

Research Article

Growth and yield performance of hybrid tomato (*Solanum lycopersicum* L.) lines at Parwanipur, Bara, Nepal

¹Suraj Gurung*, ¹Prabin Adhikari, ¹Kushal Giri, ²Tek Prasad Gotame and

²Surendra Lal Shrestha

¹Agriculture and Forestry University, Faculty of Agriculture, Rampur, Chitwan, Nepal

²Nepal Agriculture Research Council, Horticulture Research Division (HRD), Khumaltar, Lalitpur, Nepal

*Correspondence: suraj.grg1996@gmail.com; ORCID ID: <https://orcid.org/0000-0001-5602-4691>

Received: August 22, 2019; Accepted: November 19, 2019; Published: January 7, 2020

© Copyright: Gurung et al. (2020)



This work is licensed under a [Creative Commons Attribution-Non Commercial 4.0 International License](https://creativecommons.org/licenses/by-nc/4.0/).

ABSTRACT

An experiment was conducted to evaluate the performance of hybrid tomato lines on growth and yield performance at Regional Agriculture research Station (RARS), Parwanipur, Nepal during end of September, 2018 to April, 2019. The experiment was laid out in randomized complete block design (RCBD) with seven hybrid tomato lines as treatments and three replications. The tested lines included Srijana and Dalila as check varieties and other lines, developed by crossing HRA and HRD lines which showed better performance under late blight conditions. HRA 20× HRD 1 showed significantly higher plant height (110.67 cm) which was statistically at par with genotype HRA 14× HRD 7. The highest number of fruits per plant (69) was recorded from Srijana whereas the lowest number of fruits per plant (37) was recorded from cv. HRA20 × HRD1. The fruit yield of the lines ranged from 50.54 t/ha to 32.2 t/ha with Srijana having the highest yield and HRA 20× HRD 1 as the lowest. Similar results were shown regarding the marketable fruit yield. However, the highest individual fruit weight (34.67g) was recorded in HRA 14× HRD 7 and the least fruit weight was recorded in Srijana (24.22 g). Results showed that the maximum TSS (5.53 °Brix) was recorded from Dalila which was similar as Srijana. Hence, the overall performance of Srijana was recorded superior regarding both quantitative and qualitative suggesting Srijana as the recommended variety in the given domain. Here authors concluded that Srijana is still a comparatively better hybrid variety in Nepal.

Keywords: Tomato, Hybrid, Srijana, HRD lines

Correct citation: Gurung, S., Adhikari, P., Giri, K., Gotame, T. P., & Shrestha, S.L.(2020).

Growth and yield performance of hybrid tomato (*Solanum lycopersicum* L.) lines at Parwanipur, Bara, Nepal. *Journal of Agriculture and Natural Resources*, 3(1), 180-189. DOI: <https://doi.org/10.3126/janr.v3i1.27166>

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is considered as the most cultivated and produced vegetable in the world (FAOSTAT, 2017). The tomato cultivation covers 21,389 ha of land with the total production of 400,674 t and the average productivity of 19 t/ha (MoALD, 2016). The high infestation of bacterial wilt and late blight in most of the commercial varieties has drastically affected the yield and productivity of tomato in Nepal (Bhandari & Maniratna, 2016). Apart from that, late blight and bacterial wilt has been the major cause leading to the rapid decline of solanaceous crop in the central terai (Timila & Manandhar, 2016). Srijana, the first hybrid of Nepal, has been developed by Horticulture Research Division (HRD) which is superior in terms of productivity and also tolerant to bacterial wilt and late blight (HRD, 2015). After the development of Srijana variety, studies have shown that the popularity and demand of Srijana variety has been increasing among farmers (Magar et al., 2016). Development of promising hybrids and continuous varietal evaluation is required to develop the best hybrids for the given domain (Chapagain et al., 2011). Therefore research should be carried out in regular basis towards the development and improvement of tomato hybrids through proper hybridization, selection and varietal evaluation based on yield attributes, qualitative parameters, disease resistance and consumer preference.

MATERIALS AND METHODS

Experimental details

The experiment was conducted at Regional Agricultural Research Station (RARS), Parwanipur from the end of September, 2018 to April, 2019. Geographical location of the command area of RARS is situated between 84° 15' to 86° 15' east longitude and 26° 15' to 26° 45' north latitude with elevation of 115 meters above sea level (ORD, 1997). Experimental design was randomized complete block design (RCBD) which comprises of 7 treatments and 3 replications. The size of individual plot was 4.2 m² (3m ×1.4m) and the plants were transplanted in the spacing of 70 cm (Row to Row) and 60 cm (Plant to Plant) respectively.

Plant materials

Srijana which was used as a check variety is an indeterminate hybrid variety of tomato developed by Nepal Agricultural Research Council which is made from the cross between HRD-1 (female line) and HRD-17 (male line). Similarly, Dalila is a determinate hybrid variety which is also used as check varieties in the experiment. The other five hybrids (F1) were developed by the Horticulture Research Division, Khumaltar which were selected as treatments for the experiment. All the hybrids used were tolerant to late blight and bacterial wilt (HRD, 2017). The HRD lines were collected from the Horticulture Research Division, Khumaltar under the supervision of RARS, Parwanipur.

Climatic conditions

The meteorological data for cropping season was recorded from meteorological station of Regional Agricultural Research Station (RARS), Parwanipur. The average maximum and minimum mean daily temperature was 29.8°C and 19.6°C respectively and average relative humidity was 50.4 % in entire growing period from September 2018 to April 2019 (Figure 1).

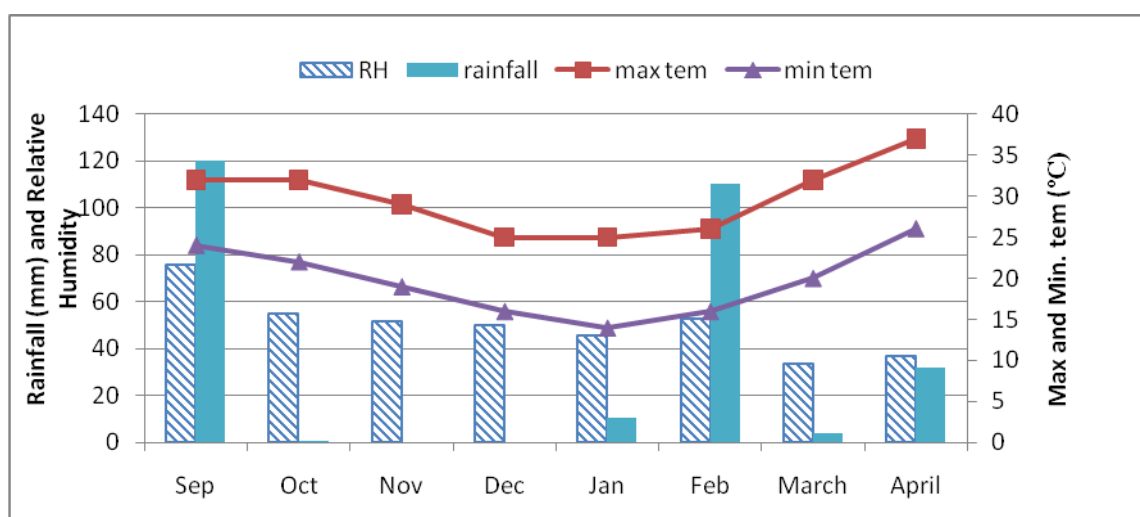


Figure 1. Weather data of experimental location at 30 days interval during the growing season at Parwanipur, 2018/19

Cultural practices

The seed was shown in the last week of September and the transplanting of 45 days old seedling was done in the month of November, 2018. Fertilizer dose of 25 t/ha FYM and 180:150:70 kg NPK/ha was applied. One third of Nitrogen and entire dose of Phosphorus and Potash was applied during field preparation. The remaining dose of Nitrogen was applied in equal doses at 25 and 50 days after transplanting.

Observation

The plant height was measured using a measuring scale from the sample plants. The Total Soluble Solid (TSS) in ^oBrix was calculated from the ten sample fruits of each treatment using refractometer. Similarly, the diameter of the tomatoes was calculated randomly from ten fruits of each treatment with the help of Vernier caliper. On the basis of yield per plant, calculation of yield per hectare was done. Multiple manual harvesting of fruit was done at 2 to 3 days interval. The number of diseased fruit per plant was recorded at regular interval and disease scoring was done based on the scale of 1 to 5 with 1 being the least and 5 being the most affected by diseases (HRD, 2017).

Plant Vigour

The relative degree of foliage mass of a genotype is plant vigor. Vigor is recorded at about 50% flowering stage using a 1 to 5 rating scale.

- 1= Poor (all plants are small, few leaves, weak plants, very thin stems and light green color)
- 2 = Weak (75% of the plants are small or all plants are shorter than normal plant height, plants have few leaves, thin stem and light green color)
- 3= Medium, intermediate or normal growth
- 4= Vigorous (75% of the plants are taller than normal, robust with foliage of dark green color, thick stems and leaves are well developed)

5= Excellent (all plants are taller than normal, ground completely covered by foliage, plants are robust, with thick stem and abundant foliage of dark green color)

Late blight score

The disease was scored during flowering and at pick harvesting time. Scoring was done using 1-5 scale with the following criteria.

<u>Plant Status</u>	<u>Score (1-5)</u>
Healthy plants	= 1
About 25% of the plants foliage is infected with late blight	= 2
About 50% of the plants foliage is infected with late blight	= 3
About 75% of the plants foliage is infected with late blight	= 4
The entire plant is infected with late blight	= 5

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). Analysis of variance (ANOVA) was performed and the significant differences between treatments were determined using Duncan's multiple range Test (DMRT) at 1% and 5% level (Gomez & Gomez, 1984; Shrestha, 2019; Devkota *et al.*, 2019; Pandey *et al.*, 2019).

RESULTS AND DISCUSSION

Plant height and plant vigor

The plant height was recorded higher (110.7 cm) in cv. HRA 20× HRD 1 which was statistically at par with cv. HRA 14× HRD 7 and cv. HRA 20× HRD 2. Similarly, Dalila was the most dwarf (60.33 cm) variety which was statistically at par with cv. HRD20 × HRD6. Likewise, Srijana was found to have least plant vigor (3.4) while all other lines showed statistically similar level of plant vigor (Table1). All the varieties were indeterminate type except Dalila which is a determinate variety (Singh & Bhandari, 2015). As plant height is a genotypic character, they vary with cultivar (Shrestha & Sah, 2014). The results of variation in the plant height among the lines are in agreement with those results by RARS, Nepalgunj where they have reported that there is difference in the plant height ranging from 75 cm to 168 cm in cv. HRA 20× HRD 6 and cv. HRA 20× HRD 1 respectively (RARS, 2016). Likewise, the plant height obtained from a research on hybrid tomato at Advance Varietal Trial (AVT) at Kathmandu has recorded the maximum plant height (160 cm) from Srijana (HRD, 2016). Such difference could be due to the genotypic and environmental interaction. The growing environment has a direct effect in the plant structure and composition (Caliman *et al.*, 2010). Similar results were recorded on the research conducted in RARS, Lumle where the maximum plant height was observed in cv. HRA20 ×HRD1 (RARS, 2016). In our study, Srijana had the least plant plant vigor (3.4) among the tested lines. Thus the result is supported by the findings of Horticulture Research Division, among 9 cultivars of hybrid tomato where Srijana had the least plant vigor (HRD, 2017).

Table 1. Plant height and plant vigor of different tomato hybrid lines at Parwanipur,

2019

Hybrids	Plant height(cm)	Plant Vigor (1-5)	Growth habit
HRA 13× HRD 7	84.09 ^{bc}	3.93 ^a	ID
HRA 14× HRD 7	107.80 ^a	4.067 ^a	ID
HRA 20× HRD 1	110.67 ^a	4.10 ^a	ID
HRA 20× HRD 2	104.00 ^{ab}	3.93 ^a	ID
HRA 20× HRD 6	76.67 ^{cd}	3.83 ^a	ID
Srijana (Check)	95.33 ^{abc}	3.40 ^b	ID
Dalila (Check)	60.33 ^d	4.10 ^a	D
Grand Mean	91.3	3.92	
LSD _{0.05}	19.1	0.368	
CV, (%)	11.8	5.28	
SEm(±)	6.19	0.16	
F-test	**	*	

Means within the column followed by the same letter for lines are not significantly different at 5% level of significant by LSD

Plant vigor: 1: poor,

5: excellent

Growth habit: ID: indeterminate

D: Determinate

Fruit characteristics

Total soluble solid (TSS) is considered as an important qualitative parameter to determine the suitability of the tomato (Kadar et al., 1977). The TSS content of the fruit ranged from 4.07⁰Brix to 5.53⁰Brix. The maximum TSS (5.53⁰Brix) was observed in Dalila which was statistically at par with Srijana whereas the least TSS (4.07⁰Brix) was seen in cv. HRA 13× HRD 7 which was statistically at par with cv. HRA 20× HRD 6 and cv. HRA 20× HRD 1. Fruits of cv. HRA 20× HRD 2 was found to have highest number of locules (4 locules) which was statistically at par with cv. HRA 20× HRD 1. Other than that, all other lines were statistically par with each other in terms of number of locules. The fruits size of cv. HRA20 × HRD1 was largest (42.54 mm) among the tested lines. The smallest fruit diameter (33.5 mm) was recorded in Srijana variety which was statistically similar to Dalila, cv. HRA 20× HRD 6 and cv. HRA 13× HRD 7 respectively (Table 2).

The number of locules, fruit diameter and TSS all are its genetic traits (Rai et al., 2016). It is also noted that the TSS content varies according its maturity stage (Teka, 2013). The highest TSS, recorded in Dalila, was due to its determinate nature in which all the nutrients were deposited only to its fruits while in indeterminate variety, the nutrients were distributed between fruits and vegetative structures. Teka (2013) reported that higher degree Brix values are correlated with higher tomato yield. Likewise, variation in the fruit diameter among 12 hybrid tomato lines was reported ranging from 41.2 g to 66.14 g in which 'Srijana' had the least fruit diameter while cv. HRA 16 X HRD 4 had the maximum fruit diameter respectively (Devkota, et al., 2018). Furthermore, the results obtained is further supported by the findings of Horticulture Research Division- Khumlatar in which cv. HRA 20× HRD 1 had the maximum fruit diameter (HRD, 2016).

Table 2: Total soluble solid (TSS), number of locules and average fruit diameter of

different lines of tomato at Parwanipur, 2019

Hybrids	Total Soluble Solid (⁰ Brix)	Average number of Locules	Average fruit diameter (mm)
HRA 13× HRD 7	4.07 ^d	2.167 ^b	36.58 ^{bc}
HRA 14× HRD 7	5.27 ^{ab}	2.67 ^b	38.43 ^b
HRA 20× HRD 1	4.60 ^{cd}	3.67 ^a	42.54 ^a
HRA 20× HRD 2	4.83 ^{bc}	4.00 ^a	35.65 ^{bc}
HRA 20× HRD 6	4.40 ^{cd}	2.33 ^b	34.33 ^c
Srijana (Check)	5.46 ^a	2.50 ^b	33.49 ^c
Dalila (Check)	5.53 ^a	2.0 ^b	33.67 ^c
Grand Mean	4.88	2.76	36.4
LSD _{0.05}	0.577	0.64	3.78
CV, (%)	6.64	13.1	5.84
SEm(±)	0.19	0.20	1.22
F-test	*	**	**

Means within the column followed by the same letter for lines are not significantly different at 5% level of significant by LSD

Yield and yield attributing parameter

The result on the number of fruits per plant, individual fruit weight and marketable fruit yield showed highly significant difference among the tested lines. The highest number of marketable fruits per plant (64.66) was recorded from Srijana Variety which was statistically at par with cv. HRA13× HRD7 and Dalila variety. Likewise, cv. HRA20 × HRD1 had the least number of fruits per plant (36.66) which was statistically at par with cv. HRA14 × HRD7 and cv. HRA 20 × HRD6. HRA 20 × HRD1 was found to have superior individual fruit weight (35.95 g) which was statistically at par with cv. HRA 14× HRD 7 while all other lines shows similar individual fruit weight. The highest fruit yield (50.54 t/ha) was recorded from Srijana variety which was statistically at par with cv. HRA13× HRD7. Cv. HRA20 × HRD6 had the least fruit yield (30.71 t/ha) which was statistically at par with cv. HRA20 × HRD1 (Table 3).

Studies have revealed that the difference among the tested variety is attributed by its genetic diversity (Rai et al., 2016). Furthermore, Chapagain et al. (2011) suggested that marketable fruit yield is the major determining factor for selecting appropriate commercial cultivation. Based on the study by RARS, (2017) among the 12 tested cultivars; Dalila was found to have the maximum number of fruits per plant (85) which supports our findings. Similarly, it was found that Srijana had the maximum number of fruits per plant (64) among the 10 tested cultivars of hybrid tomato lines in AVT at HRD (2016). Such difference can be attributed to different growing environment.

Likewise, it is reported that there was a variation in the average individual fruit weight among tomato lines ranging from 51.5g to 82 g in the research entitled evaluation of the hybrid tomato lines in AVT at Khumaltar where highest individual fruit weight (82 g) was recorded from HRA 20× HRD 1 and the lowest individual fruit weight (51.5 g) was recorded from Dalila respectively which further supports our findings (HRD, 2016). Finally, similar research conducted in evaluation of hybrid tomato lines in CVT, Nepaljung including 10 tested cultivars have shown superior yield in Avinash-3 followed by Srijana variety (RARS, 2016) which further supports our findings.

Table 3: Yield and yield attributing parameters of hybrid lines,Parwanipur 2019

Hybrids	Marketable fruit per plant	Individual fruit weight (g)	Marketable yield (t/ha)	Total yield (marketable and non-marketable) (t/ha)
HRA 13× HRD 7	60.00 ^a	26.93 ^b	40.09 ^{5ab}	42.85 ^{ab}
HRA 14× HRD 7	37.33 ^{bc}	34.67 ^a	36.67 ^{bc}	39.65 ^b
HRA 20× HRD 1	36.66 ^c	35.96 ^a	30.531 ^{cd}	32.20 ^c
HRA 20× HRD 2	45.33 ^b	27.87 ^b	34.918 ^{bcd}	36.95 ^{bcd}
HRA 20× HRD 6	40.33 ^{bc}	28.40 ^b	28.031 ^d	30.71 ^c
Srijana (Check)	64.66 ^a	24.22 ^b	46.024 ^a	50.54 ^a
Dalila (Check)	57.00 ^a	26.311 ^b	32.586 ^{bcd}	36.85 ^{bc}
Grand Mean	48.8	29.2	35.6	38.5
LSD _{0.05}	7.88	4.48	7.71	7.18
CV, (%)	9.08	8.63	12.2	10.5
SEm(±)	2.55	1.45	2.50	2.33
F-test	**	**	**	**

Means within the column followed by the same letter for lines are not significantly different at 5% level of significant by LSD

Disease scoring and number of fruit infested by disease

Genotype HRA 20× HRD 6 was found to have highest disease scoring (2.033) but the overall lines were found to be statistically non-significant. Srijana variety was found to have the highest number of fruits infested by disease (33) which was statistically at par with cv. HRA 20 × HRD 6 (Table 4). This signifies the higher sugar content in Srijana might have attracted more insects thus causing the rapid spread of the diseases in the plant. It has been known that vitamin C and fruit acidity lowers the pathogen infection in tomato (Mohammed et al., 1999). In addition, research related to grapevine has suggested that the increase in TSS has direct impact in the activity of the virus (Royo et al., 2016). However, Chapagain et al. (2011) reported that the lowest damage by the late blight was recorded in Srijana variety. Such variation could be due to difference in the climatic condition as it directly effects of plant composition (Caliman et al., 2010).

Table 4: Disease scoring and number of diseased fruits at Parwanipur 2019

Hybrids	Disease scoring (1-5)	Number of diseased fruits per plot
HRA 13× HRD 7	1.35	23.33 ^{abc}
HRA 14× HRD 7	1.46	16.00 ^{bcd}
HRA 20× HRD 1	1.16	5.33 ^d
HRA 20× HRD 2	1.46	9.00 ^{cd}
HRA 20× HRD 6	2.03	30.00 ^{ab}
Srijana (Check)	1.87	33.33 ^a
Dalila (Check)	1.56	26.33 ^{ab}
Grand Mean	1.56	20.5
LSD _{0.05}	0.564	13.5
CV, (%)	20.3	37.1
SEm(±)	0.18	4.38
F-test	NS	**

Means within the column followed by the same letter for lines are not significantly different at 5% level of significant by LSD

Disease Scoring: 1: poor,

5: excellent

CONCLUSION

The preliminary study showed that Srijana variety was found to superior in terms of yield attributing characters like marketable fruits per plant and total fruit yield. Similarly, while regarding the qualitative parameters like TSS, Dalila and Srijana were found to have higher TSS content. Hence, it is recommended to grow Srijana variety in the context of Bara district from both quantitative and qualitative perspective.

AUTHOR CONTRIBUTIONS

S.G. and T.P.G. designed and performed the experiment. S.G. performed the analysis while S.G., K.G. and P.A. contributed to analyze and interpret the results. S.G. worked on the manuscript. S.L.S. and T.P.G. was involved in planning and supervising the experiment.

CONFLICT OF INTEREST

The authors declare no conflicts of interest regarding publication of this manuscript.

ACKNOWLEDGEMENTS

The authors would like to extend our deepest sense of gratitude to Agriculture and Forestry University, Rampur. We further want to acknowledge Regional Agriculture Research Station (RARS) and Horticulture Research Division (HRD) for providing the research materials for conducting the experiment. Our heartfelt thank goes to Prime Minister Modernization Project (PMAMP), Project Implementation Unit-Vegetable zone, Parsa and their staffs for supporting us during research period.

REFERENCES

- ABPSD. (2016). *Statistical Information of Nepalese Agriculture*. Kathmandu, Nepal: Agribusiness Promotion and Statistics (ABPSD).
- Bhandari, N. B., & Maniratna, D. B. (2016). *Demand and supply of tomato in Nepal*. Hariharbhawan, Lalitpur: Agribusiness Promotion and Marketing Development Directorate, Government of Nepal.
- CAFS. (June, 2018). *Baseline Survey Report on Vegetable Zone, Parsa*. Parsa, Nepal: Center for Agriculture and Food Studies (CAFS).
- Caliman, F. R., Silva, J., Sringheta, P. C., Fontesa, R., Moreira, G., & Mantovani, E. (2010). Quality of tomatoes grown under a protected environment and field conditions. *IDESIA* 28, 75-82.
- CBS. (November 2012). *National Population and Housing Census 2011*. Kathmandu, Nepal: Central Bureau of Statistics (CBS), Governmnet of Nepal.
- Chapagain, T. R., Khatri, B. B., & Mandal, J. (2011). Performance of Tomato Varieties during Rainy Season under Plastic House Conditions. *Nepal Journal of Science and Technology*, 12, 17-22.

- Dadzie, B. K., & Orchard, J. E. (1997). *Routine post-harvest screening of banana/plantain hybrids: criteria and methods*. Rome, Italy: International Plant Genetic Resources Institute .
- Devkota, S., Panthi, S., & Shrestha, J. (2019). Response of rice to different organic and inorganic nutrient sources at Parwanipur, Bara district of Nepal. *Journal of Agriculture and Natural Resources*, 2(1), 53-59.
- Devkota, S., Shrestha, S., Dhakal, D., Shakya, S., & Pandey, A. (2018). Evaluation of tomato hybrids for yield attributes under Khumaltar condition. *Journal of Institute of Agriculture and Animal Science*, 35, 191-196.
- FAOSTAT. (2017). *Food and Agricultural Organization (FAO)*. Retrieved August 25, 2019, from Food and Agricultural Organization Web site: <http://www.fao.org/faostat/en/#data/QC>
- Ghimire, N., Kandel, M., Bhattarai, D., & Aryal, M. (2017). Assessment of tomato consumption and demand in Nepal. *The Journal of Agriculture and Environment Vol: 18*, 83-94.
- HRD. (2015). *Annual Report*. Khumaltar, Lalitpur, Nepal: Horticulture Research Division (HRD).
- HRD. (2016). *Annual report*. Khumaltar, Lalitpur, Nepal: Horticulture Research Division (HRD).
- HRD. (2017). *Annual Report*. Khumaltar, Lalitpur, Nepal: Horticulture Research Division(HRD).
- Kadar, A. A., Stevens, M., Holton, M., Morris, L., & Algazi, M. (1977). Effect of fruit ripeness when picked on flavor and composition in fresh market tomatoes. *Journal of the American Society for Horticultural Science*, 102 (6), 724-731.
- Kelley, W. T., Boyhab, G., Harrison, K. A., & Sumner, P. E. (2010). *Commercial tomato production handbook*.
- Magar, D. B., Gauchan, D., Timsina, K. P., & Ghimire, Y. N. (2016). *Srijana Hybrid Tomato: A Potential Technology for Enterprise Development in Nepal*. Khumaltar, Lalitpur, Nepal: Socioeconomics & Agricultural Research Policy Division, Nepal Agricultural Research Council (NARC).
- Magar, D., & Gauchan, D. (2016). Production, Marketing and Value Chain Mapping of 'Srijana' Tomato Hybrid Seed in Nepal . *Journal of Nepal Agricultural Research Council*, 2, 1-8.
- MoALD. (2016). *Statistical Information of Nepalese Agriculture*. Kathmandu, Nepal: Agri-Business Promotion and Statistics, Ministry of Agriculture and Livestock Development (MoALD).
- MoF. (2018). *Economic Survey 2017/18*. Singhadurbar, Kathmandu, Nepal: Ministry of Finance, Government of Nepal.
- Mohammed, M., Wilson, A., & Gomes, P. (1999). Postharvest sensory and physiochemical attributes of processing and non-processing tomato cultivar. *J. Food Qual.* 22, 167-182.
- ORD. (1997). *RARS Parwanipur Command Area Outreach Research Site Description Survey*. Khumaltar, Lalitpur, Nepal: Outreach Research Division .

- Pandey, D., Chaudhari, H.K., Upadhyay, S.R., Gautam, N.R., Ghimire, B.R., Shrestha, J., & Thapa, D.B. (2019). Participatory on-farm evaluation of wheat varieties. *Journal of Agriculture and Natural Resources*, 2(1), 312-321.
- R Core Team. (2013). R: A Language and Environment for Statistical computing. Vienna, Australia: [http:// www.R-project.org/](http://www.R-project.org/).
- Rai, A., Vikram, A., & Pandav, A. (2016). Genetic Variability Studies in Tomato (*Solanum lycopersicum* L.) for Yield and Quality Traits. *International Journal of Agriculture, Environment and Biotechnology*, 9 (5), 739-744.
- RARS. (2016). *Annual Report*. Khajura, Nepaljung, Nepal: Regional Agricultural Research Station (RARS).
- RARS. (2016). *Annual Report*. Lumle, kaski, Nepal: Regional Agriculture Research Station (RARS).
- RARS. (2017). *Annual Report* . Parwanipur, Bara, Nepal: Regional Agricultural Research Station (RARS), Nepal Agriculture Research Council (NARC).
- RARS. (2017). *Annual Report*. Lumle, Kaski, Nepal: Regional Agriculture Research Station (RARS).
- RARS. (2017). *Annual Report*. Tarahara, Sunsari: Regional Agricultural Research station(RARS).
- Royo, J. B., Miranda, C., Toda, F. M., Martínez, L., & Balda, P. (2016). Direct and indirect effects of three virus infections on yield and berry composition in grapevine (*Vitis vinifera* L.) cv. 'Tempranillo'. *Scientia Horticulturae*, 212, 20-28.
- Shrestha, J. (2019). P-Value: A true test of significance in agricultural research. Retrieved from <https://www.linkedin.com/pulse/p-value-test-significance-agricultural-research-jiban-shrestha/>
- Shrestha, S. L., & Sah, R. L. (2014). Evaluation of Tomato Cultivars for Central Tarai of Nepal. *Nepal Journal of Science and Technology*, 11-16.
- Singh, K. P., & Bhandari, R. R. (2015). *Vegetable Crops Production Technology*. Kathmandu: Samikshya Publication.
- Teka, T. A. (2013). Analysis of the effect of maturity stage on the postharvest biochemical quality characteristics of tomato (*Lycopersicon esculentum* MILL.). *International Research Journal of Pharmaceutical and Applied Sciences*, 3(5), 180-186.
- Timila, R. D., & Manandhar, S. (2016). Biovar Differentiation and Variation in Virulence of *Ralstonia solanacearum* Isolates Infecting Solanaceous Vegetables. *Journal of Nepal Agricultural Research Council*, 2, 22-26.