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ORIGINAL RESEARCH ARTICLE

Farmers' knowledge and adoption of improved mandarin orchard management practices in Syangja district, Nepal

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ABSTRACT

Mandarin is one of the major fruit crops in the mid-hills of Nepal. Since improved farming practices appear to offer a significant chance to boost production and revenue, a study was conducted in Syangja, Nepal with the objective to assess farmers' knowledge and adoption of improved mandarin orchard management practices and identify factors affecting their adoption. Primary data were collected by the use of pretested semi-structured questionnaire from randomly selected 97 respondents within the study area. Data were entered and analyzed using MS Excel, SPSS, and STATA, and the inferences were retrieved using the binary logistic regression model. Findings revealed that the respondents were familiar with most of the improved orchard management practices, however, there was variation in the scale of adoption of these practices. The majority (>90%) were found to practice pruning, FYM application, and weed control; however, there were relatively fewer adopters when it came to the use of Bordeaux paste (75.25%), chemical fertilizers (17.52%), mulching (57.74%), irrigation (44.33%), and soil testing and amendment (39.18%). The study showed that the adoption of Bordeaux paste and soil amendment differ significantly by gender (p=0.069 and p=0.041, respectively). Training has a positive impact on the use of Bordeaux paste (p=0.026), chemical fertilizers (p=0.075), and soil amendment practices (p=0.003). The usage of chemical fertilizers is more prevalent among people with formal education (p=0.075). Knowledge level also positively influences the adoption of mulching (p=0.014) and soil amendment practices (p=0.000). The number of trees is positively and significantly associated (p=0.008) with irrigation practice. It is recommended that expanding access to irrigation facilities and encouraging the use of the recommended amount of fertilizers, mulch, and Bordeaux paste must be prioritized in the study area.

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INTRODUCTION

The majority of Nepalese people depend on agriculture for their livelihood. It contributes to about 27.6% of the total GDP of Nepal (MoALD, 2021). Within agriculture, fruit is one of the important sub-sectors. Citrus, the genus of plants belonging to the Rutaceae family, is believed to be originated in South East Asia including South China, North Eastern India, and Burma (Langgut, 2017). Citrus cultivation is done in 62 districts in Nepal covering 46,502 ha of area (NCRP, 2021). The three economically important plants in this group include Mandarin (*Citrus reticulata*), Sweet Orange (*Citrus sinensis*), and Lime (*Citrus aurantifolia*). Mandarin is one of the major citrus species grown commercially in tropical and subtropical regions. It is grown in 6591.18 ha and its production and productivity are 156179.68 mt and 10.73 mt/ha respectively in Nepal (MoALD, 2020).

Syangja, lying in hilly areas, holds the potential for successful mandarin cultivation in terms of climatic conditions and unique topography. In Syangja, mandarin is cultivated in 1793 ha and its production and productivity are 10073 Mt and 13.52 mt/ha respectively (MoALD, 2020).

For successful cultivation and production of mandarin, various factors need to be considered, out of which orchard management is the most crucial one. It includes canopy management like training-pruning of trees, nutrient management that includes manuring and fertilizer application, intercropping, irrigation, mulching, plant protection, and soil amendment. Correct management of the canopy, water, and mineral resources is necessary for high-quality production, increased efficiency in the use of the resources themselves, and low environmental impact (Xiloyannis *et al.*, 1999). Canopy management is essential to keep the tree healthy and provide ideal shape. The best time for pruning is just after harvest and when the plant is dormant i.e., in winter, especially during Poush-Magh in Nepal (PIU, 2018). Similarly, efficient use of applied irrigation water aids in supplying a significantly higher amount of available nutrients in the soil, ensuring favorable leaf nutrient status, which collectively helped plants develop a good canopy, a prerequisite to improved bearing capacity (Panigrahi *et al.*, 2012). More than 250 species of insects and mites are known to damage citrus throughout the world. Management of insects and diseases is essential for increasing the orchard's capacity for production (Ashraf *et al.*, 2014). Likewise, mulching is one of the easiest practices we can undertake in an orchard that will produce significant results in terms of moisture conservation, temperature regulation, prevention of surface compaction, reduction of runoff and erosion, improvement in soil structure, and weed control. (Ranjan *et al.*, 2017). Appropriate and timely implementation of these management activities enhances plant physiological functions with the final outcome of economic efficiency, i.e., in terms of resource use (Dorji *et al.*, 2016).

Due to the increasing demand for mandarin in local markets as well as in various national and international markets, many farmers are attracted to its cultivation. To enhance mandarin productivity, the Program Implementation Unit (PIU) Syangja has proposed a list of improved orchard management practices that farmers should follow for optimum productivity. However, they have not been effectively adopted by mandarin growers in the district resulting in a large gap between the production potential of mandarin and its production at farmer's fields. Likewise, poor orchard management is also the major cause of the citrus decline in Nepal (Panth and Dhakal, 2019). This shows the immediate need for suitable intervention against poor orchard management practices to improve the production of the orchard as well as to motivate citrus growers for uplifting livelihood through better production. It is widely accepted that orchard management extension will be more robust when farmers' knowledge and practices are taken into account (Heong, 2002). So, the final result obtained from this study will provide baseline information on farmers' knowledge and adoption status of various orchard management practices and will serve as a prelude to developing effective strategies essential for mandarin commercialization. In addition, the target group for information dissemination can be identified and technology transfer can be strengthened by assessing the relationship of different variables with the adoption of these practices.

MATERIALS AND METHODS

Site selection and sampling techniques

The study was conducted in the Syangja district situated in the Gandaki Province between 27°52' to 28°13' long latitude and 83°27' to 84°46' long longitude (CBS, 2071). Putalibazar, Bhirkot, and Waling municipality and Arjunchaupari rural municipality were purposively chosen because these sites were major mandarin-producing areas in the district (Figure 1). A preliminary study was carried out to collect information regarding the socio-economic, demographic, and geophysical conditions of the site. Altogether 97 mandarin-growing farmers were selected by using a simple random sampling technique.

Research instrument and design

Household survey was conducted in the major citrus-producing wards at the study site. Primary data was collected with help of pretested questionnaires, Focus Group Discussions (FGDs), and Key-Informant interviews.

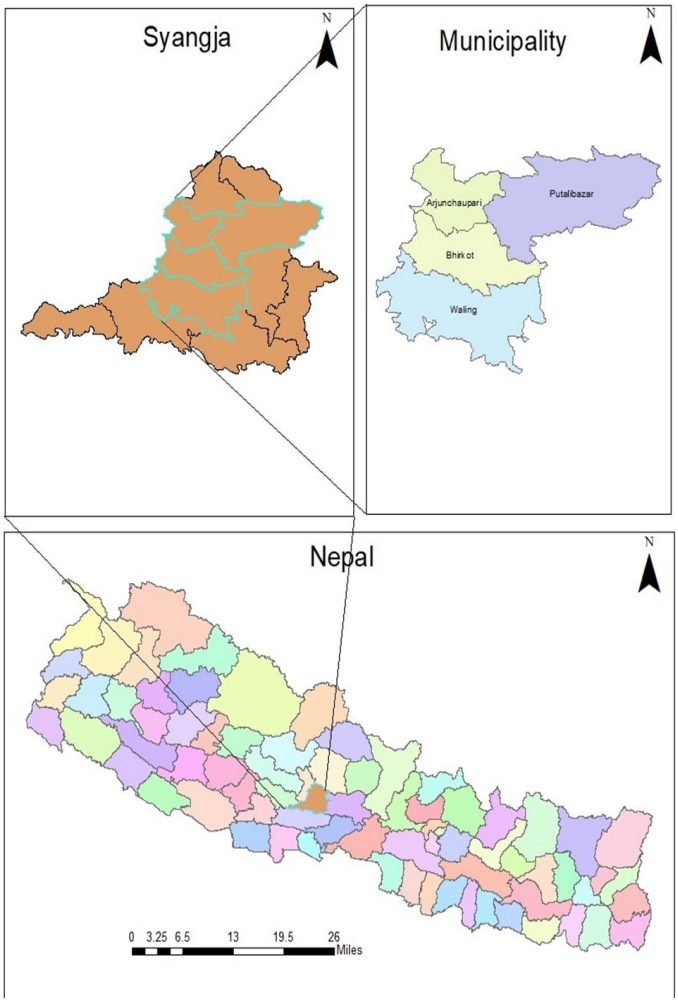

Figure 1. *Map showing the study area.*

Table 1. Description of the variables.

Variables (type)	Description of the variable
Gender (dummy)	Gender of the respondent, the decision maker in the household (=1 if the respondent is male or =0 if female)
Age (continuous)	Age of the respondent (years)
Education (dummy)	Education status of respondents (=o for illiterate or informal education, 1=Formal education)
Family Size (continuous)	Total number of family members involved in agriculture
Training (dummy)	Whether the respondent had received any training related to mandarin cultivation or not (=1 if took training, 0 otherwise)
Orchard Size (continuous)	The total land under mandarin cultivation of respondents (in ropani) (1 ropani= 0.0509 hectare)
Total trees (continuous)	Total number of mandarin trees in the orchard
Intercropping (dummy)	Intercropping practice in the mandarin orchard (0=no, 1=yes)
Experience (continuous)	Years of experience in commercial mandarin farming
Knowledge of Plant protection means (dummy)	Whether the respondent is familiar or not with the plant protection means (0=non-familiar, 1=familiar)
Knowledge of Mulching (dummy)	Whether the respondent is familiar or not with mulching practice (0=non-familiar, 1=familiar)
Knowledge of Soil amendment (dummy)	Whether the respondent is familiar or not with the soil testing and amendment (0=non-familiar, 1=familiar)

Data and data types

The primary data was collected from the mandarin farmers of the respective site and secondary data was collected from publications of the Program Implementation Unit (PIU) Syangja, Agriculture Knowledge Centre (AKC) Syangja, Ministry of Agriculture and Livestock Development (MoALD), Central Bureau of Statistics (CBS), District Administrative Office (DAO) Syangja as well as other relevant journals and articles.

Data analysis techniques

The data collected were coded, entered, and analyzed using Statistical Package for Social Sciences (SPSS) 26, MS-EXCEL 2016, and STATA 17.0 Descriptive statistics such as frequency and percentage were calculated to determine the distribution of the study variables. Both closed-ended and open-ended questions were included in the semi-structured questionnaire. Respondents had the option to choose just one answer from a range of possibilities for the closed-ended questions whereas they were free to respond to the open-ended questions without utilizing any pre-set options. The questionnaire was first pre-tested with five homes, adjusted as necessary, and then deployed to understand the knowledge base of the farmers regarding improved orchard management practices. According to the knowledge possessed by farmers, they were divided into two groups: Familiar and Non-familiar (Rijal *et al.*, 2018). Similarly, the binary logistic regression model was used to derive the inferences needed. Independent variables used in the model are provided in Table 1.

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents

The majority of respondents were male (69.07%). It indicates that household decision-making in the study area is mostly dominated by males. The mean and the standard deviation of the age of the respondents were found to be 53.52 years and 14.04 years respectively. Regarding ethnicity, the majority were Brahmin (63.92%) followed by Janajati (17.52%), Chhetri (16.49%) and Dalit (2.06%). The mean family size was 6.74 and on average, the percentage of the economically active population in the family (15-59 years) was 63.97% whereas only 50.60% of members of the family were involved in mandarin cultivation. Most of the farmers were literate with 41.24% having a secondary level of education or above, 31.96% below secondary, 11.34% informal education whereas 15.46% were illiterate. After grouping on the basis of mean and standard deviation, it was revealed that the majority of respondents had the experience of 6-25 years (53.60%). The average years of experience in commercial mandarin farming was found to be 14.83 years, ranging from 3 to 45 years. Likewise, Agriculture was the primary source of income for most of the respondents (78.35%) followed by service (11.34%), remittance (6.18%), and business (4.12%).

Farm and institutional characteristics of respondents

The distribution of land holding size of respondents was categorized into 3 groups; small (up to 4 ropani), medium (4-19 ropani), and large (20 or more ropani) by using mean and standard deviation. It was revealed that the majority of respondents had medium-sized land holding (61.86%) followed by small-sized (20.62%) and large-sized (17.52%) land holding. The mean land holding size and orchard size were found to be 11.32 ropani and 7.71 ropani respectively. The average number of mandarin trees was found to be 346, ranging from 37 to 3200 trees. It is retrieved that 56.67% of the total trees in the study area were at the bearing stage. The average productivity of mandarin in the sample population was found to be 16.87 mt/ha which is higher than the national average of 10.73 mt/ha (MoALD, 2020). 51.55% of respondents had taken training related to mandarin cultivation. 89.69% of respondents prepared recommended pit size for planting mandarin trees before establishing an orchard whereas only 42.26% of respondents maintained

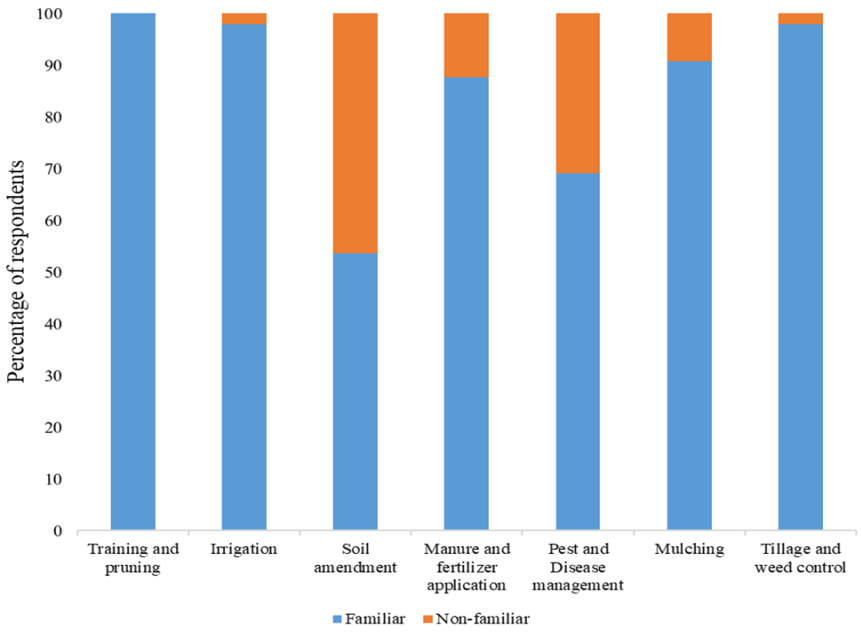

Figure 2. *Distribution of respondents based on knowledge of orchard management practices.*

recommended spacing. The planting material used in the study area was from different sources like seedlings from seeds only (22.2%), grafted saplings only (14.4%), seedlings and grafted saplings (17.8%), seedlings and layering (15.6%), and mixed (30%). 56.70% of respondents practiced intercropping in their mandarin orchard. Maize (40%), maize and millet (20%), and ginger (10%) were the most popular intercrops.

Knowledge of improved orchard management practices

The study revealed most of the respondents were familiar with training and pruning, irrigation, tillage and weed control, mulching, and manure and fertilizer application with 100%, 97.93%, 97.93%, 90.72%, and 87.63% of respondents familiar with the above practices. However, only 69.07% were familiar with plant protection means and 53.60% were aware of soil amendment needs (Figure 2).

Adoption of improved orchard management practices

Training and pruning: Training is not generally practiced in the Syangja district. However, 96.91% of respondents said they regularly prune mandarin trees in their orchards. The study revealed the majority of farmers perform pruning in the month of Poush (31.91%), Magh (43.61%), and Falgun (22.34%).

Soil testing and amendment: The study revealed only 39.58% of respondents had tested the soil of their orchards in the last 5 years. Among them, only 11 respondents practiced liming and the average rate of liming was found to be 2 kg per tree.

Irrigation: The study revealed only 43% of farmers had irrigation facilities to meet water requirements in critical periods like flowering and fruit sets. Among those, 81.39% practiced basin irrigation system whereas 18.60% had another form of irrigation installed like sprinkler irrigation.

Manure and fertilizer application: 100% of respondents used Farm yard manure in their orchards. 11.34% used other forms of organic manure like poultry manure, mustard cake, etc. in addition to FYM. The average amount of FYM used was found to be:

For trees, less than 5 years average rate of FYM used = 16.49 kg/tree

For trees, more than 5 years average rate of FYM used = 48.46 kg/tree

FYM application was mostly done during the month of Poush (30.92%), Magh (31.95%), and Falgun (34.02%). The fertilizer was applied by digging basin by the majority of respondents (84.53%) whereas few (15.46%) spread them in the field. Also, only 17.52% of respondents used chemical fertilizers in their orchards. Regarding micronutrient application, a minority (27.3%) of farmers used micronutrients in their orchards. Boron and zinc used by farmers are also given by the government as subsidies. Mainly, Zn micronutrient (trade name V-tamin) mixed with Rogor and sticker (glue-like) @1 ml V-tamin+1ml rogor per liter of water was applied by those who used micronutrients.

Mulching: 57.74% of respondents practiced mulching in their orchards. Time and labor shortages are understood to be possible reasons behind the low adoption of mulching. Dry weeds and leaves (94.64%) are the most preferred option for mulching.

Tillage and weed control: 97.96% of respondents regularly perform tillage and weed-controlling practices in their orchards. Only mechanical means of weed control are practiced.

Insect pest and disease control: The study revealed that 90.72% of the respondents prune the affected parts due to insect pests and disease, 73.19% practice hand picking of insect pests, 31.95% of the respondent were found to use traps, 25.77% of them were found to apply chemical pesticides,

Table 2. Factors affecting the use of Bordeaux paste.

Use of Bordeaux Paste	Odds ratio	Std. Err.	Z	p>|z|	dy/dx	p>|z|
Age	0.983	0.023	-0.72	0.472	-0.003	0.472
Gender	3.959	2.668	2.04	0.041**	0.243	0.069***
Education	1.528	1.119	0.58	0.563	0.069	0.583
Family Size	0.985	0.196	-0.08	0.937	-0.002	0.937
Training	4.032	2.61	2.15	0.031**	0.211	0.026**
Experience	0.999	0.028	-0.03	0.979	-0.000	0.979
Total trees	1.000	0.001	-0.33	0.745	-0.000	0.745
Knowledge of plant protection means	1.872	1.103	1.06	0.288	0.099	0.303

*** *p*<.01, ** *p*<.05, * *p*<.1

Table 3. Factors affecting the adoption of mulching practice.

Mulching	Odds ratio	Std. Err.	Z	p>|z|	dy/dx	p>|z|
Age	1.009	0.020	0.45	0.655	0.002	0.655
Gender	0.620	0.378	-0.78	0.433	-0.114	0.421
Education	1.589	0.973	0.76	0.449	0.114	0.451
Family Size	1.111	0.178	0.65	0.514	0.026	0.514
Training	1.334	0.652	0.59	0.556	0.070	0.554
Experience	0.978	0.220	-1.00	0.316	-0.006	0.316
Total trees	1.000	0.001	0.28	0.780	0.000	0.780
Knowledge of mulching	6.195	6.088	1.86	0.064*	0.411	0.014**

*** *p*<.01, ** *p*<.05, * *p*<.1

Table 4. Factors affecting the use of chemical fertilizers.

Use of chemical fertilizers	Odds ratio	Std. Err.	Z	p>|z|	dy/dx	p>|z|
Age	1.018	0.029	0.64	0.524	0.002	0.522
Gender	1.662	1.404	0.60	0.548	0.056	0.516
Education	4.768	4.554	1.64	0.102	0.144	0.030**
Training	3.153	2.053	1.76	0.078*	0.139	0.075*
Experience	0.987	0.030	-0.43	0.664	-0.002	0.664
Total trees	1.000	0.001	-0.05	0.961	-0.000	0.961
Intercropping	1.158	0.693	0.24	0.807	0.017	0.805

*** *p*<.01, ** *p*<.05, * *p*<.1

77.31% used fungicides and 28.07% practiced other indigenous means of insect pests and disease control like cattle urine. The reason for higher fungicide use compared to pesticides is the subsidization of Bordeaux mixture by the superzone office, which most of the farmers use to formulate Bordeaux spray and use it against fungal attacks.

Use of Bordeaux paste: The study reveals that 75.26% of the farmers of the study area use Bordeaux paste while the remaining 24.74% of farmers do not use it, citing, that they don't have access to it.

Factors affecting the adoption of different management practices

Factors affecting the use of Bordeaux paste: Gender and training were found to influence the use of Bordeaux paste significantly. Through marginal effect after logistic, we find that male respondents were 24.3% more likely to use Bordeaux paste than females at a 1% level of significance. Moreover, individuals who received training are 21.1% more likely to use Bordeaux paste, which is significant at a 5% level of significance. Age, family size, experience, and the total number of trees negatively influenced the use of Bordeaux paste. Farmers who attained formal education and are familiar with plant protection means are also more likely to use Bordeaux paste in their orchards (Table 2).

Factors affecting the adoption of mulching practices: Knowledge of mulching was found significant in the adoption of mulching practice at a 10% level of significance. Through marginal effect after logistic, it is predicted that the probability of practicing mulching increases by 41.1% if farmers are familiar with the practice. Age, education, family size, training, and total trees positively influenced the adoption of mulching, however, experience was surprisingly found to negatively influence the adoption of mulching (Table 3).

Factors affecting the use of chemical fertilizers: As revealed in Table 4, Training is found to be the significant variable influencing the use of chemical fertilizers at a 10% level of significance. From marginal effects after logistics, we find that the probability of using chemical fertilizers increases by 13.9% if farmers are trained. Also, it is predicted that individuals with formal education are 14.4% more likely to use chemical fertilizers at a 5% level of significance. Intercropping was positively associated with the use of chemical fertilizers, while experience and total trees negatively influenced it.

Table 5. Factors affecting the adoption of soil testing and amendment practices.

Soil testing and amendment	Odds ratio	Std. Err.	Z	p>|z|	dy/dx	p>|z|
Age	1.000	0.027	0.00	0.999	0.000	0.999
Gender	4.462	3.917	1.70	0.088*	0.249	0.041**
Education	0.612	0.638	-0.47	0.638	-0.100	0.650
Training	7.417	5.653	2.63	0.009***	0.381	0.003***
Experience	0.938	0.032	-1.89	0.059*	-0.012	0.062*
Orchard Size	1.008	0.077	0.11	0.916	0.002	0.916
Total trees	1.000	0.001	-0.07	0.94	-0.000	0.940
Knowledge of Soil testing and amendment	64.930	67.068	4.00	0.000***	0.651	0.000***

*** *p*<.01, ** *p*<.05, * *p*<.1

Table 6. Factors affecting the adoption of irrigation practices.

Irrigation	Odds ratio	Std. Err.	Z	p>|z|	dy/dx	p>|z|
Age	0.998	0.02	-0.09	0.928	-0.000	0.928
Gender	1.408	0.778	0.62	0.536	0.085	0.532
Education	1.164	0.697	0.25	0.800	0.038	0.799
Training	1.153	0.561	0.29	0.769	0.036	0.769
Experience	0.967	0.025	-1.29	0.197	-0.008	0.769
Total trees	1.003	0.001	2.70	0.007***	0.001	0.008***

*** *p*<.01, ** *p*<.05, * *p*<.1

Factors affecting the soil testing and amendment practices: Training and knowledge level was found highly significant (at a 1% level of significance) whereas years of experience and gender were found significant at 10% and 5% level of significance in the adoption of soil testing and amendment practices respectively (Table 5). Through marginal effects after logistics, it is predicted that the adoption of soil testing and amendment increases by 38.1% and 65.1% if farmers have received training and have knowledge of soil amendment respectively. Also, male respondents were 24.9% more likely to practice it than female respondents. Similarly, a decrease in years of experience by 1 year will reduce the probability of practicing soil testing and amendment by 1.2%.

Factors affecting the adoption of irrigation practices: The number of total trees was found highly significant (at a 1% level of significance) in practicing irrigation. Through marginal effect after logistics, t is predicted that an increase in total trees by 100 will result in a 10% more chance to practice irrigation. Gender, education, and training are positively associated with the adoption of irrigation practices while age and experience are negatively associated (Table 6).

Mandarin growers in syangja are highly diversified in terms of their socio-economic characteristics. As a result of this, the manner and amount to which different orchard management strategies are used also vary. The outcomes of this study imply that farmers' socioeconomic characteristics impact their adoption of various orchard management strategies. The study showed that gender is still a significant variable influencing the adoption of practices like use the of Bordeaux paste and soil testing and amendment. It contradicts the findings of (Adhikari *et al.*, 2021) which stated there is no significant association between gender and the level of adoption of improved mandarin orchard management. Women often have more difficulty than men in getting good land, credit, training, and access to markets. In addition, they are also affected by social and traditional factors. Due to this, they become a disadvantaged group in adoption especially when it comes to the introduction of innovation in their areas (Ibrahim and Klock, 2002). Conversely, the age of the respondents is not significantly associated with the adoption of any improved orchard management practices. The findings are consistent with Kharjana *et al.* (2017), who stated that the age of respondents had no significant relationship with the overall extent of adoption of improved production technology of ginger whereas they contradict (Meena *et al.*, 2017) which showed age statistically significant with adoption. Similarly, the findings contradict (Dhital and Joshi, 2016), which showed farming experience is positively associated with the level of adoption. The farming experience was found to be negatively and significantly associated with the adoption of soil testing and amendment and do not influence any of the other practices positively. Farmers' suspicion towards new practices and the propensity to "old-school" means might be the possible reasons for this. Likewise, training on orchard management practices has a positive and significant impact on the adoption of different practices like Bordeaux paste use, Chemical fertilizers use, and Soil testing and amendment. This finding is also consistent with the study from (Genius *et al.*, 2014; Ashraf *et al.*, 2015). Training is helpful to make farmers aware of the benefits of various management practices and encourage their adoption. So, it can be considered a crucial part of the extension strategy. Commercial orchards with a large number of trees, perhaps for farming efficiency, are found more likely to adopt applied irrigation (Uaiene, 2011). Finally, the knowledge level is positively and significantly associated with the adoption of mulching and soil testing and amendment practices. So, the farmers familiar with these practices are more likely to practice them. However, for other management practices like the use of Bordeaux paste, Irrigation, and use of chemical fertilizers the knowledge level was not found to be statistically significant with adoption. It seems the adoption of these practices largely depends on the severity of external constraints, and not on farmers being cognizant of their benefits.

Conclusion

Most of the farmers in the study area were male, middle-aged, and from the brahmin ethnic group. The majority prepared recommended pit size while planting trees and practiced intercropping, while only a few maintained recommended spacing. Almost half of the respondents have not received any training related to mandarin cultivation. The respondents were familiar with the majority of improved orchard management practices. The practices like FYM application, pruning, weed control, use of Bordeaux paste, insect pest, and disease management, and mulching were adopted by the majority of mandarin growers while soil testing and amendment, irrigation in critical periods, and use of chemical fertilizers were not adopted by the majority of respondents. Socio-economic characteristics like training, education level, and knowledge of related practices were positively associated with the adoption of various orchard management practices. Overall, the adoption of improved management practices was satisfactory in the study area. In light of the findings, it is recommended that strengthening the supply chain and increasing emphasis on training to encourage the use of the recommended amount of fertilizers, mulching materials, and Bordeaux paste must be prioritized and the irrigation facilities must be expanded for further development of the mandarin sub-sector in the region.

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