

 RESEARCH PAPER

Adoption of soil conservation practices by mandarin (*Citrus reticulata* B.) farmers in Gulmi, Nepal

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Abstract

Mandarin has a tremendous potential for export and increased income for farmers of Nepal. However, in the recent years, soil degradation and erosion are the major challenges faced by the citrus enterprises especially in the hilly region of Nepal. The declining status of production and productivity cannot be checked without the transfer of site-specific and commodity-based knowledge and skills to the corresponding farmers. A study was carried out in 2023 to examine the soil conservation practices and status of technology adoption among the mandarin farmers. A total of 80 households from three wards of Dhurkot rural municipality of Gulmi district were selected on purpose for the study. Data were collected through interviews, key informant interviews, and focus group discussion, using semi-structured questionnaire, then the descriptive analysis was done using MS Excel and SPSS (Version 23.0). The results revealed that mainly three types of soil were presented in the study areas viz. luvisols, cambisols and sandy gravel, which are highly prone to soil erosion. The average area under mandarin cultivation was reported to be 0.74 hectare, with an estimated productivity of 7.6 metric tons per hectare. Approximately 95% of the respondents were familiar with soil degradation and its consequences in mandarin production. Accordingly, 96.2% of the respondents had adopted some forms of soil conservation practices like sod culture (40%), minimum tillage (36.2%), liming (40%), terracing and cover cropping (95%) and integrated plant nutrient system (31.2%), alongside the traditional stone bunds and mulching. The findings suggested that an increased participation in trainings and contact with extension agents has a significant influence on the importance of capacity building of the farmers regarding sustainable soil conservation technology, innovative cultivation practices, and ensuring frequent extension services to the farmers. Implementing these measures is expected to enable mandarin farmers in Nepal to check annual losses of soil fertility due to soil erosion and landslides, thereby contributing to commercialization of citrus.

Keywords

Gulmi, soil conservation, Mandarin, soil degradation

Introduction

Nepal being an agricultural economy, its prosperity and growth depend on the growth of agriculture. In Nepal, agriculture employs 57.1% of the total population and comprises a wide range of activities (MoF 2021). The varied agroecology of Nepal and its advantageous climate make it an ideal spot to cultivate cereals, vegetables and wide arrays of fruits. The agriculture and forestry sectors

contribute nearly 23.95% to the gross domestic product (GDP) of Nepal (AITC 2022), while the fruits sector generate around 5.82% of the country's total agricultural gross domestic product (AGDP) (MoF 2021). Among various fruits, citrus fruits are native to Nepal and is an important fruit tree in the home gardens of the hilly regions, i.e. 550–1300 meter above sea level (masl) (Srivastava et al. 2002), contributing about 21.61% of the total fruit production in Nepal (MoALD 2023). Mandarin orange

(*Citrus reticulata*, Blanco), locally referred to as “Suntala” is one of the major citrus fruits that can be grown and sold profitably in Nepal (Rokaya et al. 2016). Due to its ideal climate and location, the Gulmi district in the western highlands is one of the top areas for mandarin farming. As a share of total fruit sales, mandarins have been the most significant fruit in the nation. In the fiscal year (FY) 2021/22, the total national mandarin production is 185,346 Mt spanning a productive area of 19,481 hectares, and the productivity of 9.51 Mtha⁻¹. Similarly, the total of 7,164 Mt of mandarin was produced in the district from 597 ha of productive area (MoALD 2023).

Despite the fact that mandarin farming is a well-established practice, soil conservation techniques are difficult to implement in Nepal. Throughout the nation, a poor adoption of soil conservation practices (SCP) such as mulching, terracing, proper soil manipulation, causing serious concern (Lamichhane and Adhikari 2021). In order to solve this problem, this study assessed the many variables affecting regarding awareness and about various SCPs and provided recommendations for institutions, groups, and stakeholders to concentrate on raising their adoption and awareness. In Nepal, 65.3 percent of the country’s land is used for growing citrus, while 67.2 percent of that land is used for mandarin production. However, the area growth is more significant than the output growth (AITC 2022). While mandarin farming is an important sector in Nepal and the trend of production is increasing (Fig. 1), the majority of citrus orchards and soil are poorly managed or neglected, which results in poor fruit tree growth, serious diseases, and insect infestations, which eventually produce fruits of lower quality (FAOSTAT 2021). Numerous orchards around the nation are being seriously affected by a broad citrus decrease, according to the Nepal Agriculture Research Council (NARC). In order to develop and yield mandarins at their best, a healthy orchard with good soils must be considered in mandarin farming (NCRP 2022). Orchards that

are poorly maintained or ignored degrade the soil, which can impair the land’s fertility and affect the environment. Mulching, cover crops, and intercropping are examples of sustainable soil conservation techniques that can help maintain soil health, stop soil erosion, and increase biodiversity (Lamichhane and Adhikari 2021). Mandarin farming can reduce its negative environmental effects and improve the industry’s long-term viability by implementing sustainable SCPs. Farmers may raise their output, enhance the quality of their produce, and guarantee long-term financial success by using these practices (NCRP 2022). This improves farmers’ means of subsistence and helps the nation’s agriculture industry grow overall. To sum up, Nepal’s economy greatly benefits from the important industry of mandarin growing (MoALD 2023). However, the business faces significant issues due to the low adoption of soil conservation and improper management of citrus orchards, which highlight the need for increased knowledge and acceptance of sustainable orchard management practices. The productivity and longevity of citrus orchards are impacted by the loss of rainwater, soil, and nutrients owing to overland flow, which also contaminates surface water in citrus belts (He et al. 2004).

In regard of these production challenges and potential opportunities, this research aims to investigate the status of adoption status of SCP and related technology among mandarin farmers in the Gulmi district of Nepal. While imparting light on the prevailing practices, barriers, and potential mitigation strategies, this study seeks to mine out valuable insights in order to enhance the production, profitability and sustainability of mandarin enterprise. The objectives of this study encompass investigating the adoption status of SCPs along with identifying the challenges behind the adoption. In summation, this research endeavours to bridge the existing research and implementation gap by providing tangible evidence and practical implications for the mandarin farmers, policymakers, and associated stakeholders in the Nepalese citrus industry.

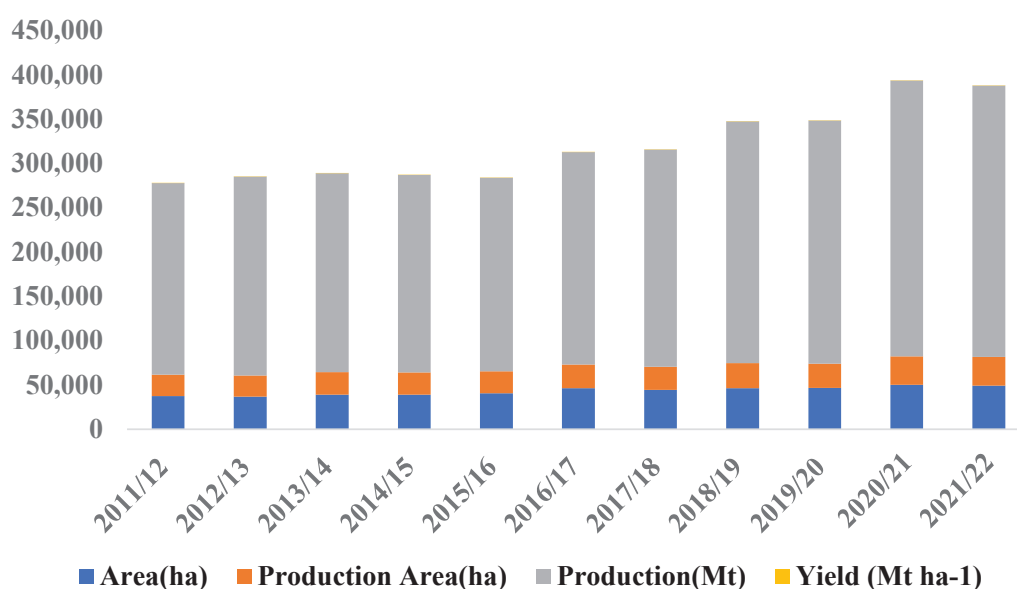


Figure 1. Trend showing area, production and yield of citrus fruits in Nepal (MoALD 2022).

Materials and methods

Study area, sampling and data collection technique

The research was conducted in the mandarin zone domain of Gulmi district in Dhurkot rural municipality (Fig. 2). The study areas lay between the latitude $28^{\circ}04'08.76''\text{N}$ and longitude $83^{\circ}18'24.84''\text{E}$, at an average altitude of 1000–1500 masl (NARC 2023). The entire registered mandarin farmers of Gulmi district constituted the sampling frame for this research. To ensure unbiased representation, a simple random sampling technique was employed. The estimate of total farmers was obtained from the database of Prime Minister Agriculture Modernization Project (PMAMP). The Prime Minister Agriculture Modernization Project is the largest existing project under the Ministry of Agriculture and Livestock Development (MoALD). This is the only project of the government of Nepal (GoN), formulated by the internal vision, backed by the internal investment and internal institutional manpower (PMAMP 2024). The sample size was estimated using the F- test. Afterwards, numbers were assigned to the units and final sample selection was accomplished. The methods for data collection included interviews, key informant interviews (KII), and focal group discussions (FGD) based

on the protocols outlined by Sedhai et al. (2022). The participants in the study were selected from among the list of farmers involved in commercial mandarin cultivation in the district, as provided by the PMAMP, Citrus Zone, Gulmi. Exclusively, farmers were taken from three wards of Dhurkot rural municipality. Using Cochran's formula, 80 households were ultimately chosen using a simple random sampling technique, from the sampling frame of 385 by applying a confidence level of 95%, an error margin of 5%, and a 50% response distribution (Cochran 1963).

Statistical analysis

The collected data and information were analysed using different statistical software like MS Excel 2010 (Version: 4.0.4734.1000, Washington, US) and SPSS (Version: IBM SPSS Statistics 28, New York, USA). Using descriptive statistics like frequencies, percentages, means, and standard deviation, the socio-demographic attributes as well as farmers' adoption practices were successfully documented. During the analysis, both the descriptive as well as analytical methods were used to analyse the quantitative data that had been gathered. However, the qualitative data were either further quantified or subjected to a qualitative analysis.

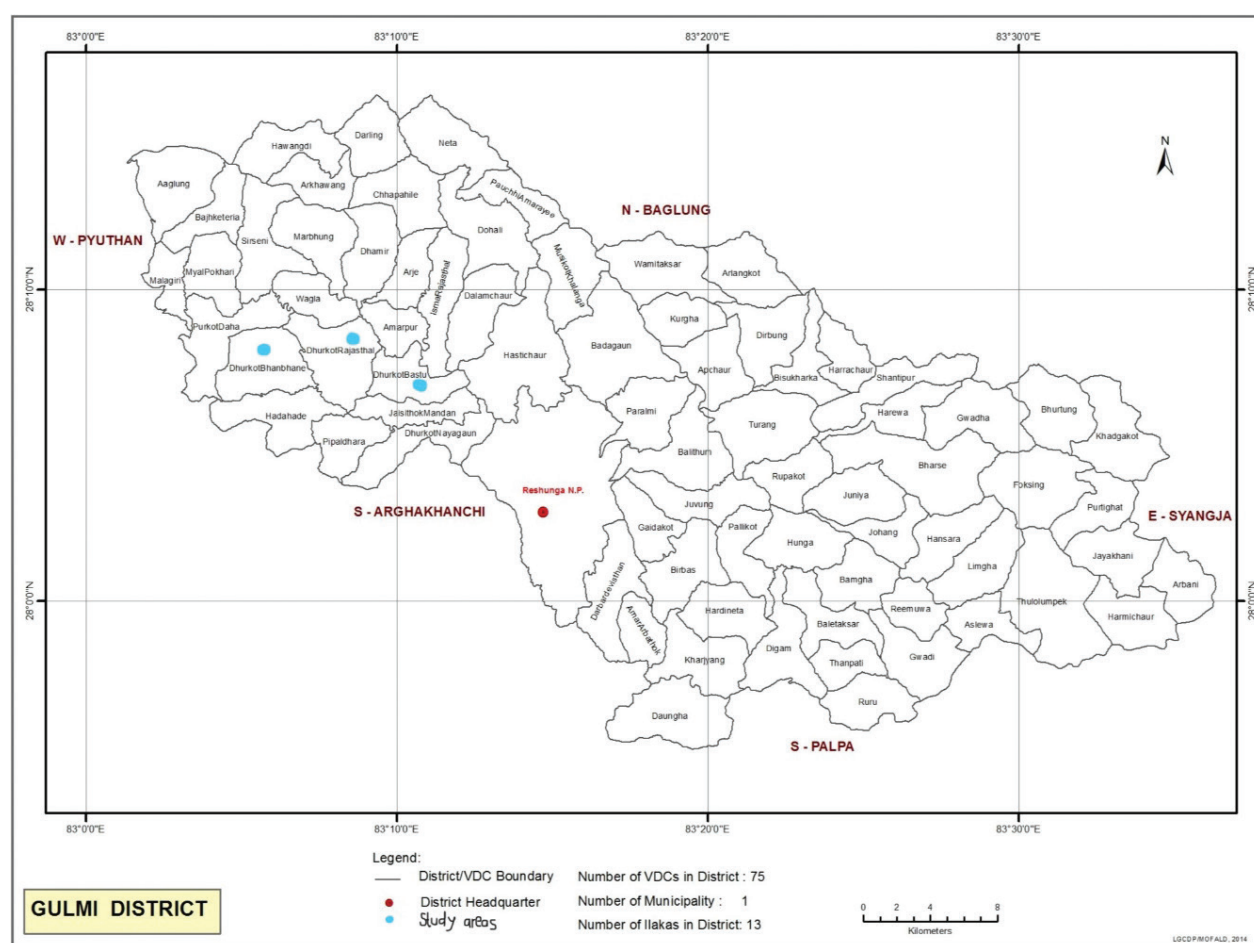


Figure 2. Map of Gulmi district showing the study areas (LGCDP 2014).

Scaling of problems in the adoption of SCP

$$I_{\text{imp}} = \sum SiFi / N$$

The index was created by taking into account qualitative data. It was done using MS Excel 2010 (Version: 4.0.4734.1000, Washington, US), for prioritizing the issues based on farmers' perceptions. The index of importance was computed by using the formula:

Where,

I_{imp} = index of importance

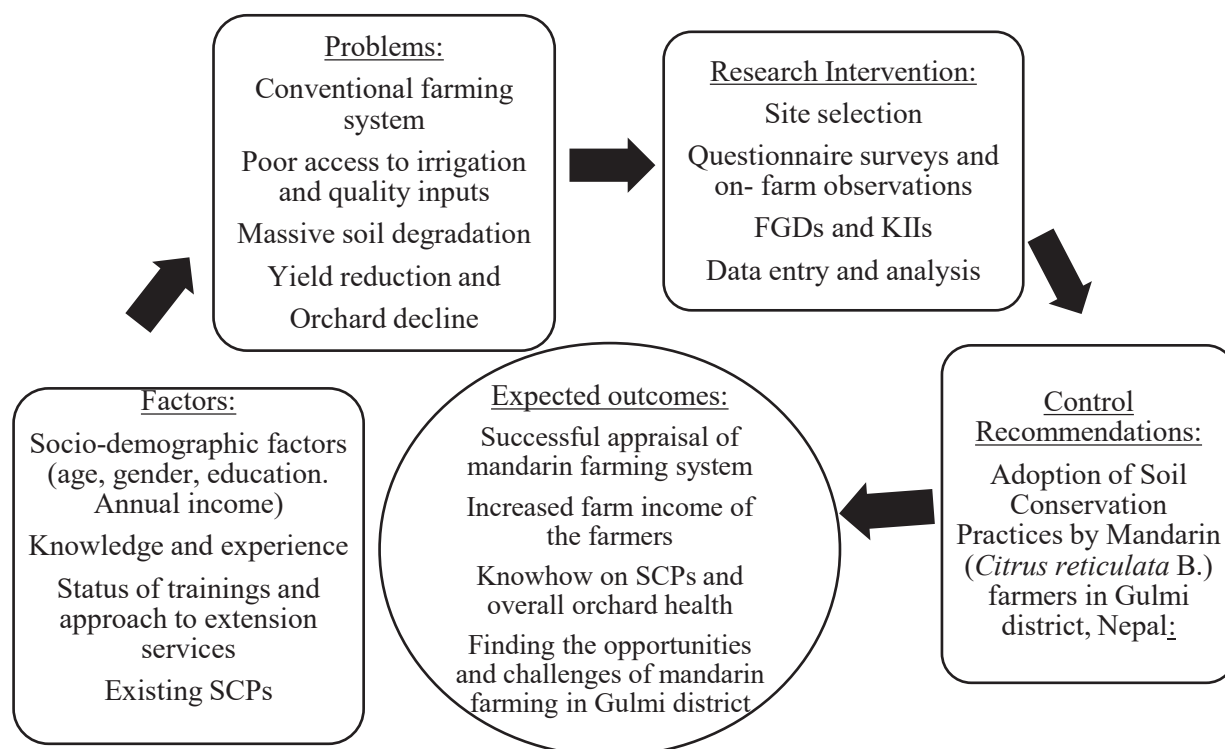
Σ = summation

Si = i^{th} scale value

Fi = frequency of i^{th} importance given by the respondents

N = total number of respondents

Conceptual Framework of the study



Scheme 1. Conceptual framework of the study.

Results and discussion

Socio-economic and demographic characteristics

Socio-economic factors such as age, education, farming experience, and farm size are considered as variables to evaluate the choices made by farmers when adopting technology or implementing particular practices (Walisinghe et al. 2017). This study found that the commercial cultivation of mandarin in Gulmi district was dominated by male farmers. Similarly, the majority (41.30%) of respondents were between the ages of 46 and 60 years. Only 7% of the respondents were as young as 18–30 years, participating in the enterprise. This indicated that elder farmers are more specifically involved in mandarin farming (Table 1). These findings are in close correspondence with the findings regarding the average age of the mandarin farmers in Gulmi district (Chhetri and Ghimire 2023). As per the respondents, the vast majority of the respondents (63%) had been involved in the mandarin farming for 5–10 years, followed by those with more than 15 years of farming experience. There was very less (1.30%) involvement of newer farmers in the farming operation in the study areas.

Additionally, it was found that, the majority (71.30%) of the respondents had attended only primary level schooling while 2.5% were found to have higher education, and very few respondents (1.25%) were found to be illiterate. The population of Gulmi district is 246,494 with a sex ratio of 83.33% and the literacy rate of 80.3% (AKC 2023), which clearly supports our findings. Agriculture was reported to be the primary source of income, while some were also involved in services, business. The average land holding of the respondents was found to be 0.72 ha, which is greater than the national average of 0.55 ha (AKC 2023). It was evident that the farming experience and educational status had correlation with adoption of good agricultural practices (GAP) and SCP measures in mandarin orchards. Similar conclusions were reported by Ye et al. (2020) and Sedhai et al. (2022).

Perception of farmers towards SCPs in mandarin farming

The perception of the respondents towards adoption of various SCPs was analysed using the semi-structured, close-ended (Yes/No) questionnaire. The study showed

Table 1. Distribution of the socio-economic and demographic characteristics of Mandarin farmers in Gulmi District (N = 80).

S.No.	Parameters	Frequency	Percentage
1	Gender		
	Male	61	76.2
	Female	19	23.8
2	Age		
	Less than 30 years	6	7.5
	31–45 years	26	32.5
	46–60 years	33	41.3
	Above 60 years	15	18.8
3	Education status		
	Illiterate	1	1.25
	Primary (Up to class 5)	57	71.3
	Secondary (Up to class 10)	20	25
	Higher (Above class 10)	2	2.5
4	Sources of income		
	Agriculture	63	78.8
	Agriculture and Services	17	21.2
5	Farming experience (Years)		
	<5 years	1	1.25
	5–10 years	5	6.25
	10–15 years	24	30
	>15 years	50	62.5
6	Farm holding size (ha)		
	Less than 0.1 ha	2	2.5
	0.1–0.25 ha	11	13.75
	More than 0.25 ha	67	83.75

that majority (95%) of respondents were aware of the major causes of soil degradation and its consequences such as short-term fertility issues (48%), increased yield with poor quality (52%) on mandarin production. Similarly, 31.2% of respondents were familiar with the negative effects of chemical fertilizers in soil health. According to them, heavy monsoon and thus induces soil erosion was the major cause behind soil degradation issues in mandarin farms of Gulmi district (Fig. 3).

However, incorporating SCPs was perceived to be a time-consuming and cumbersome procedure by the majority (78%) of the respondents. Contrarily, the majority (81%) of them also agreed that SCPs imparted tangible

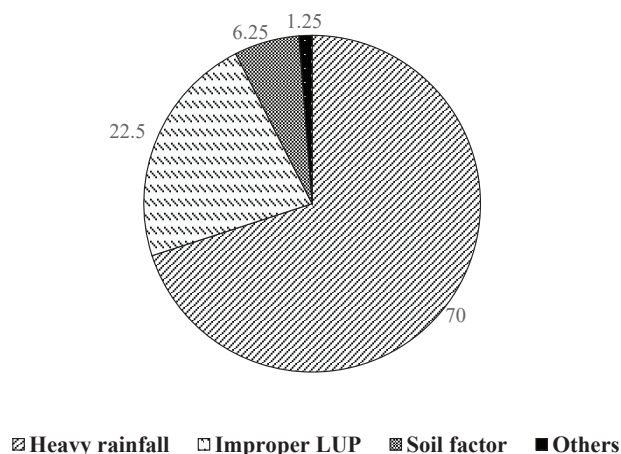


Figure 3. A pie-chart showing major causes of soil degradation (in percentage).

benefits via reduced cost of production and increased the farm income, while also reducing the occurrences of soil erosion, landslides and localized fertility decline.

Status of general orchard management

In the study, it was revealed that majority (72.50%) of the respondents never conducted any soil tests of the orchard. Only 18.8% of respondents occasionally conducted the soil test and 7% rarely conducted soil analysis test. Regarding the kinds of soil analyses, only 15% of the respondents performed soil pH test; 2.5% for nutrient analysis and mere 7.5% of them conducted both soil pH and nutrient analysis. Approximately 61.25% of the respondents reported luvisols-type of soil, while cambisols and sandy gravel soil were reported by 36.25% and 2.50% of the respondents in their mandarin orchards.

As per the nutrient management in Mandarin orchards, the majority (58.75%) of the respondents acknowledged that they applied only organic manure in their mandarin farm, while 40% reported the integrated nutrient management (INM) approach. Similarly, 1.25% stated that they only applied chemical fertilizers in their farm. Various organic fertilizers being used are mentioned in the Fig. 4 below:

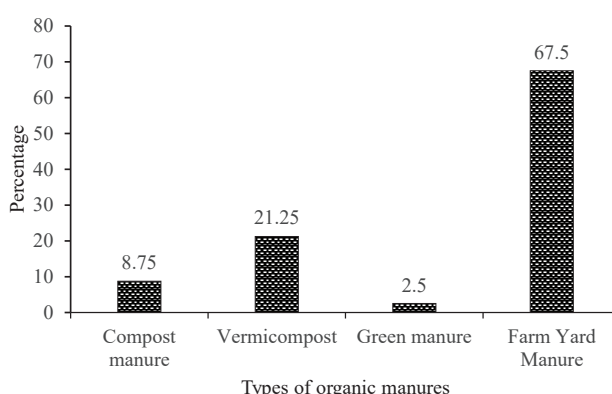


Figure 4. Types of organic fertilizers used by the mandarin farmers in Gulmi district.

Status of FYM usage per year per plant in mandarin farms

The study showed the increasing trend of doses of FYM per year of plant with minimum 1 kg and maximum 10 kg in first year to minimum 30 kg and maximum 60 kg in sixth year or above (Table 2).

Table 2. Different doses of FYM (kg plant⁻¹) used in mandarin orchards.

Variables	Doses (Kg per plant)				Std. Deviation
	Minimum	Maximum	Sum	Mean	
Year 1	1	10	139	4.09	1.848
Year 2	2	15	302	8.87	4.002
Year 3	5	30	570	16.8	6.382
Year 4	15	45	900	26.5	9.336
Year 5	25	60	1180	34.7	11.278
Year 6 or above	30	60	1590	46.8	7.165

Status of chemical fertilizers used in the mandarin orchards

In order to supply the recommended doses, majority of the respondents preferred chemical fertilizers Urea, DAP, SSP and MOP in the study areas. It was reported that all the farmers exclusively used Urea as the source of nitrogen; DAP (33.8%) and SSP (10%) as source of phosphorus, and MOP as the source of potassium respectively. Similarly, 21.3% of the respondents determined the required dose of fertilizer through mere experience; 20% via recommendation from agro-inputs dealers and 1.3% determined it based on soil test and formal studies. Table 3 below shows the general observations regarding application of chemical fertilizers in mandarin orchards in the study area.

Table 3. Status of sources and doses of chemical fertilizers used in mandarin orchards.

Variables	Quantity	Years					
		Year 1 st	Year 2 nd	Year 3 rd	Year 4 th	Year 5 th	Year 6 th or above
Urea (g plant ⁻¹)	Mean	11.47	21.32	46.47	80.88	144.12	270.59
	Std.	2.62	6.78	19.17	36.96	48.87	70.84
	Deviation						
SSP (g plant ⁻¹)	Mean	15.00	25.71	70.00	135.71	242.86	392.86
	Std.	0.00	10.97	46.90	55.64	120.52	83.81
	Deviation						
DAP (g plant ⁻¹)	Mean	19.26	38.89	85.56	133.33	242.59	387.04
	Std.	5.50	18.15	33.67	61.24	100.67	116.51
	Deviation						
MOP (g plant ⁻¹)	Mean	17.94	35.59	82.65	123.53	263.24	397.06
	Std.	4.46	17.48	37.12	50.73	116.98	102.94
	Deviation						

Relative impacts of various fertilizers on the yield and quality of mandarin

In the survey, significant responses were obtained regarding yield, fruit quality and shelf life of the produce in favour of the organic fertilizers (Fig. 5). Similar outcomes were revealed in the study conducted by Yadav et al. (2024) in their soil nutrients trial on carrot.

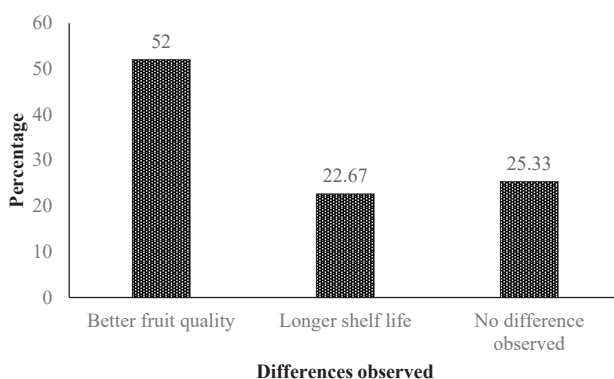


Figure 5. Bar diagram showing positive influence of organic fertilizers on mandarin farming.

Adoption status of soil conservation practices

The study revealed that 96.2% of respondents had adopted various SCPs in the orchard (Fig. 6). Minimum tillage and liming were done to strengthen soil structure and enhance soil fertility status by checking upon soil erosion. Very few respondents (2.5%) reported no-till farming while 5% of them also reported to practice both mulching as well as RCT. Similarly, practices like contour farming (31.3%) and terracing (17.1%) were also commonly practised for designing citrus orchards in the study areas. The study done by Dorji et al. (2016) also validate our findings that adoption of improved farming practices apparently improved the mandarin production and productivity (Dorji et al. 2016).

Mulching was yet another SCP widely practised in mandarin orchards in the study area. It was reported that sod culture and mulching greatly reduced field heat impact on fruit trees. In mulching, 85% of the respondents practised organic mulching using maize straw (63%), grasses (13%) and forest litter (11%). Similarly, 1.3% of them used plastic mulching although 13% neither followed organic nor inorganic mulching. They reported the mulching interval to be yearly (76.3%) and once very crop cycle (8.8%). Mulching as recommended by Poudel et al. (2020), to be done in the dry period when the moisture content in soil is low which is in the dry month of December-April after fruit harvesting and tree fertilization. This apparently supports our findings.

Moreover, for weed management, majority (98.8%) of the respondents practised hand-hoeing while the use of synthetic herbicides was minimal (1.3%). Likewise, 91.3% of the respondents applied micronutrients. Foliar application of zinc was the most common practice among the mandarin farmers. These findings are backed by the study conducted by Srivastava et al. (2002), on organic citrus production, which emphasized the importance of micronutrients application in citrus yield and quality.

Similarly, this study revealed that highest number of respondents (57.5%) to be using Biological Soil Amendments (BSAs), which also signifies the conventional and organic farming of mandarin. Although, 35% of producers used both manure and fertilizer as the major soil amendments. Moreover, 40% of the respondents performed liming their orchard quite regularly. Such findings are in correspondence with the studies done by Srivastava et al. (2002) and Dorji et al. (2016).

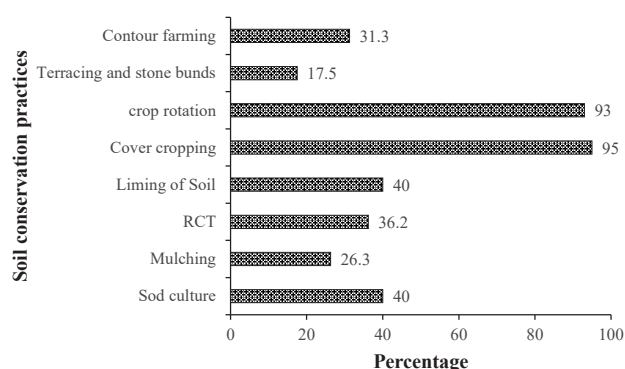


Figure 6. Soil Conservation Practices adopted by mandarin farmers in Gulmi district.

According to the study, it was also found that adoption of SCP greatly influenced production of mandarin farm while also influencing the soil health and economic efficiency. For instance, 41.56% of the respondents reported increased yield whereas 55.84% reported apparently reduced events of soil erosion in the study areas. Similarly, 3.5% of the respondents experienced reduced moisture stress and decreased labour requirements as well. Similar findings were also reported by Dorji et al. (2016) and Organic Africa (2023). Moreover, the majority (81%) of them also agreed that SCPs imparted tangible benefits via reduced cost of production and increased the farm income, while also reducing the occurrences of soil erosion, landslides and localized fertility decline.

Barriers behind adoption of SCP in mandarin production

Majority of the farmers practised conventional orchard management and production. From the study, three major barriers were reported to linger the adoption of SCP in mandarin production (Fig. 7). The similar findings have been documented by Organic Africa (2023), in relation to citrus orchard improvement. In the study areas, only 21.3% of respondents, usually the educated ones, were willing towards adopting technology regarding SCPs in response to such deleterious effects of soil degradation. This may be attributed to the farmers' perception that adoption of SCPs was a time-consuming and cumbersome procedure by the majority (78%) of the respondents. However, Ye et al. (2020), through his study on willingness model to social change, emphasized the significance of extension services and trainings to change farmer's general perception towards adoption of new technologies and/or practices for good.

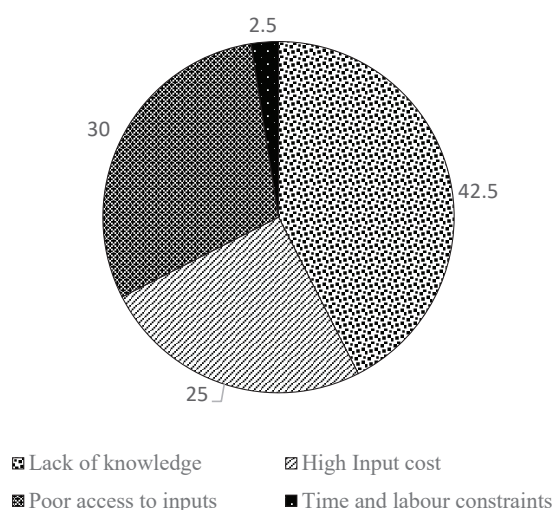


Figure 7. Pie-chart showing barriers of adoption of SCP (in percentage).

Factors influencing awareness of SCPs

The awareness and information regarding SCPs are influenced by multiple factors, both the socio-demographic aspects of the farmers as well as due to the institutions involved

in agricultural extension. It was evident that the farmers' expertise, their education and knowledge status, training, landholding size and contact with extension agents had significant association with the prompt and effective adoption of the soil conservation practices in their orchards. These findings are supported by the independent studies done by Walisinghe et al. (2017) and Sedhai et al. (2022).

Major challenges faced by the mandarin farmers

In the study, 96% of the respondents were found to practise traditional cultivation practices, and faced inputs and irrigation-related problems such as scarcity of water (88.2%), lack of irrigation system (5.3%) and lack of other farm inputs (6.5%). As per the mitigation strategy, they used a traditional method to cope up with this problem such as drip irrigation (65%); rain water harvesting (5.8%) and improved drainage system (23.8%) [8].

Majority of producers ranked lack of irrigation facilities and high-quality farm inputs such as planting materials, fertilizers, pesticides and tools, as most serious problem followed by the poor extension services, lack of assessment of citrus greening, and several other issues related to production and marketing of mandarin (Table 4). The result shows that, among the production problems, poor extension services regarding SCP are perceived as the most serious issue, followed by occurrence of diseases and pests, resulting in poor resource use efficiency. Lack of quality planting materials, farm inputs and annual fruit drops also leads to lower productivity. Similar indications were also reported by the studies Paudyal et al. and Shrestha R.L. emphasizing upon the advancement of research on production and pathological aspects of citrus fruits in Nepal (Shrestha 2010; Paudyal and Shrestha 2015).

Table 4. Major problems in the adoption of SCP in mandarin farming.

Problems in mandarin farming	Rating value	Ranking scale	Rank
Lack of proper irrigation and quality inputs	1	Most serious	I
Poor extension services regarding SCP	0.6	Moderate	III
Diseases and pests' occurrences	0.8	Serious	II
Lack of marketing facilities	0.4	Somewhat serious	IV
Fruit drop	0.2	Least serious	V

SWOT analysis of mandarin sub-sector

A brief account on the strength, weakness, opportunities and threats (SWOT) analysis of mandarin in Gulmi district is mentioned in Fig. 8. Mandarin in the western hills of Nepal is considered as one of the remunerative production options because of its agro-ecological feasibility in marginal hill-slopes and high value nature (Paudyal and Shrestha 2015). Similarly, it was reported that the marketing system of the mandarin in the study area was unorganized, season glut and often malfunctioning and devoid

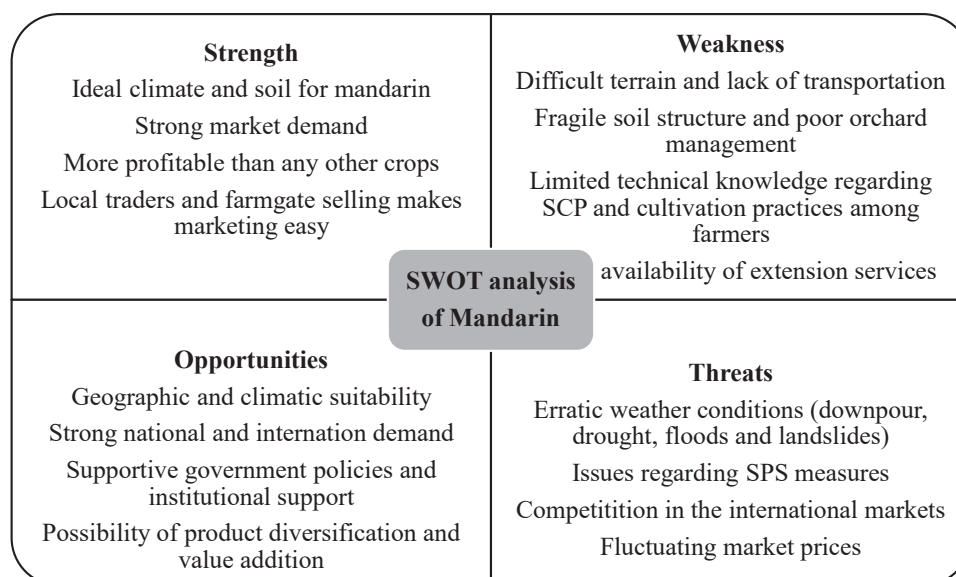


Figure 8. SWOT analysis of Mandarin enterprise in Gulmi district, Nepal.

of systematic post-harvest technologies, transportation and storage facilities. Similar findings were reported by Shrestha et al. (2000) and Baral et al. (2021), which support our findings.

Conclusion

From this study, it can be concluded that farmer's awareness and perception of agricultural practices may get affected by various reasons and circumstances. Thus, this research strongly recommends training and regular touch-up between farmers and extension systems to strengthen farmers' understanding of appropriate SCPs. The research also highlights an apparently strong correlation between orchard health and enhanced production and yield attributed due to adoption of appropriate SCPs in mandarin although only a small majority actually adopted the conservation measures. The continuation of indigenous SCPs such as mulching, stone bunds, terrace ditches, contour farming, bamboo fencing, plantation of local trees and grasses, along with adoption of modern conservation technologies like scientific orchard layout, sod culture, SALT technology and IPNS looks promising in regard to the control of erosion. This research revealed that the main challenge to the adoption of these SCPs was lack of knowledge and extension services; indicating that knowledge about these practices should be spread via radio, television, newspapers, and social media to the grassroot level. There is an immense need for formulation and effective

implementation, by the concerned authority, of strategic plans to address the major constraints faced by farmers in the adoption of SCPs and come up with effective measures.

Limitations

This research shall be a preliminary account to future studies on the status of SCP adoption in mandarin farms in the future. However, it is important to also acknowledge certain limitations regarding the scope of this research to further enhance the understanding of future researches. This study was conducted on the basis of the experience and intellect of the farmers, and that they had been reluctant to answer some questions and providing information, it has had created problems during data analysis. Distant sites and narrow-time routine equally challenged in time and monetary management. In this regard, it is recommended, while conducting future studies on mandarin, to potentially involve exploring different districts, or provinces or nation-wide broad studies in order to obtain a broader perspective.

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Supplementary material

Supplementary material 1

Ranking of problems (.xlsx file)

Link: <https://doi.org/10.3897/ia.2024.134984.suppl1>

Supplementary material 2

Soil conservation practices adopted by the farmers (.xlsx file)

Link: <https://doi.org/10.3897/ia.2024.134984.suppl2>

Supplementary material 3

SCPs adopted by the farmers (.xlsx file)

Link: <https://doi.org/10.3897/ia.2024.134984.suppl3>

Supplementary material 4

Sociodemographic status (.xlsx file)

Link: <https://doi.org/10.3897/ia.2024.134984.suppl4>

Supplementary material 5

Organic manuring in mandarin orchards (.xlsx file)

Link: <https://doi.org/10.3897/ia.2024.134984.suppl5>

Supplementary material 6

Fertilizer application in mandarin farms (.xlsx file)

Link: <https://doi.org/10.3897/ia.2024.134984.suppl6>