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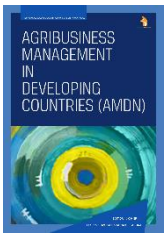

RESEARCH ARTICLE

OPTIMIZING MANDARIN FARMING IN GORKHA NEPAL: A HOLISTIC FRAMEWORK FOR SUSTAINABILITY, PRODUCTIVITY, AND DISEASE CONTROL

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ABSTRACT

The mid-hill regions of Gorkha in Nepal demonstrate fragmented practices, increased disease incidence, and insufficient technical support that challenge the sustainability and productivity of the mandarin-growing farmers. This study focuses on the characteristics of mandarin cultivation, farmer's demographics, orchard practices, and disease control in Gorkha in terms of diversity, utilization, and management practices. A total of 60 mandarin-growing farmers from the Citrus Zone of PMAMP were selected via simple random sampling. The data was collected using a semi-structured interview schedule, key informant interviews, and focus group discussions, and were then analyzed using STATA with descriptive statistics and problem indexing. The findings indicate that 80% of farmers cultivate local mandarin varieties; mainly using the pit method (76.67%) on the north (78.33%) orientated orchards. Training and pruning (85.00%) and Bordeaux mixture application (76.67%) were routine; soil testing (55.00%) and hormone use were rare. High awareness exists for diseases like citrus canker (99.67%) and greening, but only 1.66 % identified viral diseases. Integrated disease management was adopted by 60%, while 6.67% practiced no control measures. Major constraints of Mandarin in Gorkha included insect pests and diseases, irrigation problems, and inadequate technical expertise. It highlights the need for improved disease diagnostics and better availability of soil testing and cultivation practices. A holistic approach of technical interventions, focused learning, and policy support could result in the overall optimization of the productivity and sustainability of the hill mandarin in Nepal.

KEYWORDS

Bordeaux, Disease management, Gorkha, Mandarin, Training and pruning

1. INTRODUCTION

Mandarin farming has been an important part of the agricultural landscape of Gorkha, Nepal, and is a significant contributor to the economic livelihood of the local farmers (Poudel et al., 2020). However, this sector is of huge importance, but it is not sustainable and productive (Poudel et al., 2022). This is due to the little or no access to modern farming techniques, poor pest and disease management, and low technical knowledge and resources among the farmers (Panth and Dhakal, 2019). Such challenges are a critical problem given their stark implications on the productivity and sustainability of mandarin farming.

These issues need an urgent holistic approach to the promotion of sustainable mandarin cultivation (Tram et al., 2024). Although much has been done to push mandarin farming in the region, key gaps remain in disease management, soil testing, and the use of modern fertilizers and plant hormones (Adhikari et al., 2021; Thakre, 2020). There is a clear research gap as the existing knowledge and practices are not sufficient to address the growing challenges in Mandarin farming. Although there is much local experience here, lack of modern technical knowledge and failure to adopt the best practices continue to limit the full potential of Mandarin cultivation. Thus the gap then is in the integration of modern agronomic techniques with traditional farming practices, particularly in disease management and soil health.

As Mandarin is a cultivated crop primarily for its agronomic purposes, a rudimentary understanding of standard orchard practices of mandarin is relatively important (Adhikari et al., 2021; Panth and Dhakal, 2019). While farmers adopt those optimal practices to various degrees, there is a big gap in awareness and training in important areas such as pest and disease management, soil health, and the use of modern agricultural technologies. Additionally, even if mandarin cultivation on a large scale is widespread, pest and disease breakdowns have been the prevailing problem and substantially affect productivity (Poudel et al., 2021). This situation implies the demand for more focused research on disease management and the implementation of modern agronomic practices.

Mandarin cultivation is the basis of the regional economy, so it is important to research to find out how to control diseases and give technical advice to the local farmers. These barriers can be overcome by a comprehensive strategy of improving farmer education programs and helping make better 'resources,' and technical assistance available. The reason behind this research is to fill in the gap between the current agricultural practices that are being analyzed and the areas where farmers lack knowledge, disease control, and productivity improvement. This study thus aims to elevate Mandarin farming productivity and sustainability in Gorkha by emphasizing disease management and agronomic practices. It will provide intuitive tools to completely harness disease management strategies, agronomic best practices, and farmer education to improve production and enhance sustainability in the study.

This research aims to improve production of mandarin in Gorkha through strategic disease management and farmer education as well as agronomic improvements. A study that incorporates these elements in a unified approach would provide actionable recommendations to address the current challenges and significantly improve the mandarin farming in the

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region.

2. Material and Methods

2.1 Study area and sampling techniques

The study was conducted in the Gorkha district situated in the Gandaki Province. Command areas of Citrus Zone of Prime Minister Agriculture Modernization Project (PMAMP) within Gorkha municipality were purposively taken for the study. A total of 60 mandarin-growing farmers were selected by using a simple random sampling technique.

2.2 Research design and data collection

The study incorporated both primary data obtained through field surveys together with secondhand information extracted from government documents and additional relevant sources. The research instrument evolved from farm visits with local experts and key informant interviews with farmers and experts for additional clarification.

2.3 Data analysis techniques

Data were entered and analyzed using SPSS, with descriptive statistics and preferential analysis applied to evaluate significance of the study. Data regarding disease management and orchard practices were cross checked with focus group discussions.

2.4 Socio-demographic variables

Various socio-demographic factors such as age, gender, level of education, land ownership, ethnicity and type of family, and major occupation were analyzed using descriptive statistics; such as standard deviation, mean, frequency, and percentage.

2.5 Preferential ranking

Preferential ranking was done by force ranking technique as used by (Karki et al., 2023).

$$I = \sum \frac{Sifi}{N}$$

Where I_{imp} = Index of importance

$\sum$ = Summation

Si = Scale value

fi = Frequency of problem provided by respondents

N = Sample size

3. Results and Discussion

3.1 Socio-demographic information of mandarin growers in Gorkha

The study shows that 63.33 % of the household heads were engaged in agriculture. Hinduism was the most popular religion (90.00%), followed by Buddhism with 10.00%. Almost half of the household heads were above 50 years of age and 88.33% were male. The population consisted of various ethnic groups among which, the Janjati group formed 36.67% of it. Variability in educational attainment was found and many achieved secondary education (41.67%). Most households followed the nuclear family structure (68.30%). Credit was available only to a tiny proportion of household heads (16.67%). Only 11.67% of them participated in cooperatives.

According to the study, among Gorkha's Mandarin growers, the Janjati wee the dominant ethnic group, the household head was engaged in agriculture as a major occupation, and the household head's education was up to a secondary level (Dahal et al., 2021). The results of this study also confirm the fact that Mandarin producers in Gorkha have always been majorly involved in agriculture and that it is so, which itself forms the socioeconomic setting of these farmers. The fact that the Janjati group is so predominant in both studies brings out the ethnic significance of the region and may influence some cultural practices, such as preferred land uses and types of farming.

Descriptive statistics indicates the average household head's age was 51 years. The average duration of experience in the mandarin farming was 12 years. The average area under mandarin cultivation was 7 ropani. The number of mandarin plants per farm/household averaged about 202. The study area was characterized by high diversity in Mandarin farming experience, land allocation, and plantation size among farmers.

Table 1: Socio-economic and demographic characteristics (categorical variables) of mandarin growing households in Gorkha

Variables	Frequency	Percentage
Major occupation of HHH		
Agriculture	38	63.33
Non-agriculture	22	36.67
Religion		
Hindu	54	90.00
Buddhist	6	10.00
Gender of HHH		
Male	53	88.33
Female	7	11.67
Age of HHH		
Below 40	8	13.33
41-50	25	41.67
51-60	16	26.67
61-70	10	16.67
Above 70	1	1.66
Ethnicity		
Janjati	22	36.67
Chhetri	19	31.67
Brahmin	16	26.67
Others	3	4.99
Education of HHH		
Literate only	4	6.67
Primary	17	28.33
Secondary	25	41.67
Higher secondary	11	18.33
University	3	5.00
Family type		
Nuclear	41	68.30
Joint	19	31.70
Access to credit		
Yes	10	16.67
No	50	83.33
Cooperative involvement		
Yes	7	11.67

Table 2: Socio-economic and demographic characteristics (continuous variables) of mandarin growing household heads in Gorkh

Variables	Mean	Range
Age of household head	51.33±10.56	33-77
Mandarin farming experience	12.41±5.43	6-30
Mandarin cultivated area (ropani)	7.11±5.05	2-30
Average plants	202.33±161.79	30-1000

Note: The figure after ± represents standard deviation

3.2 Crop management practices

Table 3: Crop management practices adopted by Mandarin growers in Gorkha

Crop management practices	Crop management practices	Crop management practices
Mandarin variety		
Khoku	4	6.67
Kinno	8	13.33
Local	48	80.00
Planting methods		
Pit method	46	76.67
Traditional method	14	23.33
Orientation of orchard		
East	2	3.33
West	9	15.00
North	47	78.33
South	2	3.34
Training/Pruning		
Yes	51	85.00
No	9	15.00
Application of Bordeaux mixture/paste		
Yes	46	76.67
No	14	23.33
Soil testing		
Yes	33	55.00
No	27	45.00
Chemical fertilizer		
Yes	58	96.70
No	2	3.30
Organic fertilizer		
Yes	25	41.70
No	35	58.30
Weeding		
Manual	55	91.67
Manual and chemical	3	5.00
No weeding	2	3.33
Mulching		
Yes	35	58.33
No	25	41.67
Hoeing		
Yes	52	86.67
No	8	13.33
Timely irrigation		
Yes	40	66.67
Insect control methods		
Mechanical	11	18.33
Mechanical and chemical	18	30.00
No control measure	31	51.67
Intercropping		
Yes	44	73.33
Types of intercrops		
Maize	21	35.00
Cowpea	7	11.67
Maize and Millet	5	8.33

Table 3 (cont): Crop management practices adopted by Mandarin growers in Gorkha		
Millet	5	8.33
Maize and Legumes	3	5.00
Vegetables	2	3.33
Maize and Mustard	1	1.67
Use of plant hormone		
No	60	100.00
Grading		
Yes	60	100.00

The findings revealed that the majority of farmers grew local Mandarin varieties (80.00%) rather than Kinno or Khoku. Most of the farmers used the pit method (76.67%) while some were practicing the traditional method (23.33%). The predominant orientation of most orchards was north (78.33%), but there were few in the east, west, or south. More than half of the farmers trained and pruned as well as applied Bordeaux mixture (85.00% and 76.67%, respectively). Soil testing, however, was not common (45.00%). There was a very wide difference between chemical fertilizers (96.70%) and organic fertilizers (41.70%). Most farmers mulched (58.33%) and hoed (86.67%) and timely irrigation (66.67%) was assured. Intercropping was widely adopted (73.33%) as maize, cowpea, millet, legumes, and vegetables were major intercrops. Farmers followed different cultivation practices except the use of plant hormones and all of them practiced grading. These indicate a large range of diversity in the Mandarin cultivation management practice as well as big gaps in between the soil testing and hormone application.

Among the mandarin cultivar types grown in the mid-hills of Nepal, the local variety was found to be the dominant cultivar in the mandate by (Shrestha et al., 2024). Similar findings were also reported that almost all the mandarin growers in Gandaki province engage in grading (Acharya et al., 2023). From the findings of the current study as well as others in the area, it seems that local cultivars and the use of a universal grading technique are commonplace and a significant cultural preference as well as conventional agricultural methods. Local varieties adapt better to the climatic and soil conditions of the mid-hills and grading is one of the major techniques to sustain fruit quality. According to this, they found most of the mandarin growers practiced some management practices like Bordeaux mixture/paste application, soil testing, weeding, mulching, timely irrigation, and intercropping (Subedi et al., 2024). Similar to this, they noted that mandarin growers use practices like mulching for soil conservation (Khang et al., 2024). Results from previous research are consistent with Gorkha's extensive use of mulching and Bordeaux mixture, indicating a common focus on soil fertility improvement and disease control, both of which are critical to keeping mandarin orchards healthy. In addition, they mentioned that mandarin growers also use irrigation and intercropping in their orchard management (Regmi et al., 2020). Additionally, stated that many mandarin growers frequently undertake training and pruning in their orchards (Bhandari et al., 2022). Similarly, noted the adoption of such practices as mulching, intercropping, etc (KC et al., 2025). Moreover, reported the adoption of pruning, Bordeaux mixture, intercropping, mulching, irrigation, and chemical fertilizers in mandarin orchards of Gorkha (Poudel et al., 2021). Since these practices are repeated in all areas, farmers are aware of the effectiveness of these practices and also are keen to utilize them in their operations to enhance production and control disease.

3.3 Source of information regarding mandarin diseases

Farmers primarily obtain their disease information through training programs as well as seminars (70.00%) and discussions with neighbors (16.67%) although Mandarin disease resources remain accessible to them. Most citrus farmers show awareness about citrus greening (99.67%), citrus canker (100.00%), and powdery mildew (100.00%) yet knowledge of viral diseases remains minimal. The research shows wide recognition of basic fungal and bacterial diseases but highlights the critical need for specific education programs on viral diseases.

In Sankhuwasabha, mandarin was attacked by powdery mildew, sooty mold, and citrus canker which were the major diseases as noticed by (Timsina et al., 2025). Like, the sources most used by Mandarin growers in Gorkha were training programs and seminars (Dahal et al., 2021). Extension services play a critical role in sharing agricultural expertise because they are a consistent source of data that allows studies to show that training programs are a primary source of information. However, the lack of knowledge in all of the studies, including the present study, suggests the need for more extensive awareness about disease management.

Table 4: Awareness and knowledge of mandarin diseases among farmers in Gorkha		
Information on mandarin diseases	**Frequency**	**Percentage**
Exposure to information		
Yes	55	91.67
Source of information		
Trainings and seminars	42	70.00
Neighborhood	10	16.67
Media (Digital and Paper)	3	13.33
Knowledge on mandarin diseases		
Citrus greening		
Yes	58	99.67
No	2	3.33
Citrus canker		
Yes	60	100.00
No	0	0.00
Powdery mildew		
Yes	60	100.00
No	0	0.00
Sooty mold		
Yes	55	91.67
No	5	8.33
Viral disease		
Yes	1	1.66
No	59	98.34

3.4 Disease management strategies

Findings showed that the majority of farmers (60.00%) were using integrated disease management that is mechanically and chemically controlled. There were also local strategies practiced in smaller percentage. Few proportion of farmers (23.33%) were reliant on mechanical methods. Nevertheless, a significant proportion of farmers never employed control measure suggesting perhaps gaps in disease management awareness or availability of appropriate solutions. The findings are relevant to improving farmer education and the selection of appropriate disease management strategies in Gorkha.

Mechanical and chemical management practices accounted for more than half of the management practices used by Mandarin growers in mid hills of Nepal as mentioned by (Dahal et al., 2021; Subedi et al.,2024). This is a reflection of the wider implementation of integrated disease management (IPM) in the region's mandarin farming. However, the divergent tendency of more farmers not to adopt disease control measures suggests a need for continued extension efforts and the development of more practical, inexpensive disease control strategies.

Table 5: Disease management strategies adopted in Mandarin cultivation in Gorkha

Disease management strategies	Frequency	Percentage
Mechanical control	14	23.33
Mechanical and chemical control	36	60.00
Other local practices	6	10.00
No control measures	4	6.67

3.5 Major challenges on mandarin orchard

Farmers identified insect pests together with diseases (Index value: 0.88) as their principal farming obstacles with irrigation problems (Index value: 0.68) following in second place and insufficient technical expertise as their third major issue (Index value: 0.66). The least critical issues of mandarin cultivation include flower and fruit drop (Index value: 0.45) together with market price fluctuations (Index value: 0.39) according to farmer rankings. The data indicates that implementing effective management practices for pests and diseases, irrigation systems, and technical knowledge dissemination services will improve Mandarin productivity.

The major barriers to mandarin production according to the study they include problems with irrigation and pesticide infestations and disease outbreaks along with substandard orchard management practices in Gorkha (Poudel et al., 2020). The hilly region of Gulmi showed inadequate irrigation and disease along with pest incidence and fruit drop as major production problems in mandarin orchards according to (Khang et al., 2024). They identified disease and pest outbreaks alongside poor irrigation and workforce shortage as essential barriers for Mandarin orchards in Dailekh (Adhikari et al., 2021). Studies by researchers demonstrated that disease and pest outbreaks together with inadequate technical support affected the development of mandarins in Dailekh (Regmi et al., 2020). The main obstacles faced by Mandarin farmers in Syangja were disease and pest infestations together with weak technical understanding and lacking irrigation services as well as minimal support programs according to (Acharya et al., 2024). The research conducted in Sankhuwasabha demonstrated inadequate irrigation, pest and disease damage, adverse climatic conditions along poor technical knowledge as major producing obstacles (Timsina et al., 2025). Gandaki province mandarin growers faced difficulty adopting postharvest technology because they lacked adequate knowledge according to (Acharya et al., 2023). The findings of the new research are similar to those of previous studies and indicate that irrigation and pest and disease control are still the major obstacles to the production of mandarins in the region. The frequent mention of irrigation in research also suggests that Gorkha's output may be significantly increased through improvements in the water management facilities and the provision of access to professional or technical assistance.

Table 6: Ranking of major challenges in Mandarin cultivation

Major challenges in mandarin cultivation	Index value	Rank
Insect pest and diseases	0.88	I
Flower/fruit drop	0.45	IV
Irrigation	0.68	II
Market price fluctuation	0.39	V
Technical knowledge	0.66	III

4. Conclusion

This study reveals that the mandarin cultivation in Gorkha is influenced by a multivariate set of socio demographic, traditional agronomic, disease information, and knowledge and management gaps. Most mandarin growers were older male household heads without access to institutional credit and cooperative involvement, and it seems these were systemic barriers to adoption of modern technologies. Despite a relatively high level of secondary education among farmers, the uptake of technical innovations-such as soil testing and hormone application-remains limited. Most farming was conventional and consisted of local mandarin cultivars grown using pit planting methods. Pruning, training and application of Bordeaux mixture were all commonly employed, but a substantial number of farmers had inadequate orchard management strategies. Citrus canker and greening were almost certainly known to everyone, and recognition of viral diseases of citrus was critically low. There was no consistency in disease control practices and a large fraction of farmers did not use any control practices. Insect pests and diseases, lack of technical knowledge, and irrigation problems were the main constraints to mandarin production as identified by index based ranking. In conclusion, achieving sustainable and productive mandarin farming in Nepal's mid-hill regions needs an integrated approach with technical solutions combined with addressing socio economic and institutional barriers. To build a resilient and knowledge driven mandarin farming system, it is important to strengthen extension services, enhance credit and inputs access to farmers, as well as implement targeted farmer training programs.

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Declarations

Author contribution statement

The research plan and methodology were conceptualized by G. Pandey and D. Bhatta. G. Pandey collected the data from the respondents and performed the formal analysis and investigation. Resources for the preparation of this manuscript were collected by N. P. Devkota. The original draft of this manuscript was prepared by G. Pandey. The revision and editing were carried out by N. P. Devkota. Additionally, G. Pandey, N. P. Devkota, and D. Bhatta provided comments and suggestions to finalize this manuscript. D. Bhatta had the overarching supervision and direction of the research process. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest

The author(s) declare that there are no conflicts of interest regarding the publication of this manuscript.

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