Archives of Agriculture and Environmental Science 7(2): 218-225 (2022)
https://doi.org/10.26832/24566632.2022.0702010

e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes

ORIGINAL RESEARCH ARTICLE

# Influence of socio-economic attributes of farmers on the adoption of orchard management practices of mandarin in Myagdi district, Nepal

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**ARTICLE HISTORY**

Received: 24 April 2022
Revised received: 06 May 2022
Accepted: 11 June 2022

**Keywords**

Citrus
Farmers
Management practices
Orchard
Productivity

**ABSTRACT**

Mandarin is one of the major and highly commercialized fruit crops of Nepal. However, its productivity is widely varied throughout the country. The association of socio-economic characteristics of the farmers with the adoption of different orchard management practices and ultimately productivity is less known. Therefore, survey research was conducted in the Myagdi district to study the influence of socio-economic attributes on the adoption of different orchard management practices and their relation to the productivity of mandarin. A total sample size of 94 was selected by simple random sampling technique and interviewed with a pre-tested, semi-structured questionnaire. Data were entered and analyzed using MS Excel, Statistical Package for the Social Sciences (SPSS), and STATA, and the inferences were retrieved using the binary logistic regression model and multiple linear regression model. The study showed that the education level of the farmers has a positive influence on the adoption of mulching ($p = 0.04$) and pruning ($p = 0.07$). The secondary income source of the household has a positive impact on the adoption of chemical fertilizers ($p = 0.08$) and pruning ($p = 0.03$). Commercial mandarin farming in larger area has a positive influence on the adoption of Bordeaux mixture ($p = 0.03$) and insect management ($p = 0.01$). Extension services has great influence on the adoption of chemical fertilizers ($p = 0.02$), mulching ($p = 0.03$), Bordeaux mixture ($p = 0.00$) and insect management ($p = 0.1$). However, education level ($p = 0.05$), area under mandarin farm ($p = 0.09$), and extension services ($p = 0.00$) discourage the adoption of intercropping in the mandarin orchard. The productivity of mandarin orchards was significantly enhanced by FYM application, chemical fertilizers, irrigation, weeding, and Bordeaux application. This study shows that the farmers with better socio-economic conditions are more likely to adopt improved management practices in mandarin orchard which in turn enhance their productivity.

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**Citation of this article:** Poudel, A., Sapkota, S., Bhatt, R. P., Bhandari, S., & Nepal, S. (2022). Influence of socio-economic attributes of farmers on the adoption of orchard management practices of mandarin in Myagdi district, Nepal *Archives of Agriculture and Environmental Science*, 7(2), 218-225, https://dx.doi.org/10.26832/24566632.2022.0702010

## INTRODUCTION

Nepal, a South Asian country with an area of 147,516 sq. km is geographically divided into three distinct regions; the Terai region, the Hilly region, and the Himalayan region with a wide range of agro-ecological and climatic diversity that supports a wide variety of crops. Agriculture has been an important economic sector of the country contributing 27.64 % of national gross domestic product (GDP) and about 65% of economically active populations are involved in Agriculture (MoALD, 2021). The hilly geography of the country with undulating slopes is highly suitable for horticultural crops. Horticulture commodities contribute 14% of total agricultural GDP (AGDP) and of which fruit alone shares 7.04% of AGDP (MoALD, 2019).

Citrus in general and mandarin in particular has been traditionally grown as one of the most important fruit crops in Nepal.

Citrus is commercially grown in mid-hilly terrains of the country in around 62 districts (NCRP, 2021). It shares nearly 32% of the total fruit growing area of the country among which the contribution of mandarin is nearly 21% (MoALD, 2019). Mandarin (*Citrus reticulata* Blanco), a sub-tropical fruit belonging to the family Rutaceae has been highly suitable for undulating and marginal topography of the country. The high demand for fruits and higher profitability has galvanized some farmers for large-scale commercial production of the fruit. It is grown in 26,591 ha of land with the production of 156,179.68 metric tons (Mt) and national average productivity of 10.73 Mt/ha (MoALD, 2021).

Improved management practices ensure good health of the orchard which in turn augments the productivity of the trees. Farm Yard Manure is the most common type of fertilizer used by farmers. Organic manure has a positive response on soil health in addition to enhanced fruit yield and quality (Obreza *et al.*, 1993). Adequate irrigation with the proper methods has a positive influence on tree health as well as fruit yield, size, and quality (Dorji *et al.*, 2016). Regular weeding, the practice of mulching, and effective pruning help to maintain better health of the orchard (Gauchan *et al.*, 1994; Froud-Williams, 2002; Tucker *et al.*, 1994). Insect and disease management are crucial for enhancing the productive potential of the orchard (Ashraf *et al.*, 2014).

Mandarin is the indigenous fruit of Nepal and our primogenitors have developed a package of cultivation practices through years of experience. Most of the farmers involved in mandarin farming use indigenous knowledge of orchard management that has been handed over the generations. Socio-economically diversified groups of people in the country have their own extent of practicing orchard management. Most of the farmers in Nepal, however, are marginalized with fragmented landholding. A small piece of land is to be utilized for cereal crops for staple needs as well as fruit crops for immediate cash. This has led to extensive intercropping of the mandarin orchards with exhaustive crops like maize, millet, barley, buckwheat, etc. Srivastava *et al.* (2007) have reported that intercropping of the exhaustive crops has a negative impact on the fruit yield of citrus.

Furthermore, despite the advancement in sophisticated technologies and improved management practices for mandarin farming in Nepal, they are less being adopted by rural farmers of Nepal. Illiterate and economically poor farmers are less likely to adopt improved technologies in their nominal size of the orchard. In addition to this, ignorance of the orchard and poor management practices are highly associated with declining productivity of the orchard. Many trees in the orchard have been declining and also the productivity of different orchards within the country varies greatly. Paudel and Shrestha (1995) mentioned that citrus decline is the symptomatic expression of many causes and no single measure can manage the problem. FAO (2011) has focused on the improved orchard management practices in combating citrus decline problems in Nepal. However, few studies have been carried out to study the orchard management practices in relation to citrus productivity and the factors affecting the adoption of these practices. This study aims to know the influence of socio-economic characteristics on the adoption of different orchard management practices in mandarin and ultimately on its productivity.

## METHODOLOGY

The survey was conducted in Beni municipality and Malika Rural municipality of Myagdi District, selected purposively, as they were the prominent regions for mandarin production in the district. Total mandarin growing farmers from the region were taken as a sampling frame of which 94 farmers were randomly selected as samples. The questionnaire was designed and pre-tested before administering to the actual respondents for checking the reliability and validity of the questionnaire. The pre-testing was done on 10 percent of respondents near the study area, and the necessary adjustment was made in the final interview schedule. The primary data were collected through face-to-face interviews, focus group discussions, and key informants surveys, and the secondary information was obtained from various publications of the Ministry of Agriculture and Livestock Development (MoALD), Central Bureau of Statistics (CBS), Citrus Zone, Myagdi, journals, and articles, etc. The data were entered and analyzed using computer software such as MS Excel, STATA, and Statistical Package for Social Science (SPSS). Analytical models: binary logistic regression model and multiple linear regression models were used to derive the inferences needed.

## RESULTS AND DISCUSSION

### Socio-economic characteristics

**Gender of the respondents:** The study showed that a higher percentage (76.40%) of the respondent farmers were male and fewer (23.40%) of the respondent farmers were female. It indicates that mandarin farming and decision-making are dominated by males in the study area whereas females were mostly restricted to household activities.

**Age of the respondents:** The average age and the standard deviation of the age of the respondents in the study area were found to be 47.82 and 11.41 years, respectively. The respondents were found within the range of 21 years and 80 years.

**Ethnic composition of the respondent household:** The majority of the respondent households in the study area were from Janajati ethnic community (57.40%). 21.30% of the sampled household were Chhetri and 14.90% of the sampled household were Brahmin. Only 6.40% of the respondent households were from Dalit ethnic community.

**Education status of the respondents:** Figure 1 reveals that the majority of the respondents had a Secondary level of education (23.4%) followed by illiterate respondents (22.3%) and then by a lower secondary level of education (21.3%). Respondents having higher secondary level and primary level of education were

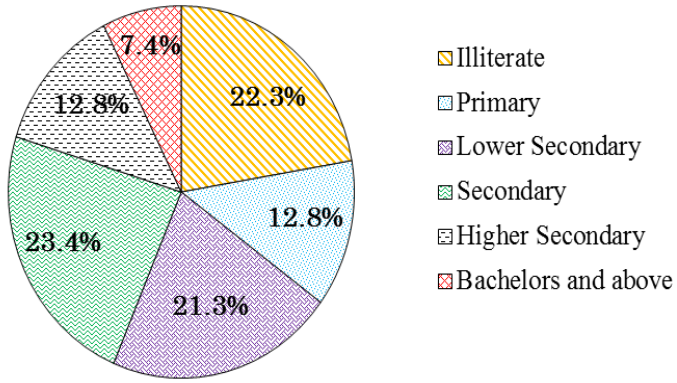


**Figure 1.** *Education status of respondents of sampled households.*

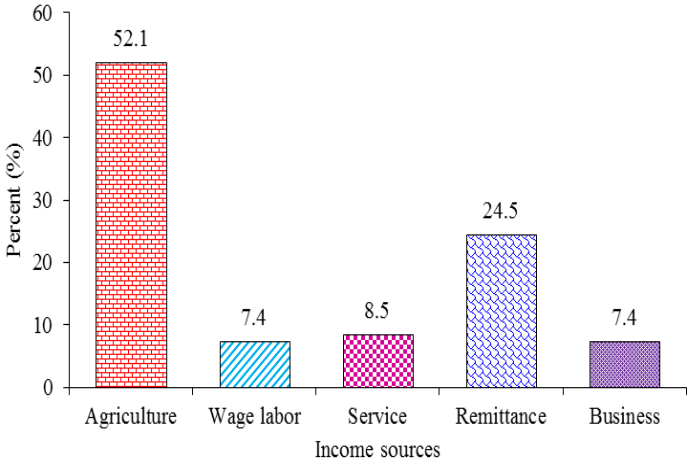


**Figure 2.** *Major source of income of the sampled household in the study area.*

12.8% each. Only 7.4% of the respondents had a bachelor's and above level of education. It predicted that the majority of the mandarin growing farmers in the study area were educated with a considerable proportion of the illiterate population.

**Distribution of respondent's family members by age group:** The age of the respondent's family members was categorized as younger age group (<15 years of age), economically active age group (15-59 years of age), and older age group (≥) 60 years of age). The study revealed that the majority of the respondent's family members were under the economically active age group (56.55%) followed by the younger age group (29.83%) and then by the older age group (13.62%).

**Distribution of major sources of income of the respondent household:** The study showed that agriculture (52.1%) was the primary source of income for most of the respondent households. A substantial number of households in the study area had remittance (24.5%), service (8.5%), wage labor (7.4%), and business (7.4%) as secondary sources of income (Figure 2).

**Livestock holding:** Livestock has been the integral component of farming for most of the mandarin growing farmers in the study area as they provide cash income in addition to organic manure for mandarin. The average population of buffalo, cow, goat, and poultry per household in the study area was 1.84, 0.59, 2.91, and 5.44, respectively.

**Time involved in mandarin farming:** The study showed that the farmers spend an average of 2.01 hours per day on orchard management and super visioning of the farm. Time spent by farmers in the field on daily basis was found within the range of 30 minutes per day to 8 hours per day.

**Involvement of family members in mandarin farming by gender:** The study revealed that male members of the household (63.48%) were highly involved in orchard management than female members (36.52%). This figure portrays that males are actively involved in mandarin farming and have greater knowledge of orchard management than females.

**Distribution of area under mandarin farming and tree population:** The average land holdings for mandarin farming per household in the study area were found to be 7.49 ropani (0.38 ha). The highest area under mandarin farming in the study area was 75 ropani (3.81 ha). The average number of mandarin trees per household was 185.93 and the average number of fruiting trees per household was 99.09.

**Distribution of mandarin trees based on the age of trees:** The average number of trees per household aged less than 5 years was 83.79, between 5 and 10 years was 32.33, between 10 and 15 years was 42.61, between 15 and 20 years was 16.76, and aged above 20 years was 8.12. It is retrieved that 54.37% of the total mandarin trees in the study area were at the bearing stage.

**Production and productivity of mandarin:** The total production of mandarin in the study area was 391.04 Mt in the year 2019/020 and 340.61 Mt in the year 2020/021. Similarly, the average productivity of mandarin in the study area was 12.39 Mt/ha in the year 2019/020 and 10.82 Mt/ha in the year 2020/021. The decrease in production and productivity might be due to several factors including climatic factors, and insect and disease incidence.

**Cost of production and income from mandarin:** It can be inferred that the farmers, in the study area, spend an average of NPR (Nepalese Rupee) 140.01 per tree on orchard management and has an average income of Rs.1230.98 per fruit-bearing tree per annum. This reflects that mandarin farming has been one of the highly profitable businesses in the study area.

**Organizational information:** The study showed that 79.8% of the mandarin growing farmers in the study area were involved in either co-operatives or farmers' groups or both. This indicates that there is harmony among farmers and they have strong organizational support. 20.2% of the farmers were not involved in any of the organizations.

**Access to Input support, training, and extension services:** While 26.6% of the farmers had not got any of the input services to support, 73.4% of the farmers had got institutional support for input services like saplings, CuSO4, pesticides, etc. from

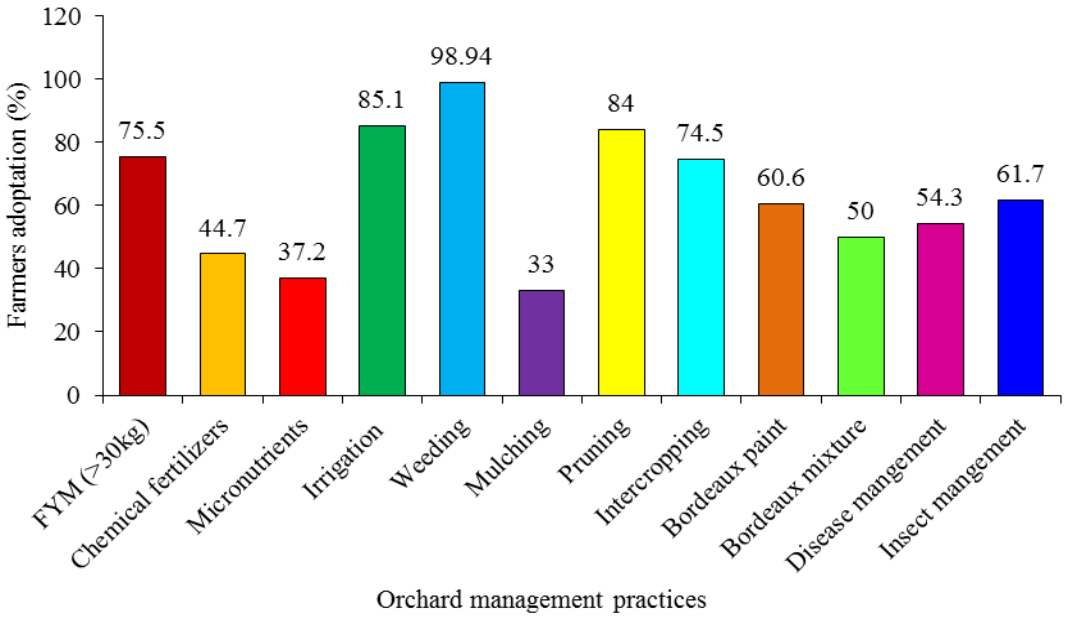


**Figure 3.** *Different orchard management practices adopted by the farmers.*

Agriculture Knowledge Center (AKC) and citrus zone. Furthermore, 53.2% of the farmers in the study area had got training and extension services on orchard management whilst 46.8% of the farmers did not have access to such training and extension services.

**Adoption of different orchard management practices in mandarin:** The study showed that 75.5% of the farmers used farmyard manure (FYM) of more than 30 kg per plant per year, 44.7% of the farmers used chemical fertilizers in their mandarin orchard, 37.2% of farmers adopted micronutrients in their orchard, 85.1% of the farmers irrigated their orchard, 98.94% farmers practiced weeding, 33% of the farmers adopted mulching practices, 84% of the farmers practiced pruning of mandarin trees, 60.6% of the farmers adopted the use of Bordeaux paint, 50% of the farmers sprayed Bordeaux mixture in mandarin trees, 54.3% of the farmers practiced disease management, and 61.7% of the farmers practiced insects insect management (Figure 3).

**Influence of socio-economic characteristics on adoption of different management practices**

**Influence of socio-economic characteristics on the use of chemical fertilizers:** The use of chemical fertilizer was positively influenced by education level, ethnic community, active population, secondary income, and extension services and negatively influenced by the area under mandarin. Through marginal effect after logistic, it is predicted that households with secondary income sources are 20% more likely to use chemical fertilizers as compared to households with no secondary income source which is significant at a 5% level of significance. Similarly, farmers who got training and extension services on orchard management have an 11% more probability of adopting chemical fertilizers in their orchards (Table 1).

**Influence of socio-economic characteristics on adoption of mulching practices:** The adoption of mulching practices was positively influenced by education level, ethnic community, active population, secondary income, the area under mandarin, and extension service. Through marginal effect after logistic, it is predicted that educated farmers are 22% more likely to adopt mulching practices as compared to illiterate farmers which is significant at a 5% level. Likewise, extension service to the farmers is likely to increase the adoption of mulching practices by 22% (Table 2).

**Influence of socio-economic characteristics on adoption of pruning practices:** The adoption of pruning practices was positively influenced by education level, ethnic community, active population, secondary income, and extension service and negatively influenced by the area under mandarin. Through logistic analysis, it is predicted that educated farmers are 3.56 times more probable of adopting pruning practices as compared to illiterate farmers which is significant at a 10% level of significance. Similarly, households with secondary income are 15% more likely to adopt pruning practices as compared to households with no secondary income source (Table 3).

**Influence of socio-economic characteristics on adoption of intercropping:** The adoption of intercropping was positively influenced by the active population and negatively influenced by education level, ethnic community, secondary income, the area under mandarin, and extension service. Through marginal effect after logistic, it is predicted that educated farmers are 15% less likely to adopt intercropping as compared to illiterate farmers. Similarly, with a unit increase in area under mandarin, adoption of intercropping is likely to decrease by 2%. Moreover, farmers who got extension services are 35% less likely to adopt intercropping. However, higher the active population in farmers' households, there is a 5% more chance of adopting intercropping in the mandarin orchard (Table 4).

**Table 1.** Influence of socio-economic characteristics on the use of chemical fertilizers.

| Chemical fertilizer | Odds ratio | Std. Err. | Z | p>\|z\| | dy/dx | p>\|z\| |
|---|---|---|---|---|---|---|
| Education level | 1.33 | 0.81 | 0.47 | 0.64 | 0.69 | 0.63 |
| Ethnic community | 1.88 | 0.94 | 1.28 | 0.20 | 0.16 | 0.20 |
| Active population | 1.11 | 0.15 | 0.78 | 0.42 | 0.03 | 0.43 |
| Secondary income | 2.26 | 1.08 | 1.70 | 0.08* | 0.20 | 0.08* |
| Area under mandarin | 0.97 | 0.03 | -1.10 | 0.27 | -0.01 | 0.27 |
| Extension services | 2.94 | 1.432 | 2.21 | 0.02** | 0.11 | 0.02** |

Source: Field Survey, 2021; Notes: ** and * indicates significant at 5% and 10% level, respectively.

**Table 2.** Influence of socio-economic characteristics on adoption of mulching practices.

| Mulching | Odds ratio | Std. Err. | Z | p>\|z\| | dy/dx | p>\|z\| |
|---|---|---|---|---|---|---|
| Education level | 3.69 | 3.06 | 1.57 | 0.12 | 0.22 | 0.04** |
| Ethnic community | 1.73 | 0.89 | 1.06 | 0.29 | 0.12 | 0.23 |
| Active population | 1.05 | 0.16 | 0.31 | 0.75 | 0.01 | 0.75 |
| Secondary income | 1.73 | 0.89 | 1.05 | 0.29 | 0.11 | 0.28 |
| Area under mandarin | 1.04 | 0.05 | 0.90 | 0.37 | 0.01 | 0.38 |
| Extension service | 3.02 | 1.64 | 2.03 | 0.04 | 0.22 | 0.03** |

Source: Field Survey, 2021; Notes: **indicates significant at 5% level.

**Table 3.** Influence of socio-economic characteristics on adoption of pruning practices.

| Pruning | Odds ratio | Std. Err. | Z | p>\|z\| | dy/dx | p>\|z\| |
|---|---|---|---|---|---|---|
| Education level | 3.56 | 2.47 | 1.84 | 0.07* | 0.14 | 0.17 |
| Ethnic community | 1.10 | 0.83 | 0.13 | 0.90 | 0.01 | 0.90 |
| Active population | 1.17 | 0.28 | 0.70 | 0.48 | 0.01 | 0.48 |
| Secondary income | 6.08 | 5.33 | 2.06 | 0.04** | 0.15 | 0.03** |
| Area under mandarin | 0.96 | 0.04 | -1.09 | 0.27 | -0.00 | 0.26 |
| Extension service | 2.99 | 2.31 | 1.43 | 0.15 | 0.09 | 0.17 |

Source: Field Survey, 2021; Notes: ** and * indicates significant at 5% and 10% level, respectively.

**Table 4.** Influence of socio-economic characteristics on adoption of intercropping.

| Intercropping | Odds ratio | Std. Err. | Z | p>\|z\| | dy/dx | p>\|z\| |
|---|---|---|---|---|---|---|
| Education level | 0.18 | 0.23 | -1.34 | 0.18 | -0.15 | 0.05** |
| Ethnic community | 0.53 | 0.33 | -1.02 | 0.31 | -0.08 | 0.34 |
| Active population | 1.58 | 0.38 | 1.88 | 0.06 | 0.05 | 0.06** |
| Secondary income | 0.86 | 0.56 | -0.22 | 0.82 | -0.02 | 0.81 |
| Area under mandarin | 0.87 | 0.06 | -1.95 | 0.05** | -0.02 | 0.09* |
| Extension service | 0.05 | 0.04 | -3.38 | 0.00*** | -0.35 | 0.00*** |

Source: Field Survey, 2021; Notes: ***, **, * indicates significant at 1%, 5% and 10% level, respectively.

**Table 5.** Influence of socio-economic characteristics on the use of Bordeaux mixture.

| Bordeaux mixture | Odds ratio | Std. Err. | Z | p>\|z\| | dy/dx | p>\|z\| |
|---|---|---|---|---|---|---|
| Education level | 2.42 | 1.52 | 1.4 | 0.16 | 0.22 | 0.14 |
| Ethnic community | 0.87 | 0.45 | -0.26 | 0.79 | -0.03 | 0.79 |
| Active population | 0.94 | 0.14 | -0.42 | 0.68 | -0.02 | 0.68 |
| Secondary income | 0.97 | 0.47 | -0.06 | 0.96 | -0.01 | 0.96 |
| Area under mandarin | 1.15 | 0.07 | 2.13 | 0.03** | 0.04 | 0.03** |
| Extension services | 4.59 | 2.34 | 2.98 | 0.00*** | 0.36 | 0.00*** |

Source: Field Survey, 2021; Notes: *** and ** indicates significant at 1% and 5% level, respectively.

**Influence of socio-economic characteristics on the use of Bordeaux mixture:** The use of the Bordeaux mixture was positively influenced by education level, the area under mandarin, and extension service whereas negatively influence by the ethnic community, active population, and secondary income. Through marginal effect after logistic, it is predicted that with a unit increase in area under mandarin, use of Bordeaux mixture is likely to increase by 4% which is significant at 5% level of significance. Likewise, farmers who got extension service are 36% more likely to use Bordeaux components, which is significant at a 1% level of significance (Table 5).

**Influence of socio-economic characteristics on the adoption of insect management:** The adaptation of insect management practice was positively influenced by education level, ethnic community, secondary income, the area under mandarin, and extension service and negatively influenced by active population. Through marginal effect after logistic, it is predicted that

**Table 6.** Influence of socio-economic characteristics on the adoption of insect management practices.

| Insect management | Odds ratio | Std. Err. | Z | p>\|z\| | dy/dx | p>\|z\| |
|---|---|---|---|---|---|---|
| Education level | 1.88 | 1.56 | 1.02 | 0.31 | 0.14 | 0.33 |
| Ethnic community | 2.14 | 1.19 | 1.37 | 0.17 | 0.16 | 0.15 |
| Active population | 0.85 | 0.13 | -1.09 | 0.28 | -0.04 | 0.28 |
| Secondary income | 1.38 | 0.70 | 0.64 | 0.53 | 0.07 | 0.52 |
| Area under mandarin | 1.20 | 0.09 | 2.34 | 0.01** | 0.04 | 0.01** |
| Extension services | 3.61 | 1.94 | 2.39 | 0.07* | 0.27 | 0.01** |

Source: Field Survey, 2021; Notes: ** indicates significant 5% level and * indicates significant at 1% level.

**Table 7.** Linear regression analysis of productivity of mandarin orchard with different management practices (R-squared = 0.5014).

| Ln Productivity (MT/ha) | Coef. | Std. Err. | t value | P>\|t\| |
|---|---|---|---|---|
| North facing | -0.05 | 0.15 | -0.31 | 0.76 |
| FYM application | 0.59 | 0.22 | 2.71*** | 0.008 |
| Chemical fertilizers | 0.39 | 0.18 | 2.12** | 0.03 |
| Micronutrient | -0.12 | 0.17 | -0.70 | 0.48 |
| Irrigation facility | 0.57 | 0.24 | 2.44** | 0.02 |
| Weeding frequency | 0.14 | 0.06 | 2.12** | 0.04 |
| Mulching | -0.047 | 0.19 | -0.19 | 0.85 |
| Pruning | -0.01 | 0.26 | -0.04 | 0.97 |
| Intercropping | 0.21 | 0.19 | 1.12 | 0.26 |
| Bordeaux paint | -0.26 | 0.20 | -1.30 | 0.19 |
| Bordeaux mixture | 0.33 | 0.18 | 1.80* | 0.08 |
| Insect management | -0.16 | 0.17 | -0.93 | 0.36 |
| Disease management | -0.01 | 0.20 | -0.03 | 0.97 |

Source: Field Survey, 2021; Notes: ***, **, * indicates significant at 1%, 5% and 10% level, respectively.

with a unit increase in area under mandarin, adoption of insect management is likely to increase by 4% which is significant at a 5% level of significance. Additionally, farmers who got extension services are 27% more likely to adopt insect management which is significant at a 5% level of significance (Table 6).

### Productivity of mandarin with different management practices

The productivity of mandarin orchards is positively and significantly influenced by FYM application, chemical fertilizers, irrigation, weeding, and Bordeaux application (Table 7). Productivity of mandarin increases by 59% in FYM applied more than 30 kg condition as compared to FYM applied less than 30 kg condition which is statistically significant at a 1% level of significance. Similarly, the productivity of mandarin increases by 39% when chemical fertilizers are applied than when chemical fertilizers are not applied which is significant at a 5% level of significance. The productivity of mandarin increases by 57% in irrigated conditions as compared to rain-fed conditions which is significant at a 5% level of significance. With the unit increase in weeding frequency, productivity increases by 14% which is significant at a 5% level of significance. Productivity of mandarin increases by 33% in Bordeaux mixture applied condition as compared to no use of Bordeaux mixture (Table 7).

Nepalese farmers are highly diversified in terms of their socio-economic characteristics. The extent of diversities varies from illiterate farmers to graduated farmers, lower-class farmers to higher class farmers, conventional farmers to hipsters, subsistence to commercial farmers, and young aged farmers to older aged farmers. Similarly, some farmers are females while some are males, some engage few hours in farming while some engage several hours in farming, some practice mono-cropping while some practice mixed farming. Correspondingly, with their diversified nature, ways and extent of practicing different orchard management practices also varies which in turn are highly associated with variation of productivity of mandarin. The findings from this study suggest that the adoption of different orchard management practices which affect the productivity of mandarin are influenced by the socio-economic attributes of farmers.

The study showed that the education level of the farmers has a significant and positive influence on the adoption of mulching practices and pruning practices. Education gives farmers a better ability to perceive first-hand information, make them aware for use of technologies, search for better opportunities and analyze the future outcome to solve their production problems (Uaiene, 2011; Ramirez, 2013; Ghimire *et al.*, 2015). Additionally, the study shows that educated farmers have a significantly low propensity for intercropping. Educated farmers are aware of the fact that intercropping with the exhaustive crops have a negative impact on the fruit yield of mandarin which might be due to tree-crop competition for nutrients, moisture, and space (Srivastava *et al.*, 2007).

A higher the number of the active population in the family, however, has a significant and positive impact on the intercropping practices. This might be due to the availability of active human resources: by utilizing which, the farmers seek the benefit from diverse crops within a small and fragmented piece of land. Though the intercropping with exhaustive crops augments the intercrop competition, intercropping with legumes has a positive impact on restoring soil fertility and enhancing the produc-

tivity of nearby crops. Similarly, the secondary income of the farmer's household has a significant and positive influence on the adoption of chemical fertilizers and pruning practices. Secondary income provides strong financial assets for the installation of the inputs and adoption of improved technologies; so farmers are more likely to adopt technologies if their households have diverse income sources (Carrer *et al.*, 2017; Carrer *et al.*, 2019; Kattel *et al.*, 2020).

Likewise, commercial farming with a large area under the mandarin farms has a significant and positive influence on the adoption of Bordeaux application and insect management practices. Perhaps, the higher adoption of management practices in commercial farming is for farming efficiency. Uaiene (2011), Mariano *et al.* (2012), and Asfaw *et al.* (2012) also reported that the larger holding is positively associated with the adoption of improved technologies. On the other hand, commercial farmers with larger areas under mandarin farming are less likely to adopt intercropping. This might be due to the fact that commercial farmers are aware of the competitive interaction of multi-crops or they eschew the management complexities of multi-cropping and focus on profiteering from mandarin only.

Furthermore, the study shows that the extension services including training on orchard management, and input subsidies have a positive and significant impact on the adoption of different orchard management practices such as chemical fertilizers, mulching, pruning, Bordeaux application, and insect-pest management. Extension services help to disseminate information and knowledge on better adoption of management practices and make aware of its benefits of it (Genius *et al.*, 2014; Mwangi & Kariuki, 2015). Extension services, however, have a significantly negative influence on intercropping. This might be due to the fact that the extension services make aware the farmers of the effect of intercropping with exhaustive crops on the productivity of mandarin (Poudel *et al.*, 2021).

As a result, the finding shows that the socio-economic attributes of the farmers have a strong influence on the adoption of different orchard management practices. Further, multiple linear regression a of different orchard management practices with productivity showed that the productivity of mandarin is highly associated with different management practices. The study reveals that effective orchard management practices like manuring and fertilizer application, irrigation, weed management, and the application of Bordeaux mixture have significant and positive impacts on the productivity of mandarin. These findings are at par with the findings of Panth *et al.* (2019); Shirgure *et al.* (2014); Al-Obeed *et al.* (2018); Huchche *et al.* (1998). Manuring and fertilizer fulfil the nutrient requirements of the plants, irrigation provides the moisture requirement of the plants, weed management reduces crop-weed competition, and the Bordeaux mixture helps in managing different diseases; all of which help in enhancing the productivity of the tree (Yadav *et al.*, 2013; Obreza *et al.*, 1993; Dorji *et al.*, 2016; Gauchan *et al.*, 1994; Tucker *et al.*, 1994). Consequently, these findings revealed that the socio-economic characteristics of the farmers influence the adoption of different orchard management practices which in succession affects productivity.

## Conclusion

Most of the farmers in the study area were male, middle-aged, educated, from Janajati Ethnic group, and had agriculture as a primary income source and remittance as a secondary income source. The socio-economic attributes of the farmers like education, secondary income source, commercial farming in the larger area, and access to extension services had a positive influence on the adoption of improved management practices. The productivity of the mandarin orchard, in turn, is positively and significantly increased under improved management practices such as farmyard manure application, application of chemical fertilizers, irrigation, weeding, and the Bordeaux application. This shows that farmers with better socio-economic conditions are more likely to adopt good agricultural practices in citrus orchards enhancing their productivity.

## ACKNOWLEDGMENTS

I would like to express my sincere gratitude to all friends who assisted in conception, design, and execution of this work. My special thanks goes to all the informants, my beloved parents, and friends for their worthy support throughout the journey.

## Declaration of conflict of interest

There is no any conflicting interest regarding the manuscript from the authors.

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