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Bibas Chaulagai
College of Natural Resource Management, Sindhuli, Nepal

Promise Shrestha
College of Natural Resource Management, Sindhuli, Nepal

Corresponding Author:
Bibas Chaulagai
College of natural resource management, Sindhuli Nepal

A review on economic impact of citrus greening on Mandarin production in Nepal

Bibas Chaulagai and Promise Shrestha

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Abstract
Citrus greening is found to be one of the most devastating diseases associated with three species of *Candidatus liberibacter*. The transmission takes place by Asian citrus psyllid and causes heavy yield loss in all type of citrus fruits especially on mandarin fruits. Destruction of many well established mandarin orchards by greening can be seen profusely in Nepal. It has reduced the mandarin productivity significantly on about 55 mandarin producing districts of Nepal. Yield was declined to around 9 Mt/ha from 12mt/ha in the course of only four years which might have gone very low if no proper control measures has been applied. Greening does not have any specific remedial therapy but application of various integrated management technologies can control the disease. Symptoms of greening can be seen on canopy as mottled leaves, on root system as reduced fibrous root, on fruits as lower juice quality and can be detected from external appearance of trees but the confirmation should be done through various laboratory tests. The disease had reached to almost all major mandarin producing districts and had affected farmers not only by reducing the production but also by decreasing fruit quality and increasing the management cost of mandarin. Greening can be controlled only by managing plants properly from seedling stage to fruiting period. High quality planting materials, application of essential fertilizers, nutrients and hormones, proper training and pruning, regular irrigation, pest management etc can reduce the effect of greening on mandarin. Citrus-Guava inter-cropping has also been found to give best result in vector reduction.

Keywords: Mandarin, productivity, citrus psyllid, greening, *Huanglongbing, Candidatus*

Introduction

Agriculture is the backbone of Nepalese economy contributing around 27% to the total GDP and employing about 65% of the total labor force (Chaulagai & Koirala, 2021). Fruit area shares only 5.75% around three million hectare cultivated land in Nepal. Among fruits, Citrus is one of the important agriculture sub-sector contributing nearly 17.27%of the total area among the fruits area in Nepal. It covers 28.3% of fruits area and 22.95% of total fruit production and shares about 3% of total fruit expert volume in 2020/21. It is a major fruit having significant place in the socio-economic wellbeing of Nepalese farmers (MOALD, 2021) [16]. Citrus is tropical or subtropical fruit grows well in temperature range of 15-30 °C with fairly distributed rainfall of 125-185cm (FAO & MOAC, 2011). The climatic condition of mid hill region (800-2000mas1) of Nepal from east to west is considered favorable for all types of citrus fruit production (Lama, 1998) [31]. Commercial cultivation of citrus in Nepal started only after 1970 (NCRP, 2010) [17]. Nepal produced 321188 mt of citrus in 2021 and ranked 43rd in the global citrus production. Although being high value product of Nepal with strong demand on international and domestic markets, citrus production is not sufficient and satisfactory to meet the demand of the country (Dahal *et al*., 2020) [6]. Remoteness, poor access to transportation, storage facilities and processing are bottleneck for the development of citrus industry. Among all the citrus fruits in Nepal, mandarin types of citruses occupy about 64% and 68% of total citrus growing area and production respectively according to recent statistics on agriculture (K. timilsina *et al*., 2019) [25].

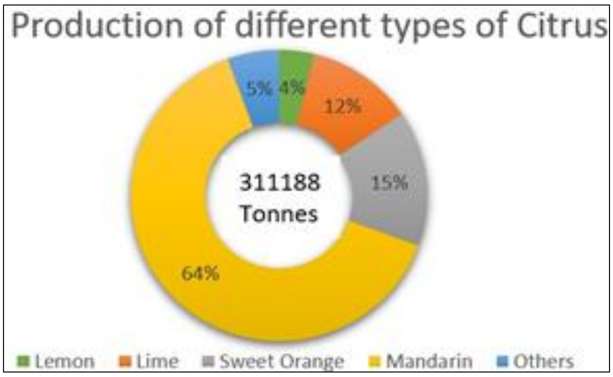

Fig 1: Production of different types of citrus fruits in Nepal (MOALD, 2022)

Mandarin variety of citrus is found indigenous to Nepal. According to Shrestha & Verma (1998) [32], native farmers of Darchula and Sankhuwasabha have claimed that their forefathers domesticated mandarin from wild form. Chinese travelers have also mentioned Nepal as 'The country of golden fruits' when they saw the yellow colour of mandarin fruits at ripening on the hills of Nepal (Lohar and Lama, 1997). Mandarin grows well with best colour and quality on subtropical region dominated with loamy or sandy loamy soil having pH range of 5.5 to 7.5. South facing slopes are found excellent for mandarin production as it gets profuse amount of sunlight there. Mandarin prefers more humid and tropical summer climate with warm winter and less rainfall than other citrus fruits. Nepal has wide scope of mandarin production and marketing as it has suitable climatic conditions and high demand all over the country. Mandarin is being cultivated in about 60 districts of Nepal among which Syangja, Tanahun, Salyan, Kavre, Gulmi, Gorkha, Udayapur, Sindhuli, Dhading, Kaski etc are the major mandarin producing districts. International market is also in favour of mandarin growing farmers but absence of suitable marketing strategy and integrated disease & pest management techniques are the bottleneck for economic development of mandarin farmers in Nepal. Kaini (2019) described that though Nepal has better climatic and edaphic conditions to grow mandarins compared to other south Asian countries, the productivity of mandarins is subsequently decreasing in Nepal.

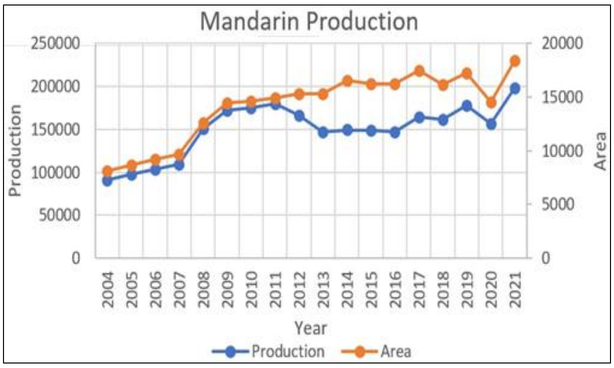

Fig 2: Mandarin Production trend in Nepal (www.fao.org)

Greening

Major reason for the declination of mandarin productivity in Nepal is Citrus greening disease. Citrus huanglongbing (HLB), also known as greening is the most devastating citrus disease in the world, posing a threat to the industry's long-term viability in major growing countries (Sheng *et al*., 2020) [23]. The disease was originated in Southern China more than a century ago, where it's named 'Huanglongbing' (HLB), or 'Yellow shoot disease' after its typical. HLB causes damage by sucking sap from the foliage and excreting sugary substance that covers the leaf with honeydew which then gets covered by sooty mold.

Although all citrus species could be affected by greening (Bove, 2006) [3]: sweet orange, mandarin and tangelo trees were severely affected while other species has displayed less pronounced symptoms. Roistacher (1996) has cautioned that "Greening will destroy citrus industry in Nepal slowly but surely if necessary measures are not taken in time" and also recommended implementation of certification programme in Nepal.

Causes

Citrus greening, a devastating disease is associated with three species of unculturable phloem limited bacteria; *Candidatus liberibacter asiaticus, Candidatus liberibacter africanus and Candidatus liberibacter americanus*. Among these three, the most common and responsible for citrus greening in Nepal is *Candidatus liberibacter asiaticus*. The bacteria are transmitted by an insect vector Asian citrus psyllid (*Diaphorina citri*).

Fig 3: Asian Citrus Psyllid. (Source: Citrus Pest and Disease Prevention Program)

The vector Asian citrus psyllid (ACP), *Diaphorina citri* (Hemiptera: psyllidae) is a small plant feeding insect with the size of an adult ranging from 2.7mm to 3.3mm long and identified by distinctive mottled brown wings and abdomen with three color ranges; gray/brown, blue/green and orange/yellow (S. Pokhrel *et al.*, 2021) [22]. Freshly deposited eggs are oval shaped and light-yellow colored while distinctive red eye spots are seen when matured (Hall *et al.*, 2013) [11]. The insects have five instars while docile early instars and mobile older nymphs and adults. The psyllid prefers lower altitude and hot & dry conditions (Hall *et al.*, 2007) [10]. So, the seedlings produced from the nurseries located below 1000-meter altitude are more susceptible to greening because the environment there favors the activity of ACP. Visible psyllids or waxy droppings is also seen during spring on infected trees.

History

Although no definite evidence of the origin of HLB disease is detected, it was observed as early as in 18th century in India. The disease was first thought to be associated with citrus tristeza virus but later suggested to be a citrus greening (Da Graca, 2008) [5]. According to Chen (1943), the clear symptoms of disease were first observed in 1938 whereas the insect vector *Diaphorina citri* was first described in 1927 (Husain and Noth, 1927) [12]. The disease was mostly detected and rapidly spreading during nineteenth century and now it has reached over 50 citrus producing countries of Africa, Asia, Europe, North America and South America (S. Pokhrel *et al.*, 2021) [22]. Citrus greening bacterium has been already found in seven of the world's top ten orange producing countries (Zhang *et al.*, 2019) [30].

China and India are among the first countries where HLB is reported (da Graca, 2008: Bove, 2008) [5, 33]. Researchers believe that HLB is transmitted in Nepal while importing the rootstocks from uttar pradesh, India. The disease entered in Nepal because of the weak quarantine regulations. The symptoms were reported for the first time in Nepal in Pokhara valley in 1968 (Thrower, 1986) [24]. According to research conducted in 1970, about 55% of the total trees sampled from the location of Pokhara to ranigaun were found to be infected by citrus greening. Presence of citrus psyllid, visual symptoms of disease and positive results of other confirmatory tests suggest that the disease has been reached to several significant citrus producing regions of Nepal (Regmi and Yadav, 2007) [20].

Symptoms

1. Symptoms associated with canopy

Blotchy mottle and yellow shoot; Blotchy mottling is one of the characteristic symptoms of citrus greening. Mottled leaves in HLB infected plants differ from other nutrient deficiency in such a way that yellowing is not symmetric among across the leaf midribs and usually crosses leaf veins (Halbert and Manjunath. 2004) [9]. Apart from mottling, infected leaves also become thicker, leathery and upright along with development of interveinal chlorosis. Midribs and lateral veins may sometimes become enlarged, swollen and corky (Bove, 2006) [3]. Off seasonal bloom and twig dieback are additional symptoms exhibited by infected shoots (Halbert and Manjunath, 2004) [9]. In advance stage of infection, it can eventually be accompanied by zinc deficiency making the leaves have on upright growth with close angle with the shoot (Bove, 2006) [3].

Fig 4: Greening infested plant canopy (Source: Citrus Pest and Disease Prevention Program)

1. Symptoms associated with roots

HLB generally affect fibrous root system. The bacterium colonizes root before showing symptoms infecting leaves (Johnson *et al.*, 2014) [13]. Loss of fibrous root is the major damage caused by HLB and the damage can be severe before any symptoms seen on canopy. Roots may also be starved led by the accumulation of food resources in the form of stored carbohydrates in the aerial parts inhibiting nutrient partitioning (Dala-Paula *et al.*, 2019) [7]. The symptoms of HLB are considered to be more apparent cooler seasons compared to warmer seasons (Dala-Paula *et al*. 2019, McCollum and Baldwin, 2017) [7, 15].

2. Symptoms associated with fruit and juice quality

Small, asymmetrical, lopsided fruit with thicker albedo is the characteristic symptom exhibited by greening affected fruit. Premature fruit drop is also common in HLB affected fruits (McCollum and Baldwin, 2017) [15]. Such fruits also show lower sugar level, higher bitter limonoids, flavonoids and terpenoid volatiles that results the lower juice content in fruits and also the off flavour of juice (Baldwin *et al*., 2018) [2]. Affected fruits are bitter and hard with small and dark aborted seeds. The fruits may remain green even when ripe.

Fig 5: Greening affected citrus fruit (Source: Citrus Pest and Disease Prevention Program)

Management

No remedial therapy is available as a cure of HLB. So, it's important to reduce transmission of the disease by controlling its vector (Yon *et al*., 2015) [36]. Since no single shot management technology is discovered yet for the disease, it's essential to practice integrated management strategies to maintain citrus health and sustain citrus production under HLB pressure (S. Pokhrel *et al*., 2021) [2]. HLB affected trees if not removed and managed in time, serves as the inoculum source. 15 minutes of feeding by psyllid is sufficient to transmit the causal agent of citrus greening to healthy plants (Hall *et al*. 2007) [10]. Integrated management techniques have been found better than any single technique application. Following are the commonly practiced management strategies:

1. Use of HLB Tolerant Citrus Rootstocks

Researchers suggest that the grafting of desired scion on the HLB tolerant rootstocks can be an effective HLB management strategy without addition of extra costs. Grafting desirable citrus varieties with the disease free and high-quality rootstocks was found to be efficient in controlling HLB infection along with other citrus diseases (Regmi *et al*., 2010) [21]. Some of the greening tolerant rootstocks suggested by various researchers are as Trifoliate mango (*Pancitrus trifoliata*), US-897, US-942. US-802 and US-812 are found to be moderately tolerant stocks to citrus greening (Albrecht and Bowman, 2012) [1]. Various indigenous citrus varieties commonly found in Nepal have already been proved to be tolerant to greening. Avoiding rootstock from below 1300masl has been proved to be the best measure to control greening in mandarin.

2. Irrigation and Nutrient Management

Greening affected trees bear weaker root system and have been found to have lower concentration of nutrients like potassium (K), calcium (Ca), magnesium (Mg), iron (Fe) etc. (Vasisth, 2016) [27]. To compliment such lower nutrient concentration, it has been found to be necessary to apply small doses of fertilizer (in leaves and roots) frequently in a regular basis to reduce potential nutrient leaching. According to Phuyal (2020) [34], Fertigation and controlled-release fertilizers are effective nutrient delivery methods. Foliar spray, root drench and trunk injection of antibiotics is effective management strategy (Puttamuk *et al*., 2014; Zhang *et al*., 2011) [19, 29].

3. Citrus Guava Intercropping

In Vietnam, Farmers has been practicing interplanting citrus and guava together and the mandarin orchards planted with guava showed lower infestation of psyllid and also low incidence of greening compared to those orchards lacking guava (Hall *et al*., 2007) [10]. International research center showed that inter planting citrus with guava reduced infestations of Asian citrus psyllid and ultimately HLB (Beattie *et al*., 2006) [35]. In reference with Gottwald (2007) [8], the normal life span of sole citrus tree in Vietnam is 2 to 4 years but those inter planted with guava are surviving up to 15 years. The mechanism by which guava as intercrop reduce the psyllid population is still unknown but it has been postulated that it could be due to the physical/mechanical disruption on host recognition, chemical alteration of volatile compounds emitted by citrus reacting with guava compounds.

4. Management of Vector

The Asian citrus psyllid is reported to be spread from eastern to western borders of citrus producing areas of Nepal (Regmi *et al*., 2010) [2]. Use of yellow sticky traps and application of intensive insecticides at peak citrus flushing period is found to be necessary to achieve reduced population of ACP (Hall *et al*., 2013) [11]. Rotations of pesticides with different mode of actions should be considered to prevent psyllids from developing resistance against the used pesticides (Tiwari *et al*. 2011) [26].

Improper use of insecticides for the control of pus may cause negative environmental impact. The alternative management strategy to chemical management is biological control that reduce the harmful effect of various chemicals to natural enemies and parasitoids. Some native parasitoids of Asia such as *Tamarixia radiata* and *Diaphorencyrtus aligarhensis* are found to attack and control ACP (Hall *et al*., 2013) [11]. Pathogenic fungi like *Cladosporium spp*, *Capnodium Citrix* etc have been used for biological control of *D. citri* since a long time (Hall *et al*. 2013; S. Pokhrel *et al*., 2021) [11, 22].

The first line of defense for the management of ACP and HLB is restricting the movement of infested plants and quarantining areas where the pests are abundant (Hall *et al*.,

2013) [11]. In Nepal, about 30 km of separation distance was found to be sufficient (Manjunath, 2004) [9]. New orchards should be established at least 3 km away from infected areas. According to DOA (2011), citrus growing regions all over the Nepal are impacted by HLB. Lack of proper internal quarantine and open border with India and China are major problems causing the flow of uncertified plant materials in and out of the country.

Fig 6: Isolation of HLB affected citrus treed. (Source: PMAMP, Sindhuli)

Economic impact

Citrus greening is one of the most devastating diseases that spreads rapidly throughout the tree canopy and in the orchard, reducing the economic life of affected trees (Bove, 2014) [4]. HLB is limiting factor to citrus production. Millions of hectares of citrus orchards in China (Li *et al*. 2020) [14] and many million hectares of citrus producing area throughout the world has been damaged by the disease. Thailand has been suffering from HLB and has a large impact on citrus production since 1960s. According to Roistacher (1996), Farmers have lost $1.482 per acre at the end of 8 years by HLB in Thailand. In reference with Aubert (1992). In Thailand. 3 million adult trees and much higher number of younger nursery plants were found infected by HLB in a single decade after 1960 (Gottwald *et al*. 2007). In Philippines, citrus plantations were estimated to cover 25,000 hectares but 10 years later 5 million trees were found affected and the citrus planted area was reduced by 40%. In the state of Florida, Orange production is reduced by 23% during 2006 and 2010 (Hodges and Spreen, 2012). Additional production of around $800 per acre is required for the proper management of HLB in Florida (Freshplaza, 2014). To prevent the spread of HLB, about 600,000 adult trees and 2,500,000 saplings from 320 nursery owners were destroyed in just two years after the detection of HLB in Paraguay in 2013 costing about one million US$ to Government as compensation for destroyed trees (Freshplaza, 2014). The market demand of greening affected fruits and juice is very low being less sweet and less orange flavoured. Processing industries are also suffering from the disease.

Mandarin and sweet orange variety of citrus has been found to be more susceptible to HLB. Citrus greening has been a major challenge for citrus growers in Nepal (Poudel *et al*., 2022) [18]. Roistacher (1996) has cautioned that “Greening will destroy citrus industry in Nepal slowly but surely, if necessary, measures are not taken in time” and also recommended implementation of certification programme in Nepal. Productive orchard size has been declined from 69.56% to 58.52% in last 12 years period (MOALD, 2021) [16]. According to Regmi (1982), 40-70% trees were infected in Thailand and Nepal in past years. As growers need to rely on various management techniques and integrated management in order to maintain the trees health and longevity, those management strategies have very high cost associated with them (Li *et al*., 2020) [14]. The disease has been discovered from several economically important citrus growing districts in Nepal resulting significant yield losses (Pokhrel *et al*., 2020) [22]. Early researchers revealed that HLB has been reported from most of the citrus growing districts in Nepal namely kaski, Tanahun, Gorkha, Syangja, Dhading, Kavre, Dhankuta (FAO, 2011). Positive result obtained from the recently submitted samples from Khotang, Sindhuli, Dailekh and Kailali districts proves the presence of greening in these districts too (Poudel *et al*., 2022) [18]. At present, the disease has been found prevalent in around 69 citrus producing districts of Nepal. Research conducted in 1980s revealed that almost 100% citrus trees of horticulture research station Malepotan were infected by HLB. Kaini (2019) described that though Nepal has better climatic and edaphic conditions in Nepal to grow mandarins compared to other South Asian countries, the productivity of mandarins is subsequently decreasing in Nepal. The productivity of mandarin has significantly decreased by greening as shown in graph below:

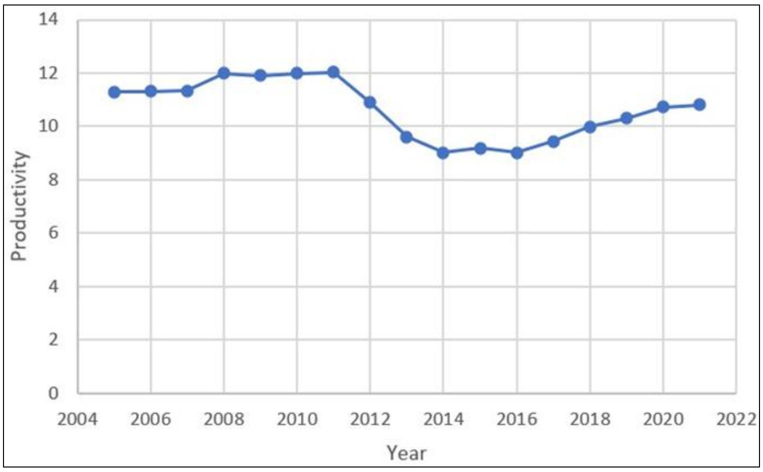

Fig 7: Mandarin Productivity Trend in Nepal (FAOSTAT, 2022)

Conclusion

After analyzing the trend of production and acreage of mandarin fruit in Nepal from 2004, It's clearly concluded that the average and productive area of mandarin is continuously increasing year by year since beginning. But the role of increasing acreage has not played significant role in productivity. The maximum productivity of mandarin is found to be 12.04mtha^{-1} in year 2011 and the minimum yield recorded was 9.03mtha^{-1} in the year 2014 &2016. Although, various factors had promising roles on the declination of mandarin productivity after 2011, citrus greening is found to be the most major cause to reduce the yield of mandarin. Although, greening was prevalent from late 20s, it started to show its major effects after 2011 when farmers started applying pesticides improperly and destroyed hundreds of hectares of mandarin orchards in many potential districts of Nepal. At its peak period, productivity was reduced to 9.03mtha^{-1} in 2014 and 2016. The peak period didn't remain for very long time as the farmers and stakeholders immediately started to apply various integrated technology to control greening. And after applying control measures i.e. proper quarantine, proper management and disease-free germplasm, the mandarin orchards again started to flourish after 2016 but also it takes decades to replenish the destruction done by greening on its peak period.

Reference

1. Albrecht U, Bowman KD. Transcriptional response of susceptible and tolerant citrus to infection with *Candidatus liberibacter asiaticus*. Plant Science. 2012;185:118-130. DOI:10.1016/j.plantsci.2011.09.008
2. Baldwin E, Plotto A, Bai J, Manthey J, Zhao W, Raithore S, *et al*. Effect of abscission zone formation on orange (*Citrus sinensis*) fruit/juice quality for trees affected by Huanglongbing (HLB). Journal of Agricultural and Food Chemistry. 2018;66:2877-2890. DOI: 10.1021/acs.jafc.7b05635.
3. Bové JM. Huanglongbing: A destructive, newly-emerging, century-old disease of citrus. Journal of Plant Pathology. 2006;88:7-37. DOI:10.2307/41998278.
4. Bové JM. Huanglongbing or yellow shoot, a disease of Gondwanan origin: Will it destroy citrus worldwide Phyto parasitica. 2014;42:579-583. DOI:10.1007/s12600-014- 0415-4.
5. Da Graça JV. Biology, history and world status of Huanglongbing in I Taller Internacional sobre Huanglongbing de los cítricos (*Candidatus Liberibacter spp.*) el psílido asiático de los cítricas (*Diaphorina citri*) (Hermosillo); c2008. p. 1–7.
6. Dahal S, Shrestha B, Bista B, Bhandari D. Production and trade Scenario of Citrus Fruits in Nepal. Food & Agro-business Management (FABM). 2020;1(1):47-53.
7. Dala-Paula BM, Plotto A, Bai J, Manthey JA, Baldwin EA, Ferrarezi RS, Gloria MB. Effect of huanglongbing or greening disease on orange juice quality, a review. Frontiers in Plant Science. 2019, 9. DOI: 10.3389/fpls.2018.01976
8. Gottwald TR, Da Graca JV, Bassanezi RB. Citrus huanglongbing: The pathogen and its impact. Plant Health Prog. 2007;6:1-18.
9. Halbert SE, Manjunath KL. Asian citrus psyllids (Sternorrhyncha: Psyllidae) and greening disease of citrus: A literature review and assessment of risk in Florida. Florida Entomologist. 2004;87:30-353. DOI: 10.2307/3496747
10. Hall DG, Lapointe SL, Wenninger EJ. Effects of a particle film on biology and behavior of *Diaphorina citri* (Hemiptera: Psyllidae) and its infestations in citrus. Journal of Economic Entomology. 2007;100:847-854. DOI: 10.1603/0022-0493(2007)100[847: EOAPFO]2.0.CO;2
11. Hall DG, Richardson ML, Ammar ED, Halbert SE. Asian citrus psyllid, *Diaphorina citri*, vector of citrus huanglongbing disease. Entomologia Experimentalis et Applicata. 2013;146:207-223. DOI: 10.1111/eea.12025
12. Husain MA, Nath D. Memoirs of the department of agriculture in India. Agriculture Research Institute, Pusa, Government of India; c1927.
13. Johnson EG, Wu J, Bright DB, Graham JH. Association of '*Candidatus liberibacter asiaticus'* root infection, but not phloem plugging with root loss on huanglongbing- affected trees prior to appearance of foliar symptoms. Plant pathology. 2014;63:290-298. DOI: 10.1111/ppa.12109
14. Li S, Wu F, Duan Y, Singerman A, Guan Z. Citrus greening: management strategies and their economic impact. Hortscience. 2020;1:1-9. DOI: 10.21273/HORTSCI14696-19
15. McCollum G, Baldwin E. Huanglongbing: devastating disease of citrus. Horticultural Reviews. 2017;44:315-361. DOI: 10.1002/9781119281269.ch7

16. MoALD. Statistical Information on Nepalese Agriculture (2075/76). Ministry of Agriculture and Livestock Development, Singhdurbar, Nepal; c2021.
17. NCRP. Annual Report of 2067/68. National Citrus Research Program, Paripatle, Dhankuta; c2010.
18. Poudel A, Sapkota S, Pandey N, Oli D, Regmi R. Causes of Citrus Decline and its Management Practices Adopted in Myagdi District, Nepal; c2022. Available at SSRN: https://ssrn.com/abstract=4039649 or http://dx.doi.org/10.2139/ssrn.4039649 https://papers. ssrn.com/sol3/papers.cfm?abstract_ id=4039649
19. Puttamuk T, Zhang S, Duan Y, Jantasorn A, Thaveechai N. Effect of chemical treatments on '*Candidatus liberibacter asiaticus'* infected pomelo (*Citrus maxima*). Crop Protection. 2014;65:114-121. DOI: 10.1016/j.cropro.2014.07.018
20. Regmi C, Yadav BP. Present status of Huanglongbing in western district of Nepal. In Proc 4th Hort. Seminar, Jan (18-19); c2007.
21. Regmi C, Devkota RP, Paudyal KP, Shrestha S, Ayres AJ, Murcia N, *et al*. Shifting from seedling mandarin trees to grafted trees and controlling huanglongbing and viroids: a biotechnological revolution in Nepal. Paper presented at the International Organization of Citrus Virologists Conference Proceedings; c2010. p. 1957-20100. DOI: 10.5070/C54F74W8P0
22. Pokhrel S, *et al*. Int. J Appl. Sci. Bio technol. 2021;9(4):227-238. DOI: 10.3126/ijasbt.v9i4.40805
23. Sheng L, Feng W, Yongping D, Ariel S, Zhengfei G. Citrus Greening: Management Strategies and Their Economic Impact. Hort Science. 2020;55(5):604-612. https:// doi.org/10.21273/HORTSCI14696-19
24. Thrower LB. Report on visit to Nepal. FAO report P:T51; c1986.
25. Timilsina K. Combating the Ravaging Huanglongbing Disease by Controlling ACP to Secure the Future of Citrus Growers in Nepal: A Review. Open Acc J Agri Res: OAJAR-100022; c2019.
26. Tiwari S, Mann RS, Rogers ME, Stelinski LL. Insecticide resistance in field populations of Asian citrus psyllid in Florida. Pest Management Science. 2011;67:1258-1268. DOI: 10.1002/ps.2181
27. Vashisth T. Managing the health and productivity of HLBaffected groves. EDIS; c2016. DOI: 10.32473/edis-pp328-2016
28. Yan H, Zeng J, Zhong G. The push–pull strategy for citrus psyllid control. Pest Management Science. 2015;71:893-896. DOI: 10.1002/ps.3915
29. Zhang M, Powell CA, Zhou L, He Z, Stover E, Duan Y. Chemical compounds effective against the citrus; c2011.
30. Zhang C. Citrus greening is killing the world's orange trees. Scientists are racing to help. Chemical & Engineering News on June 9. 2019, 97(23).
31. Lama RD, Bodziony J. Management of outburst in underground coal mines. International Journal of Coal Geology. 1998 Feb 1;35(1-4):83-115.
32. Shrestha PP, Verma SK. Development and outlook of citrus industry in Nepal. In Proceedings of the 2nd National Horticulture Workshop 1998 Jan 19.
33. Bove R, Ubertini S, editors. Modeling solid oxide fuel cells: methods, procedures and techniques. Springer Science & Business Media; 2008 Apr 20.
34. Phuyal N, Jha PK, Raturi PP, Rajbhandary S. Total phenolic, flavonoid contents, and antioxidant activities of fruit, seed, and bark extracts of Zanthoxylum armatum DC. The Scientific World Journal. 2020 Mar 16;2020.
35. Beattie* PE, Lewis- Jones MS. A comparative study of impairment of quality of life in children with skin disease and children with other chronic childhood diseases. British Journal of Dermatology. 2006 Jul 1;155(1):145-51.
36. Yon J, Bescond A, Liu F. On the radiative properties of soot aggregates part 1: Necking and overlapping. Journal of Quantitative Spectroscopy and Radiative Transfer. 2015 Sep 1;162:197-206.