



Yield Constraints of Sikkim Mandarin (*Citrus reticulata*) and Possible Management Strategies: A Review

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Review Article

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ABSTRACT

The Sikkim Mandarin (*Citrus reticulata*) is one of the most important fruit crops of Sikkim for ages. The valleys of the Tista and Rangeet rivers and their tributaries of Sikkim and the adjoining Darjeeling district of West Bengal offer an ideal Himalayan climate for the cultivation of Sikkim Mandarin. Analysis shows that during 2020-21 Sikkim produced 26.65 MT of mandarin from 13.26 thousand hectares of land with a productivity of 2.01MT /ha. It was seen that there had been an increase of 1.68-thousand-hectare area in 2020-21 from 2014-15 producing an additional 7.66MT. However, while area and production have increased, productivity has plummeted by 38.69 per cent over the period from 2014-15 to 2020-21. Due to multiple reasons, poor returns from the citrus orchards have ushered farmers' unwillingness to invest in mandarin. The constraints like declining soil productivity and non-adherence to soil amelioration measures, the incidence of pests and diseases like the fruit fly, and citrus dieback etc, and lack of marketing channels and proper storage as well as preservation units are a few to name. There is a need of increasing productivity to maintain the glory of the species. The major strategy/approach would be to manage the basic

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problem which is the nutritional management of the cropping area. Studying the soil and scientifically managing it alone may wipe -off basic problems like the incidence of some pests and diseases and soil nutrient depletion. Taking other appropriate measures to control pests and diseases should be the next important strategy. Finding the loopholes in the storage and marketing of Sikkim Mandarin and defining appropriate strategies to mitigate those remain the major scope of this study. This review is based on available secondary data and observations made on farm visits.

Keywords: Sikkim mandarin; yield decline; nutritional management; citrus; pest and diseases; storage; marketing.

1. INTRODUCTION

Sikkim Mandarin represents the most important commercial fruit of Sikkim. Citrus growing belts come under the heavy rainfall zone, hence the valleys of the Tista and Rangeet rivers and their tributaries of Sikkim and the adjoining Darjeeling district of West Bengal offer an ideal Himalayan climate for the cultivation of Sikkim Mandarin. Mandarin prefers subtropical humid climates with high rainfall and grows well under sub-mountainous tracts with rainfall ranging from 85-300 cm uniformly distributed from March to November and temperatures ranging from 10 -35 °C are suitable for mandarin cultivation. However, the fruit becomes poor in keeping quality and taste under high rainfall [1]. The important mandarin-producing areas of Sikkim are within the elevation range of 600 to 1500 m AMSL. Tashiding, Gyalshing, Omchung, Tijyah, Lingchom, Bermiok, Barthang, Rinchenpong, Chinthang, Chakung, Zoom, Timberbong, Karthik in the West district; Kewzing, Lingmoo, Sangmoo, Yangyang, Payong, Rateypani, Namthang, Tarku, Tokal-Bermiok, Turuk, Sumbuk

in the South district; Nazitam, Sang, Simiklingy, Khamdong, Sirwani, Samdong, Dikchu in the East district and Lum and Hee-Gyathang in the North district of Sikkim are the important mandarin growing areas of Sikkim (Table 1).

A decade ago the mandarin growers of the state earned a decent living from their mandarin orchards. Unfortunately, the production of mandarin has shrunk drastically because of several biotic and abiotic factors [2]. Table 1 shows the comparative analysis of the area, production, and productivity of mandarin from 2014-2021 where it is observed that during 2020-21 the state produced 26.65 MT of mandarin from 13.26 thousand hectares with a productivity of 2.01MT /ha. Over the last seven years, there is an increment of 1.68-thousand-hectare area by 2020-21 producing an additional 7.66 MT [20]. However, while area and production have increased due to area expansion, productivity has plummeted by 38.69 per cent. The productivity of Mandarin also registered lowest among all the Northeastern states during 2020-21.

Table 1. Important citrus clusters of Sikkim

Sl.	Districts	Clusters	Total
	West	Tashiding, Gyalshing, Omchung, Tijyah, Lingchom,	5
2	South	Kewzing, Lingmoo, Sangmoo, Yangang, Payong, Rateypani, Namthang, Tarku, Tokal- Bermiok, Turuk, Sumbuk	12
3	East	Nazitam, Sang, Simiklingy, Khamdong, Sirwani, Samdong	6
4	North	Dikchu and Hee-Gyathang	2
5	Pakyong	Included in east clusters	
6	Soreng	Bermiok, Barthang, Rinchenpong, Chinthang, Chakung, Zoom, Timberbong, Karthok	8
Total			33

Table 2. Comparative analysis of area production and productivity of mandarin from 2014-2021

Sl.	Crops	2014-15			2020-21			Analysis					
		A	P	AY	A	P	AY	+/- A	pc	+/- P	pc	+/- AY	pc
1	Mandarin	11.58	18.99	3.28	13.26	26.65	2.01	1.68	14.48	7.66	40.3	-1.27	38.69
2	Other fruits	6.01	7.42	1.24	6.88	24.04	3.5	0.86	14.37	16.61	224	2.25	64.47
3	Total fruits	17.59	26.42	3.13	20.13	50.69	2.5	2.54	14.44	24.27	91.9	-0.61	-24.29

A=area in '000 ha P=production in '000 mt AY=productivity in mt/hac

Production constraints of mandarin in Sikkim:

Poor returns from the citrus orchards due to the influence of multiple factors have ushered in unwillingness among the farmers to invest any more in mandarin. The problems like fruit fly infestation, citrus decline, citrus greening, fruit drop and citrus dieback are limiting the production of quality mandarin. The sub-optimal productivity of citrus orchards in the region is attributed to several factors:

1. The onslaught of unpredictable and incessant pre-monsoon rainfalls due to climate change has affected the timely flowering in the orchards [26]. Singh et al., 2017 in their study found unpredictable rainfalls to be a major cause of decline in productivity of Sikkim Mandarin.
2. Heavy rainfall erodes fertile topsoil leaving behind dead unproductive soil devoid of the essential plant nutrients to support vegetation [23] (Meena et al., 2019).
3. Severe infestation of insect pests and diseases like Tristeza and citrus greening [3]
4. Rampant use of diseased seedlings as a plant material leads to citrus decline [25].
5. Soil fertility constraints induced by soil pH and EC leads to decline in mandarin production. Soil pH should be between 5.5 to 6.5. Lack of proper and timely liming practices leads to faulty pH and hence non availability of essential nutrients. At very acidic pH tree size and yield reduced substantially due to toxic effect of Al^{3+} and H^{+} ions [12].
6. Absentee ownership pattern of citrus orchard leading to negligible to zero management practices and zero input [24].
7. Insufficient availability of quality planting material [4].
8. Nutrient deficiencies and poor soil management could be the two factors as described by Brahma et al. [4].
9. Intercropping with nutrient-exhaustive crops leads to reduction in yield. Many researchers have come up with this conclusion when they experimented different options for intercropping [5].
10. Incidence of diseases and pests [6] is a major cause of decline in Mandarin production.

11. Shortage of storage facility, post-harvest processing and marketing network play a barrier to take improved strategies for production increase [7,8,22]

Management Strategies:

1) Soil fertility management decisions:

Scientific soil management alone will solve many production constraints in mandarin. Citrus is shallow-rooted and requires a well-aerated, free-draining soil that is high in organic matter. The soil should be between pH 5.5 to 6.5 [9]. A pH value below 5.5 (acid) or above 8 (alkaline) reduces access to essential soil minerals and causes problems. So, soil testing should be prioritized before the application of amendments. Soil test done annually is still the ideal recommendation for tracking soil nutrient budget. Proper soil tests will help ensure the application of fertilizer to meet the requirements of the crop while taking advantage of the nutrients already present in the soil. It will also determine lime requirements and can be used to diagnose problem areas. The sampling technique must be correct, as the results are only as good as the samples themselves.

2) Application of organic amendments:

Organic waste amendments, such as farmyard manure (FYM), green manures, poultry manure, pig manure, biochar, crop diversification etc., are usually used as an alternative to lime application for the reclamation of acid soil infertility and build-up of depleted soil organic matter. External application of animal manure has been reported to increase soil pH and decline Al toxicity in acid soil [10] (Naramabuye & Haynes, 2006). Animal manures also supply the crops with available N P and K and improve the Physicochemical and biological properties of soil.

3) Growing acid-tolerant crop varieties:

Growing acid-tolerant crop varieties is another option. With the promotion of genotypes and/or varieties relatively tolerant to soil acidity, there is a possibility that farmers may get 2 to 3 times of crop yield as compared to the yield that they are getting now.

4) Crop diversification is very important for preserving soil health and ecosystem sustainability as well as crop productivity. Intercropping with

herbaceous crops in monocultural woody crops can provide both environmental and economic advantages. while intercrops may involve additional production costs, the correct choice of intercrops can reduce the market risks for farmers [11] (Shigure, P.S. 2012) [28] reported that the Nagpur mandarin + soybean intercrop followed by gram resulted in a maximum yield of Nagpur mandarin i.e. 20.0 tonnes per hectare. High soil moisture was observed in intercrops of soybean and groundnut.

- 5) **Liming:** Out of the total 0.7096 million hac geographical areas of Sikkim 0.6 million hac of the soils of Sikkim are acidic ranging from strong to moderately acidic [12]. Since mandarin grows well in a pH range of 6.0 to 6.5 the application of lime is the most desirable and effective practice for the amelioration of soil acidity to enhance nutrient availability and solubility of most of the plant nutrients. Lime should be applied to raise the soil pH but it should be strictly based on soil test results.

2. Pest and Disease management:

Application of Indigenous Technical Knowledge (ITK) in pest and disease management of different crops is practiced since time immemorial. The ITKs are eco-friendly and compatible with other management practices also.

- 1) Painting lime on the trunk of mandarin plants infected with gummosis (*Phytophthora spp.*), bark-eating caterpillars, and trunk borer is a common but effective technique (Gopi et al., 2016).
- 2) The use of kerosene for the management of trunk borer and stem borer in mandarin has been another effective technique [13].
- 3) Fish-washed water is applied at the base of the lemon tree to control the Citrus trunk borer [13]. The smell of the fish water act as a repellent for the insect [14].
- 4) Application of Lime powder at the base at a distance of 6 inches from the root zone area in plants like lemon, orange, chilli etc. can control snails, ants, mites etc [13].

- 5) The hole made by borer is plugged using mud or cow dung after applying kerosene. Cow dung is mixed with mud and painted on the trunk of the tree to avoid trunk-borer and bark-eating caterpillars. Gopi et al. [25] reported the effect of cow urine in the management of fruit borer and leaf beetle (*Epilachna vigintioipunctata*) due to its repelling activity.
- 6) The fruit fly infected mandarin fruits are collected in big drums upon falling on the ground. The chemicals formed during the fermentation of fruit juice exterminate the fruit fly larvae [15].
- 7) Placing the nest of the weaver ant (*Oecophylla maragadina*) on the citrus plant to manage trunk borer and defoliators has a base in the technology of hunting and killing the insect which is potentially harmful to the citrus plant [16]. The use of yellow colour traps in mandarin orchards throughout the year has been advocated by Yadav et al. [1] to control aphids, leaf miners and psylla.
- 8) Farmers in Sikkim use certain plant materials like titeypati (*Artemisia vulgaris*), chilouney (*Schima wallichii*) banmara (*Ageratina adenophora*), neem (*Azadirachta indica*), lantana (*Lantana camara*), datura (*Datura stramonium*) for protection of plants from pests and diseases.

In a fully organic state like Sikkim, the adoption of ITK-based crop protection measures will assist in restoring the biodiversity of natural enemies. So, the need of the hour is to combine ITKs with packages and practices to boost the productivity of Mandarin in Sikkim.

3. Marketing and Storage:

Organic products are often inaccessible to the consumers because of inadequate production volume and insufficient marketing chain. Farmers depend on middlemen for the sale of their products, often at exploitatively low prices as the middleman do not give preferential prices for organically produced crops. The whole sellers and retail shopkeepers purchase the goods unfairly at minimum prices as they always have the option to procure foods and veggies from farms outside the state at much lower rates. Local farmers simply cannot afford to sell their produce at lower rates even then they have to make distress sales fearing a loss in goods quality. Therefore, some are seriously

contemplating adopting an alternate career [27]. The import of conventional produce from neighbouring states hampers the organic market in Sikkim [17]. It is obvious that there is shortage of outlets /market yards for the farmers to display their farm produce in the state markets. The haat bazaars (weekly markets) provide space for the farmers to sell their produce only once a week. The farmers are usually restricted from displaying their products on weekdays citing one reason or the other. Consequently, there is a huge intra-competition among the producers on haat day to sell their products in the retail sale. Since fruits and veggies are highly perishable items, the farmers hurry to dispose of their product and ultimately, they fall prey to the wholesale purchasers who offer peanut rates whereas, the retailers sell the same product at an exorbitant price. In Mandarin, it is very important to maintain temperature. The recommended minimum safe temperature for mandarin storage is 5–8°C [18]. Furthermore, the agri-entrepreneurs manufacturing value-added products also encounter difficulties in finding regular and assured markets due to a lack of infrastructure. Failure to reach premium organic markets has diluted the very objective of the organic mission [8]. There are only two marketing agencies devoted to agricultural marketing in Sikkim viz., NERAMAC and SIMFED. who procures agro-horticulture products directly from the farmer groups, SHGS, MPCs, NGOs and GPUS in remunerative prices for organic products like mandarin to help the growers of Sikkim. [29] (Horticulture Dept, State Portal-Sikkim). High transportation cost is one of the deterrent for the producer to access better market and fetch higher price [7].

Farmer organizations can also play a significant role in the promotion of organic agriculture [19,30]. Recently emerged around thirty FPOs are registered which are helping the farmers in production and marketing activities Considering the above problems and situations faced by the farmers few recommendations are made which will benefit both producers and consumers alike [31].

1. Emphasis on Post-harvest management ensuring quality production and post-harvest management of entire state agri-horti products and promoting its sale to high-end customers of the state and abroad would play a key role.
2. Stringent laws can be enforced through legislation to make it mandatory for retail

fruit and vegetable sellers to purchase and display at least 40 percent of their fresh food items from local farmers.

3. Fixation of minimum wholesale, as well as retail purchase price based on the cost of cultivation is need of the hour.
4. Directives may be issued for Restaurants, hotels, and homestays in Sikkim to include dishes prepared using local agri-horti products.
5. Keeping a vigilant eye on the import of fruits and vegetables from outside the state and Levi inter-state import tax will contain influx of fruits and vegetables from farms outside.
6. The cooperatives can bargain for better prices and collectively arrange necessary infrastructures crucial for storage and the market chain [21].
7. The government and the FPOs can initiate the formation of a marketing board and market products and boost consumption.
8. A regular collection of market information assisting the government in making policy decisions will add value.
9. Construction of additional retail sale outlets in panchayats and municipal wards, in the urban, peri-urban areas, and national as well as state highways can mitigate the lack of spaces to sell vegetables.
- 10 The government should extend support in the packaging of the organic produce of the farmers to help producers to prevent loss.
- 11 Mobile refrigerated vans can be engaged to cart fruits and vegetables in the densely populated area of the state.
- 12 Sensitization programs for citizens about the effect of consuming fruits and vegetables treated with inorganic fertilizer and pesticides on

Recently there is a ray of hope with the agriculture and horticulture department constructing storage godowns at Rangpo, Majhitaar and Namli and other places. Quite a few refrigerator vans are also run by SIMFED.

2. CONCLUSION

Production of Sikkim mandarin is affected drastically by biotic and abiotic factors. Impediments in storage and marketing are also making the situation difficult. It would be prudent to address the underlying problems and increase the productivity of mandarin to regain

the past glory of the fruit. Soil testing and nutrient management, phyto-sanitation, collective efforts in pest management and cooperation in marketing will go a long way in achieving optimum productivity from orchards on marginal land.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Yadav A, Kalita H, Gpo R, Kumar A, Lepcha B. Handbook of organic crop production in sikkim. jointly published by Sikkim organic mission, government of Sikkim, Gangtok, Sikkim and ICAR Research Complex for NEH Region, Sikkim Centre, Sikkim, India. 2014;161-171.
2. Md. Jahir Uddin, Md. Alamin, Amimul Ahsan, Mamun Hossain SAA, Abdullah Al Faruq SM. Soil erosion due to rainfall in plane and inclined surfaces. Journal of Advance civil Engg. Practices and Research. 2015;1(1):3-10.
3. Halbert Susan E, Manjunath Keremane L. Asian Citrus *Psyllids sternorrhyncha*: Psyllidae) and greening disease of citrus: A literature review and assessment of risk in Florida. Florida Entomologist. 2004; 87(3):330-353.
4. Sanchita Brahma, Rupak, Kr. Nath, Kishore Kr. Roy, Ranjit Sarma, Perves Ahmed. Production constraints faced by mandarin cultivators in Kokrajhar District of Assam-A Case Study. Int. J. Curr. Microbiol. App. Sci. 2020;9(6):81-85.
5. Muhammad Aasim Ejaz Muhammad Umer Abdul Karim. Yield and competition indices of intercropping cotton (*Gossypium hirsutum* L.) using different planting patterns. Tarim Bilimleri Dergisi. 2008; 14(4):326-333.
6. Anit Poudel, Sabina Sapkota, Nabin Pandey, Dipesh Oli, Rajiv Regmi. Causes of citrus decline and its management practices adopted in Myagdi District, Nepal.Heliyon. 2022;8(7).
7. Garg Irina, Hema Yadav Hema, Jairath MS. Marketing. strategies for organic produce of Sikkim. Report submitted to Sikkim Organic Mission Govt. of Sikkim.CCS National Institute of Agricultural Marketing. Government of India; 2017.
8. Gurung R. Sikkim organic mission- role for farmer producer Organisations Indian Journal of Hill Farming. 2020;139 -144.
9. Kinley Tsheringl, Yeshe Zangpo, Pema Chofil, Tashi Phuntsho, Ugyen Dorji. Assessment of soil nutrients status of mandarin orchards in Dagana Bhutanese Journal of Agriculture. 2020;2(1):73-86 .
10. Tang Y, Zhang H, Schroder J, Payton EM, Zhou DM. Animal manure reduces aluminum toxicity in an acid soil. Soil Science Society of America Journal. 2007;71(6). Available:10.2136/sssaj2007.0008
11. Gorriz MB, Zabala JA, Sánchez-Navarro V, Gallego-Elvira B, Martínez-García V, Alcon F, Maestre-Valero JF. Intercropping practices in mediterranean mandarin orchards from an environmental and economic perspective. Agriculture. 2022;2:574.
12. Ganeshamurthy AN, Kalaivanan D, Satisha GC. Management of vegetable crops in acid soils of india. Innovations in Horticultural Sciences, New India Publishing Agency, New Delhi, India. 2016;559-584.
13. Gohain S, Neog M, Bhattacharyya HC. Innovative traditional pest management practices in horticultural crops, Asian Agri-History. 2019;23(1):61-64.
14. Deka MK, Bhuyan M, Hazarika LK. Traditional pest management practices of Assam, Indian Journal of Traditional Knowledge. 2006;5(1):75-78.
15. Gopi R, Avasthe RK, Kalita H, Kapoor C, Ashish Yadav A, Babu S, Das SK. Traditional pest and disease management practices in Sikkim Himalayan Region International Journal of Bio-resource and Stress Management . 2016;7(3):471-476.
16. Barzman MS, Mills J, Thu Cue N. Traditional knowledge and rational for weaver ant husbandry in the Mekong delta of Vietnam. Agriculture and human value. 1996;13(4):2-9.
17. Das J, Bhattacharyya D. An enquiry into the challenges of organic farming in Sikkim. Business Studies. 2018;XXXIX (1 & 2):105-112.
18. Zipora Tietel, Lewinsohn Efraim, Elazar Fallik, Ron Porat. Importance of storage temperatures in maintaining flavor and quality of mandarins.Postharvest Biology and Technology. 2012;64(1):175-182.
19. Singh S. Crisis and diversification in Punjab agriculture: Role of state and

- agribusiness. Economic and Political Weekly. 2004;5583-5590.
20. Government of Sikkim. Official Website of Government of Sikkim. Available: <https://sikkim.gov.in/departments/food-security-and-agriculture-development-department/storage>
 21. Henahan B. Cooperating for sustainability, USA: Cornell University; 1997.
 22. Lal D, Basha MB, Ivanov D. Indian consumer buying behaviour towards organic foods: Empirical evidence. In Proceedings of the 2019 2nd International Conference on Computers in Management and Business. 2019;14-18. ACM.
 23. Narendar Kumar Meena, Ramavtar Gautam, Pravat Tiwari, Prasant Sharma Soil nutrient loss through erosion: Impact of different cropping systems and soil amendments in Ghana. PLoS one. 2018;13(12). DOI: 10.1371/journal.pone.0208250
 24. Population of Sikkim. Available: <https://www.indiagrowing.com/Sikkim>
 25. Gopi R, Avasthe RK, Kalita H, Chandan Kapoor, Ashish Yadav, Subhash Babu, Das SK. Traditional pest and disease management practices in Sikkim Himalayan region. International Journal of Bio-resource and Stress Management. 2016;7(3):471-476.
 26. Shweta Sing, Chandramoni Raj, Ravikant Avasthe, Ashish Yadav. Impact of climate change on the traditional farming of Sikkim Himalayas; 2017.
 27. Sahasranaman M. Future of urban agriculture in India, occasional paper no. 2016;10-1216. Available: <http://irapindia.org/images/irap-Occasional-Paper/IRAP-Occasionalpaper-10.pdf>
 28. Shirgure PS. Effect of different intercropping systems on soil moisture conservation, fruit yield and quality of Nagpur mandarin (*Citrus reticulata*) in central India. Scientific J. of Agriculture. 2012;1(7):168-176
 29. Sikkim AGRISNET (www.sikkimagrisnet.org), Food Security and Agriculture Department, Government of Sikkim. Available: [http://www.sikensis.nic.in/writereaddata/Soils%20of%20Sikkim%20-%20SIKKIMAGRISNET\(dot\)ORG.pdf](http://www.sikensis.nic.in/writereaddata/Soils%20of%20Sikkim%20-%20SIKKIMAGRISNET(dot)ORG.pdf).
 30. Somavia J. ILO Recommendations No 193 on Cooperatives; 2002. Available: www.ica.coop/europe/ra2002/speech
 31. Zipora Tietel, Lewinsohn. Efraim, Elazar Fallik, Ron Porat. Taste and aroma of fresh and stored mandarins. Science of Food and Agriculture. 2010;91(1)15: 14-23.

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