1.183	0.167	0.179	49.278	0.592	1.482	0.429	1.097
F-test	ns	ns	ns	**	ns	***	**	ns
CV %	13.95	19.05	26.56	29.28	25.89	2.38	4.88	37.23

** highly significant at $P < 0.01$; *Significant at $P < 0.05$, ns= non significant

Radish:

Gotame et al (2021a) conducted a trial at RARS, Paarwanipur and reported that mean of two consecutive years was the highest root yield (28.59 t/ha) in 'HRDRAD004' followed by HRDRAD003 (27.96 t/ha) and HRDRAD005 (27.65 t/ha). The largest root size (233 g) was found in HRDRAD005 followed by HRDRAD004 (193 g) (Gotame et al., 2021a). It has been reported that the radish cultivars, HRDRAD003 and HRDRAD004 and HRDRAD005 produced significantly higher root yield and found promising for cultivation in central Terai region of Nepal

Hot pepper:

Gotame et al. (2021b) carried out FFT on hot pepper in 2017/18 and 2019/20 and found that 'HRDCHI012' produced the highest yield (7.1 t/ha and 17.0 t/ha with mean of 12.1 t/ha) followed by 'HRDCHI009' (12.5 t/ha) in 2019/20. Similarly, marketable fruit yield per plant was the highest (310 g) in HRDCHI012 followed by

HRDCHI009 (220 g) (Gotame et al., 2021b). It has been reported that the hot pepper cultivars, HRDCHI012 and HRDCHI009 produced significantly higher yield and found promising for central Terai region of Nepal.

Conclusion

DoAR, Province 2, Parwanipur is only one research station to develop technologies in vegetable crops central Terai region. Only few vegetable species are recommended for cultivation. As hybrid vegetables are dominated in the region, very few OP varieties are adopted by the farmers. To superset the imported hybrid varieties, it needs to be develop our own hybrids appropriate in the region. For the two years researches, a promising variety of brinjal 'Parwanipur Selection-1' and tomato hybrid 'HRA14 x HRD7' have been recommended for registration through the national seed system.

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Declaration of conflict of interest and ethical approval:

T.P. Gotame designed, executed the experiment and wrote the draft of the manuscript, S. Poudel, S. Sah, J.B Prasad and J,N Chaudhary involved in field experiment and data handling, S.L. Shrestha and I.P Gautam provided materials for research and finalized the initial draft of this manuscript.

The authors declare no conflicts of interest

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