Research Article

Tomato Yield Losses Due to Attack of Insects/Pests in Pakkhal Valley of District Mansehra Khyber Pakhtunkhwa, Pakistan

Ahmad Abrar Khan[1*], Ghulam Qadar[1], Asif Ali Abro[2] and Muhammad Awais[3]

[1]Department of Agricultural Extension Education and Communication, The University of Agriculture, Peshawar, Pakistan; [2]Department of Business Administration, Newports Institute of Communications and Economics, Karachi, Pakistan; [3]State Key Laboratory of Crop Stress Biology for Arid Areas, College of Plant Protection, Northwest A and F University, Yangling, Shaanxi 712100, P. R. China.

Abstract | The research study was carried out with the aims to find tomato insects/pests responsible for yield losses in Pakkhal valley of district Mansehra. Data were collected from tomato growers by using an interview schedule in the union council Baffa of the study area. The results of the study focused that maximum land under tomato cultivation was found 8.75 and minimum 0.25 acres with a major group (35.4%) of tomato growers cultivating on 2.5 acre and below size of land. Chemical fertilizers were applied by all the respondents while one-third applied natural fertilizer along with chemical fertilizers. Regarding irrigation majority (89.2%) was blessed with canals while 10.8% were rain water dependent. Two-third of the total cases relied on chemical method for insects/pests control while one-third on chemical and physical both. The highest yield recorded was above 16000 Kg/acre achieved by only less than a quarter (23.1%), while collectively above fifty percent (53.9%), tomato growers were incompetent to achieve per acre yield of 12000 Kg. Majority (81.5%) tomato growers faced aphids attack while more than 50% reported whitefly, Cutworm, mites and Armyworm. Leaf miner, thrips and fruit fly were reported by less than 50% of the total respondents. The result of regression analysis revealed that attack of insects/pests i.e. aphids, armyworm, mites, thrips and fruit fly were found non-significant while cutworm, whitefly and leaf miner have significant negative effects on per acre yield of tomato. Inappropriate and cultural practices, high dependency on agrovet dealers and fellow farmers were the key factors of yield losses. It is recommended to spray on the proper time along with follow-ups and physical control techniques. Selection of right time, control methods, appropriate insecticides/pesticides along-with recommended dose and treatments must be defined by the recommendations of agriculture experts instead of fellow farmers and agrovet sellers. Trainings, workshops and field activities should be organized regarding improved farm management practices especially on the aspect of insects/pests management to minimize the yield losses.

Received | September 05, 2022; **Accepted** | December 22, 2022; **Published** | January 21, 2023
***Correspondence** | Ahmad Abrar Khan, Department of Agricultural Extension Education and Communication, The University of Agriculture, Peshawar, Pakistan; **Email:** abrarswati46@gmail.com
Citation | Khan, A.A., G. Qadar, A.A. Abro and M. Awais. 2023. Tomato yield losses due to attack of insects/pests in Pakkhal Valley of District Mansehra Khyber Pakhtunkhwa, Pakistan. *Sarhad Journal of Agriculture,* 39(1): 21-28.
DOI | https://dx.doi.org/10.17582/journal.sja/2023/39.1.21.28
Keywords | Tomato, Insects/Pests, Yield losses, Baffa Pakhal, District Mansehra

Introduction

The rural development and food security in Pakistan are directly linked with sustainable progress of the agriculture industry. It contributes significantly to both employment and earnings from foreign exchange. In addition to that it provides industrial raw material, thus, the development of this sector has numerous connections to the national economy. Around 37.4% of the labour market is employed by it and contributes 22.7% to the national GDP (GoP, 2022). Horticulture unit pays around 12% to the state agriculture GDP. Vegetables are prominent horticultural products of the country. Tomato, potato, chilies, onion, carrot, turnip, peas, cauliflower and gourd are main vegetables grown nationwide covering 78 percent of the total area and representing 81 percent of the total production. By the year 2019-20 vegetable export was 8.80 million ton with a growth of 16.1% from the previous year (GoP, 2020). Globally tomato is one of the most popular vegetables. Short growing season and high yield make tomato crop economically more attractive and area under cultivation is expanding by time. Tomato fruit is a rich source of vitamins, minerals, sugar, dietary fibers and essential amino acids. It contains abundant amount of iron, phosphorus, vitamin B and C. Lycopene is a powerful antioxidant naturally found in tomato, helps prevent the growth of different types of cancer. Tomatoes are consumed in fresh form as salads and also cooked in sauces, soups, curries and dishes. Tomato fruits are processed into ketchup, juices and purees. Dried and canned tomatoes are processed items with high market value. A relatively cool and dry climate is required for high yield and premium quality of tomato. However, it is adaptable to a variety of weather conditions including humid tropical and temperate to hot climate (Naika et al., 2005; Adenuga et al., 2013).

According to the FAO statistical reports during the year 2020, China was the largest producer of tomatoes worldwide with production of 64,768,158 tonnes followed by India and Turkey with 20573000 and 13204015 tonnes, respectively (FAO, 2020). In Pakistan all four provinces produce tomatoes (GoP, 2020). In the country by the year 2020, devoted land for tomato cultivation was 57838 hectares with a production of 594210 tonnes. Regarding tomato production, Pakistan doesn't possess prominent place in the world ranking (FAO, 2020). Except a few districts of Khyber Pakhtunkhwa, tomatoes are cultivated throughout the province. During the year 2020, collectively Kharif and Rabi tomato crops were cultivated on 34,257.944 hectares with production of 125,485 tonnes. Mansehra is a major tomato producing districts of Khyber Pakhtunkhwa. The district covered 716 hectares (1769.236 acres) with 3570 tonnes (3,570,000 Kg) of tomatoes during 2020 including Kharif and Rabi seasons (Crop Reporting Service, 2022). Vegetables and fruits are commonly cultivated in district Mansehra due to promising climatic and weather conditions. The Pakhli plain (Pakkhal valley) has productive and fertile land because of its irrigation infrastructure (SMEDA, 2009). Despite of all suitable conditions of cultivation, Mansehran ever placed itself in high tomato yielding districts of the province because of its pitiable yield per area as compared to other districts of the province like Dir Upper, Nowshera, Mardan, Dir Lower, Malakand, D.I. Khan, Swat and Chitral (Crop Reporting Service, 2022). In Mansehra district, tomato cultivation is a common trend since independence of the country but it is still deprived of its actual productive potential. There is an urgent need of exploring different aspects, responsible for low yield and stagnant production of the tomato crop in the area. In this regard current study was initiated on the aspect of identification of major insects/pests responsible for low yield and production of tomato crop in the district.

Materials and Methods

This research study was conducted in district Mansehra located in east west mountains zone of Khyber Pakhtunkhwa Province of Pakistan. To obtain the required sample for the current study, the multistage sampling approach was employed (Cochran, 1977). Pakkhal valley is the rich tomato belt of the district and most of the tomato growers exist here. A list of all union councils of Pakkhal valley was prepared with the help of agricultural extension office working in the valley. Among all the Baffa union council was selected randomly. For selection of sample size of tomato growers, first the probability of tomato growers in the area was found out as 60% through a pilot survey then a sample of 65 tomato growers was taken through sampling technique for unknown population suggested by Kasely and Kumar (1989) based on 60% probability of tomato growers in the area. Which is expressed in Equation 1.

The sample size was determined on assumed variability such as 50 % for the farmers those are involved in the use of pesticides on their farms as suggested by Kasely and Kumar (1989).

$$n = \frac{Z^2(p \times q)}{e^2} \quad \ldots(1)$$

Where, n = Sample size, Z = Reliability coefficient = 1.645 (constant at 90% confidence level), p = 60% = 0.6 (Because tomato growers' probability was found out as 60% during pilot survey).

$$q = (1 - p) = (1 - 0.6) = 0.4$$

e= 10% = 0.1 (because assumed marginal error is 10%).

$$n = \frac{(1.645)^2(0.6 \times 0.4)}{(0.1)^2} = 65$$

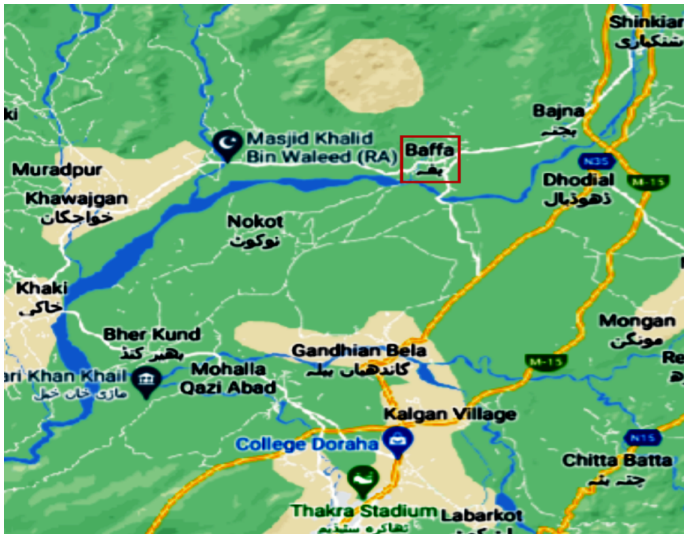

Figure 1: *Map of Pakkhal Valley in Mansehra district, Khyber Pakhtunkhwa (Pakistan).* **Source:** *Google maps.*

Collection of data

In light of the objectives of the study, a well-structured interview schedule was developed. A pilot phase was carried out to test the interview schedule. The researcher conducted in-person interviews with each and every farmer of the study to collect the required data and information.

Data analysis

Simple data analysis included frequency distribution with percentages. Since production is dependent on insects/pests attacks, a multiple linear regression model was selected to examine the influence of insects/pests attacks on per acre yield of tomato. When performing a regression analysis, quantitative is not the only variable which affects the dependent variable but it is also affected by qualitative variable to some extent. An indication of a particular variable refers to the absence or presence of an attribute. The approach for determining such an attribute uses dummy variables with values of 0 or 1, indicating absence or presence, respectively (Gujarati, 2004). Each insect/pest attack influences the dependent variable individually and its absence or presence was taken in the form of dummy variable. In order to examine the influence of independent variables (i.e., insects/pests attack) on dependent variable (i.e., tomato yield per acre) regression model with dummy variable approach was applied. The specific form of the model is given in Equation 2.

$$Y = \beta_0 + \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_3 + \beta_4 D_4 + \beta_5 D_5 + \beta_6 D_6 + \beta_7 D_7 + \beta_8 D_8 + \varepsilon i \ldots\ldots (2)$$

Where; Y= Tomato yield per acre, D_1= Dummy for cutworm attack; 1 for Yes, 0 for otherwise, D_2= Dummy for aphids attack; 1 for Yes, 0 for otherwise, D_3= Dummy for whitefly attack; D_4= Dummy for armyworm attack;1 for Yes, 0 for otherwise, D_5= Dummy for leaf miner attack; 1 for Yes, 0 for otherwise, D_6= Dummy for mites attack; 1 for Yes, 0 for otherwise, D_7= Dummy for thrips attack; 1 for Yes, 0 for otherwise, D_8= Dummy for fruit fly attack; 1 for Yes, 0 for otherwise. β0 = Intercept, εi = Error term.

Results and Discussion

Data about specified characteristics of the tomato growers, collected during field survey is presented in Table 1.

Area under tomato crop

Table 1 show that a major group (35.4%) of tomato growers cultivated tomato on 2.5 acres and below size of land, followed by 32.3% who cultivated on 2.51-5 acres. Smallest group (12.3%) cultivated tomato on above 7.5 acres of land. The maximum land under tomato cultivation was found 8.75 and minimum 0.25 acres. Collectively more than half of total respondents were cultivating tomatoes on an area of 5 acres and less. The study findings are in agreement with Usman and Bakari (2013) who examined the financial viability of small-holder farmers' dry-season tomato production and found that around 63.8% of them possessed less than 2.0 hectares (4.942 acres) of land.

Table 1: *Characteristics of the tomato growers.*

Characteristics of tomato growers		Frequency	Percent
Land under tomato crop	2.5 acres and below	23	35.4
	2.51-5 acres	13	20
	5.1-7.5 acres	21	32.3
	Above 7.5 acres	8	12.3
	Total	65	100
Fertilization	Chemical	43	66.2
	Chemical and natural both	22	33.8
	Total	65	100
Irrigation Source	Canal	58	89.2
	Rain Water	7	10.8
	Total	65	100
Insect/ pest control	Chemical	49	75.4
	Chemical and physical both	16	24.6
	Total	65	100
Yield per acre	8000 Kg and below	18	27.7
	8001-12000 Kg	17	26.2
	12001 - 16000 Kg	15	23.1
	Above 16000 Kg	15	23.1
	Total	65	100

Source: *Field Survey.*

The results of the study are also corroborated by Barasa et al. (2019) who noted that a major group of tomato producers possessed farms ranged in size from 0.25 to 1.0 hectares (0.17 to 2.471 acres). In the study area rapid urbanization was recorded as main cause of minimized land under tomato cultivation.

Fertilizers application

Table 1 further show that tomato growers of the study area applied chemical and natural fertilizers to their tomato crops. Majority (66.2%) tomato growers were applying chemical fertilizers only while rest 33.8% were those who applied chemical and natural both type of fertilizers to their tomato crop. It was revealed that fertilizers application was a common practice and tomato growers were well aware about importance of fertilizers. NPK and Urea were two common adopted types of chemical fertilizer while animal manure as natural fertilizers. Chemical fertilizer was applied by all (100%) tomato growers while only 33.8% applied natural fertilizer were those who had their own castles or have better economic conditions. Study findings are same with the findings of Feng et al. (2011) who found very limited usage of natural fertilizer with common utilization of chemical fertilizers. According to Kaur et al. (2005) it is crucial to fertilize in a balanced manner using both chemical and organic fertilizers in order to maintain lasting soil health, soil organic substances levels and crop yield.

Irrigation sources

Table 1 also illustrates the irrigation sources of the tomato growers in the study area. Majority (89.2%) irrigated their land through canals while rest (10.8%) was rain water dependent. River Siran flows through the Pakkhal valley has two well-developed canal irrigation system irrigates the 70% agricultural land of the valley. Rest of the land is rain water dependent.

Insects/pests management

In connection with inspects/pests management, Majority (75.4%) tomato growers used chemical method to combat insects/pests attack while remaining (24.6%) used chemical and as well as physical method. Tomato growers in the study area are highly (100%) reliant on insecticides/pesticides in order to control insects/pests attack. Respondents with large family size and labour force furthermore used physical method along with chemicals application. Small-scale tomato growers heavily rely on synthetic chemicals to combat diseases and pests (Nashwa and Abo-Elyousr, 2012; Asante et al., 2013).

In addition, Barasa et al. (2019) reported that tomato growers applied a range of chemical groups to manage tomato pests and diseases.

Per acre yield of tomato

In the study area a minimum yield of 4000 and maximum 18000 Kg/acre was recorded. Table 1 indicates that majority (27.7%) tomato growers per acre yield was 8000 and below Kg, followed by 26.2% who achieved8001-12000 Kg, 23.1% got 12001-16000 Kg and same (23.1%) obtained above 16000 Kg. Less than one-fourth (23.1%) of total farmers succeeded to get a potential yield above 16000 Kg/acre, but on the other hand collectively, more than fifty percent (53.9%) tomato growers were incompetent to achieve per acre yield of 12000 Kg. In Khyber Pakhtunkhwa, Dir Upper yields above 7000 Kg per acre, Nowshera, Dir Lower and Mardan above 5000 Kg, Malakand, D.I. Khan and Swat above 4000 Kg and Chitral around 4000 Kg (Crop Reporting Service, 2022) whereas the study area yields 2730.784 Kg per acre. The study found comparatively less yield than other districts of the province and a big gap between actual and potential yield in the area. Many

reasons are involved behind low yield of tomato in the study area like inappropriate and cultural farm management techniques regarding inputs utilization, plant protection, plant nutrition, pre and post-harvest techniques etc. Arthropod pests, viral, fungal and bacterial infestations are amongst the most significant biological limitations for low production (Willis et al., 2018). Since land is a crucial element of production, the small land pieces may limit production and yield of tomato in the area (Willis et al., 2018).

Table 2: *Distribution of respondents regarding insects/pests attack.*

Insect/pest attack status		Frequency	Percent
Cutworm	Yes	37	56.9
	No	28	43.1
	Total	65	100
Aphids	Yes	53	81.5
	No	12	18.5
	Total	65	100
Whitefly	Yes	40	61.5
	No	25	38.5
	Total	65	100
Armyworm	Yes	34	52.3
	No	31	47.7
	Total	65	100
Leaf miner	Yes	28	43.1
	No	37	56.9
	Total	65	100
Mites	Yes	36	55.4
	No	29	44.6
	Total	65	100
Thrips	Yes	26	40.0
	No	39	60.0
	Total	65	100
Fruit fly	Yes	23	35.4
	No	42	64.6
	Total	65	100

Source: *Field Survey.*

Table 2 depicts that majority (81.5%) tomato growers faced aphids (order: Hemiptera) attack while 18.5% did not face followed by 61.5 % who faced whitefly (order: Hemiptera) attack while 38.5% did not face, Cutworm (order: Lepidoptera) attack was reported by 56.9% respondents while 43.1% reported no attack, regarding mites (order: Trombidiformes) 55.4% reported its attack while 44.6% reported no attack of mites, Armyworm (order: Lepidoptera) was reported by 52.3% while 47.7% reported its no attack, Leaf miner (order: Diptera) attack was faced by 43.1% while 56.9% did not face, thrips (order: Thysanoptera) attack was reported by 40.0% while 60.0% reported its no attack and 35.4% faced attack of fruit fly (order: Diptera) while 64.6% did not face. The study findings are in line with the results of Ishtiaq et al. (2017) who claimed that Lepidopterans, white flies, leaf minors and aphids were identified as tomato insect pests in several sites in the Mansehra district. Study results are also in agreement with Wakil et al. (2018) who reported that aphids, African bollworm, thrips, white flies, mites and leaf miner moth are the most significant arthropod pests that attack tomato crops. Thrips and whiteflies were listed by Juma (2015) as two major pests harming production of tomato. It is observed during field study that due to lack of proper information regarding insects/pests management mostly farmers were unable to manage efficiently the insects/pests attack. Tomato growers of the study area were using chemicals on the recommendation of pesticide seller/dealers and fellow farmers.

Table 3: *Regression analysis of the influence of the insects/pests on per acre yield of tomato.*

Independent variables	Coefficients	Std. Error	t-ratio	P value
(Constant)	17516.735	1295.44	13.522	0.000**
Cutworm (D_1)	-2414.868	988.802	-2.442	0.018*
Aphids (D_2)	-506.649	1156.56	-0.438	0.663
Whitefly (D_3)	-3055.123	1111.129	-2.75	0.008**
Armyworm (D_4)	-943.198	1058.41	-0.891	0.377
Leaf miner (D_5)	-2252.665	1032.399	-2.182	0.033*
Mites (D_6)	-701.696	910.713	-0.77	0.444
Thrips (D_7)	-105.22	959.901	-0.11	0.913
Fruit fly (D_8)	-1045.226	988.119	-1.058	0.295

Indicates significance and **high significance at P ≤ 0.05 and P≤0.01, respectively. R-square: 0.495; Adjusted R-square: 0. 423; F stat: 6.873; Source: Authors' estimation based on field survey data.*

Effects of insect/pest attacks on yield

The result of regression analysis in Table 3 revealed that attack of insects/pests i.e. aphids, armyworm, mites, thrips, fruit fly were found non-significant while cutworm, whitefly and leaf miner have significant negative effects on yield of tomato per acre. Tomato growers whose crops were attacked by cutworm, whitefly and leaf miner got a significant decrease in yield by 2414.868Kg, 3055.123Kg, and 2252.665Kg/acre, respectively as compared to those who did not

face attack of these three significant pests. Although farmers of the study area use chemical and as well as physical methods to control insect/pest damages but still yield losses are observed. This might be due to lack of follow-up treatments, inappropriate, late and untimely application of insecticides/pesticides as well as unusual physical control practices. Inadequate services of agricultural extension department regarding improved techniques of insects/pests and farm management resulted in high dependency of farming community on agrovet dealers. Asif et al. (2014) found that the types of chemicals that farmers employ for crop defense are significantly influenced by the distributors in many developing nations. Huynh (2014) identified that 72.5% of the tomato growers were obtaining information from pesticide retailers regarding use of chemicals. Though, the study results are opposed by the findings of Margaret et al. (2015) who stated that agricultural extension officers were the source of information of majority (40.4%) of the farmers regarding tomato production. The results are further supported by a previous report which illustrated that a major group of the farming community was unaware about the practices of biological control techniques in the integrated pest management (IPM) for tomato crop production. Agrovet stores served as the primary source of crop protection guidance. The results showed that the region's tomato output was constrained by pests and diseases (Barasa et al., 2019).

Conclusions and Recommendations

The study concludes that farming community of the study area tended to grow cash crops including tomato. Low production relative to the area's potential and compared to other districts of the province was noted. Because of rapid urbanization, more than half of total respondents were cultivating tomatoes on an area of 5 acres and less. Use of chemical fertilizers and canal irrigation were common practices due to their easy availability while natural fertilizer was available to one-third of total respondents. Cutworm, Aphids, whitefly, armyworm, leaf miner and mites were six major while thrips and fruit fly recognized as minor insects/pests attacks, controlled by the farmers through hinsecticides/pesticides application while one-fourth of the total farmer sopted physical control method as well. In connection with injuries of insects/pests, cutworm, whitefly and leaf miner significantly and inversely affected the tomato yield. Lack of follow-up treatments, inadequate knowledge about insects/pests identification and their appropriate treatments, Late and improper timing of applications of chemicals, inappropriate cultural practices, high dependency on agrovet dealers and fellow farmers were the causes of infestation and low yield.

It is recommended to spray on the proper time, and follow-up sprays especially to meet the danger of cutworm, aphids, whitefly, armyworm, leaf miner, mites, thrips and fruit fly. Reliance only on a single insects/pests control method should be avoided and maximum control techniques have to be adopted i.e. biological, physical, chemical etc. For selection of right time, control methods and appropriate insecticides/pesticides along with recommended dose and treatments, agriculture experts should be contacted instead of following fellow farmers and agrovet sellers. Through increased and improved contacts with public and private agricultural agencies, trainings, workshops and field activities should be organized regarding improved farm management practices especially on the aspect of insects/pests management to minimize the yield losses. This should be properly implemented and monitored in order to achieve actual potential yield of tomato crop. The present study will provide guidelines for future researchers to study each identified insect/pest individually and other aspects of yield losses.

Novelty Statement

The present study was conducted to find out tomato yield losses due to insects/pests attack in the Pakkhal valley of district Mansehra of Khyber Pakhtunkhwa province. Findings and recommendations of the study will be helpful to enhance the yield of tomato in the area and will provide guidelines for future studies.

Author's Contribution

Ahmad Abrar Khan: Principal author did research, made all analysis and wrote the 1st draft of the manuscript.
Ghulam Qadar: Helped in data collection.
Asif Ali Abro: Reviewed literature and helped in performing quantitative data analysis.
Muhammad Awais: Helped in data analysis.

Conflict of interest
The authors have declared no conflict of interest.

References

Adenuga, A.H., A.M. Lawal and O.A. Rotimi. 2013. Economics and technical efficiency of dry season tomato production in selected areas in Kwara State, Nigeria. Agris Online Papers Econ. Informat., 5(1): 11-19. https://online.agris.cz/archive/2013/01/02

Asante, B., M. Osei, A. Dankyi, J. Berchie, M. Mochiah, J. Lamptey, J. Haleegoah, K. Osei, and G. Bolfrey-Arku. 2013. Producer characteristics and determinants of technical efficiency of tomato-based production systems in Ghana. J. Dev. Agric. Econ., 5(3): 92-103.

Asif, A.J., R.S. Amber, M. Najma, and M.N. Shafi. 2014. Current scenario of pesticide practices among farmers for vegetable production: A case study in Lower Sindh, Pakistan. Int. J. Dev. Sustain., 3(3): 493-504.

Barasa, M.W., R. Kahuthia-Gathu, M. Mwangi and J.W. Wackeke. 2019. Tomato production characteristics, biotic constraints and their management practices by farmers in Bungoma county, Kenya. J. Nat. Sci. Res., 9(12): 46-55.

Cochran, W.G., 1977. Sampling techniques. 3rd Edition, John Wiley and Sons, New York.

Crop Reporting Service. 2022. Final estimate of fruits production. KP. Vegetables District Wise Kharif and Rabi 2019-20. Crop Reporting Service Centre. Directorate of Agril. Ext. KP, Peshawar. Pakistan.

FAO, 2020. Food and agricultural organization. Data productions crops and livestock products. https://www.fao.org/faostat/en/#data/QCL.

FAO, 2020. Food and agricultural organization. Rankings countries by commodity. Toamtoes. http://www.fao.org/faostat/en/#rankings/countries_by_commodity

Feng, S., S. Tan, A. Zhang, Q. Zhang, G. Pan, F. Qu, P. Smith, L. Li and X. Zhang. 2011. Effect of household land management on cropland topsoil organic carbon storage at plot scale in a red earth soil area of South China. J. Agric. Sci., 149(5): 557-566. https://doi.org/10.1017/S0021859611000323

GoP, 2020. Fruit, vegetables and condiments statistics of Pakistan 2018-19. Economic wing Ministry of national food security and research Islamabad, http://www.amis.pk/files/Fruit%20and%20Vegetable%0Condiments%20of%20Pakistan%202018-19.pdf.

GoP, 2022. Government of Pakistan. Economic survey 2021-22. Finance Division. Economic Adviser's Wing, Islamabad. https://www.finance.gov.pk/survey/chapter_22/Highlights.pdf.

Gujarati, D.N., 2004. Basic econometrics: International edition. 3rd ed., Me Graw Hill Book Co., New York. pp. 47-50.

Huynh, V.K., 2014. Farmer perceptions and demand for pesticide use: A case study of rice production in the Mekong Delta, Vietnam. J. Ecol. Behaviour Stud., 6(11): 868-873. https://doi.org/10.22610/jebs.v6i11.546

Ishtiaq, S., W.A. Panhwar, S.A. Mehmood, I. Khatri and S. Ahmad. 2017. Population and incidence of pests on different tomato (*Lycopersiconesculentum* L.) varieties from district Mansehra Pakistan. J. Ent. Zool. Stud., 800(55): 800-803.

Juma, V.O., 2015. Effects of insecticide treated nets in the management of tomato pests and their impact on natural enemies and yield in Nairobi and Murang'a Counties. Msc. thesis. Kenyatta University.

Kasely, D.J. and K. Kumar. 1989. The Collection, Analysis and Use of Monitoring and Evaluation data. The World Bank, IFAD, FAO London: John Hophkins University Press.

Kaur K., K.K. Kapoor and A.P. Gupta. 2005. Impact of organic manures with and without mineral fertilizers on soil chemical and biological properties under tropical conditions. J. Plant Nutr. Soil Sci., 168(1): 117-122. https://doi.org/10.1002/jpln.200421442

Margaret, W., J.W. Mwangi, R.D. Kimenju, Narla, G.M. Kariuki and W.M. Muiru. 2015. Tomato management practices and diseases occurrence in Mwea. J. Nat. Sci. Res., 5(20): 2224-3186.

Naika, S., J.V.L. de Jeude, M. de Goffau, M. Hilmi and B. Van Dam. 2005. Cultivation of tomato. Production, processing and marketing, Agromisa/CTA. Revised edition.

Nashwa, S.M.A. and A.M.K. Abo-Elyousr. 2012. Evaluation of various plant extracts against the early blight disease of tomato plants under green house and field conditions. J. Plant Prot. Sci., 48(2): 74-79. https://doi.org/10.17221/14/2011-PPS

SMEDA, 2009. District profile Mansehra. Small and Medium Enterprises Development Authority, Ministry of Industries and

Production. Government of Pakistan.

Tonessia, C.D., F.E. Soumahin, B.M.A. Denise, N.Y.A. Toussaint, D.J. Marc, and Z.O.D. K.Y. Ju. 2018. Diseases and pests associated to tomato cultivation in the locality of Daloa (Côte d'Ivoire). J. Adv. Agric., 9: 1546–1557. https://doi.org/10.24297/jaa.v9i0.7935

Usman, J. and U.M. Bakari. 2013. Profitability of dry season tomato (Lycopersiconesculentum Mill.). Production in Fufore Local Government Area of Adamawa State, Nigeria. Int. J. Eng. Sci., 2(11): 113-117.

Wakil, W., G.E. Brust and T. Perring. 2018. Sustainable management of arthropod pests of tomato. J. Plant Prot. Res., 350-372.

Willis, N.O., N. Gideon, D.K. Nyamasyo, O. Washington, O. Miriam, C. Florence, K. Teresia and K.L. Eunice. 2018. Characteristics and production constraints of smallholder tomato production in Kenya. Sci. Afr., https://doi.org/10.1016/j.sciaf.2018.e00014