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ORIGINAL RESEARCH ARTICLE

Citrus growers' knowledge, attitudes, and implementation towards Good Agricultural Practices (GAPs) in Palpa, Nepal

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ABSTRACT

There is a high demand of citrus fruits in mid-hills region of Nepal. To increase its productivity, it is important to incorporate sustainable practices into orchard management. Therefore, the study was conducted in summer 2022 to understand commercial citrus farmers' knowledge on Good Agricultural Practices (GAPs) and correspond production methods of GAP aware farmers with GAP standards in the Palpa, Nepal. Altogether, 64 commercial citrus growers were interviewed with pre-tested semi-structured questionnaires for the data collection. The farmers were categorized into GAP aware and unaware based on the criteria made by the group discussion with the leading farmers and GAP standards. The result revealed that out of ten selected standards, adoption of GAP standards by GAP aware farmers are positive in relation to orchard management practices (99%), plantation (90%), harvest and storage (90%), soil management and fertilization (63%), and hygiene and environment management (61%)— with human welfare (100%) adopted by all of the aware respondents and GAP related to documentation and records (25%) were found to be least adopted. The entire aware respondents agreed to the fact that GAP produced fruit have a better appearance and improved quality, satisfies national and international standards and enhances the export potential of fruits but 97% of respondents didn't agree that adopting GAP helps in providing incentives or support from governmental organizations. The understanding of GAP among the citrus growers is limited and hence, it is crucial to organize awareness programs and provide supplementary training sessions to enhance their understanding and adoption of GAP practices.

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INTRODUCTION

Good Agricultural Practices (GAPs) is a new approach of contemplating food safety and a sustainable strategy to grow one's own food. The ever-expanding and increasingly global food economy is bringing this idea to life gradually. Both developing and developed nations are experiencing a shift in consumer choice. Food safety has become more and more important throughout time as a result of its effect on consumer health as well as the expansion of domestic and international food trade (MOAD and FAO, 2011). Chemicals that have been purposefully or accidentally added to foods, food processing techniques, and cutting-edge food technologies are the main sources of consumer concerns over food safety (Mergenthaler *et al.*, 2007). Additionally, food security and increased competitiveness in export markets are both dependent on food safety. Therefore, it is crucial to start addressing food safety at the agricultural level. For the purpose of ensuring a secure food supply, effective production techniques must be implemented both during production on farms and afterward. Good Agricultural Practices (GAP), as defined by Food and Agricultural Organizations of United Nations, are a "collection of principles to apply for

on-farm production and post- production processes, resulting in safe and healthy food and non-food agriculture products, while taking into account economic, social and environmental sustainability". Fruits are one of the agricultural products that are most vulnerable because they are frequently sold fresh and ready-to-eat (FAO, 2011). Unlike some other agricultural products that may undergo cooking or heating before consumption, many fruits are consumed raw, increasing the risk of direct exposure to any contaminants present on the fruit's surface. Therefore, fruit certification is required in order to guarantee its safety for consumption.

Nepal is nestled in the foothills of the majestic Himalayas. With the favorable agroecological diversity for agricultural production, particularly in the horticulture sector, the demand for high quality- secure fruits is also increasing in the home market (Shrestha, 2017). However, Nepal's agro-climatic diversity has not been successfully linked and leveraged for fruit production and commercial networking. In order to secure the quality and safety of their imports, several importing nations as well as domestic consumers, particularly organized retail, are demanding that producers use GAP as a prerequisite of purchase (Rosegrant *et al.*, 2006). The application of GAP promotes the best use of resources, including pesticides, fertilizers, and water, as well as environmentally responsible agriculture. Ghimire *et al.* (2012) and Mohammad *et al.* (2012) reported higher welfare and greater profits as a result of raise in crop yield by 36%, among the farmers that implemented GAP. Likewise, in a study conducted in Bhutan, Dorji *et al.* (2016) reported 27.5% increase in output and a more than 100% gain in income when better orchard management techniques were adopted. According to a research conducted in Nepal, adopting GAP enhanced farm income for rice, tomato, lentil, and ginger by 6.2% (Bairagi *et al.*, 2019).

Palpa is a mid-hill district of Nepal with favorable climate for mandarin cultivation. Citrus spp. is the major cash crop of this district where the productive area, production and productivity of mandarin in Palpa are 877Ha, 10,677Mt and 12.17 Mt/Ha respectively (MOAD, 2020/2021). The choice of the citrus as a major cash crop is influenced by various factors such as climatic suitability, market demand, and profitability. Citrus farming thus, serves as a significant source of income for farmers in Palpa, contributing to their livelihoods and economic well-being. However, in Nepal, the majority of the citrus orchards are either poorly managed or neglected, which results in poor orchard hygiene. The study conducted in Western Nepal, Myagdi showed that 72.3% of the mandarin growing farmers had experienced citrus decline problems in their orchards (Poudel *et al.*, 2022). To say that, citrus productivity in Nepal has decreased significantly as a result of planting trees closer together and at terrace edges, poor and uncertified seedlings, poor nutrition, excessive intercropping of crops, a lack of specialized training and pruning techniques, and ineffective disease and pest management (FAO, 2011). Most citrus in Nepal is cultivated organically, and if it were to be certified, it would fetch a greater price. Due to the great demand for Nepali oranges, Nepal has significant potential for exporting citrus fruits to the markets of its neighbors, particularly China, India, and Bangladesh. Certified citrus products often command a higher price in the market due to the assurance of quality and safety. Buyers are willing to pay a premium for produce with a recognized certification, which can lead to increased revenue for farmers. On that note, Verma *et al.* (2020) mentioned in his study that GAP adopters earn roughly a third more than non-adopters. Likewise, Kaini (2019) reported increase in citrus fruits yields to roughly 25 tons/ha by simply upgrading orchard management procedures, such as timely application of necessary amounts of manure and fertilizers, disease and insect management, tree pruning, mulching, irrigation, etc.

Although, Department of Food Technology and Quality Control (DFTQC), a GAP certification body in Nepal, have launched GAP checklist and is working on export of most prioritized commodity, disease and pest infestation has been a hurdle and restricting factor to citrus export. DFTQC's role involves quality control, certification, standardization, enforcement, training, and collaboration to ensure that agricultural products in Nepal comply with both domestic and international quality standards, enabling access to broader markets and promoting consumer confidence. Therefore, fruits must meet the phytosanitary regulations of the exporting nations in order to be considered an exportable good. Henceforth, GAP is a very recent concept in Nepalese sustainable and secure food production. Awareness to GAP among the citrus growers is necessary in order to increase the farm income. There has been little advancement on this front, and this research will be innovative in identifying GAP in Nepal's citrus cultivation. Henceforth, the research aims to understand commercial citrus farmers' knowledge of GAP and correspond production methods of GAP aware farmers with GAP standards in Palpa, Nepal. The study's findings will offer valuable insights to policy analysts, business proprietors, budding researchers, and other individuals with an interest in the subject. To elaborate, research findings can lead to evidence-based policy recommendations, aiding policy analysts in proposing measures that encourage farmers to adopt GAP, improving agricultural productivity, sustainability, and overall food safety. Businesses can use research insights to strategize market entry and expansion plans based on GAP compliance. Similarly, aspiring researchers can use existing research on GAP as a basis for their own studies, helping them identify gaps in current knowledge and contribute to further advancements in agricultural practices and food safety. All in all, citrus that is farmed organically sometimes struggles to find a market, but GAP certification can help producers to stand in a competitive market fetching better price. Therefore, the discrepancy between farmers' practices and good agricultural practices was revealed by this study.

MATERIALS AND METHODS

Study site

The study was carried out in Palpa district of Lumbini province, Nepal, in the command area of the Prime Minister Agriculture

Modernization Project (PMAMP), Project Implementation Unit (PIU), Citrus Zone, Palpa. Among the 3 rural municipalities—Bagnaskali, Ribdikot and Rainadevi Chahara—under command of citrus zone, commercial farmers of Rainadevi Chahara (Ward No. 4 and 5) and Ribdikot (Ward No. 3 and 7) were selected purposively. These regions were chosen for the study because they constitute the primary citrus growing domain and the highest number of registered commercial farmers on the zone.

Sampling procedure and determination of sample size

A list of citrus growers from selected rural municipalities was provided by citrus zone, PMAMP, PIU, Palpa and the list was used as the sampling frame to select the respondent farmers. Simple random sampling techniques without replacement was followed. For this, lottery system of sampling procedure was applied. Sample size was estimated using Cochran formula (For Smaller Population) (Cochran,1997):

$$n = \frac{n0}{1+(n0-1)/N} \quad \text{(i)}$$

$$no = \frac{Z^2.\ P\ (1-P)}{e\text{^}2} \quad \text{(ii)}$$

Where, no = Cochran's sample size recommendation i.e 68.06 (at 90% confidence level N is the population size, n is the new, adjusted sample size, e: desired level of precision, the margin of error, p: the fraction of the population (as percentage) that displays the attribute, and z: the z-value, extracted from a z-table of the 986 commercial mandarin growing farmers, total sample of 64 farmers was selected.

Research design

Personal interviews were used for the data collection process. The respondents were questioned in order to gather the desired information based on the interview schedule and checklist. The interview schedule comprised of questions related to different production techniques that the farmers were employing in their orchards in order to compare their production techniques with the GAP standards. To complement the data and information from the scheduled interviews and to gather more qualitative data, Focus Groups Discussions (FGD) were conducted. Data from both primary and secondary sources were gathered and examined.

Primary data

Pre-testing: The interview schedule was pre-tested prior to administering to the actual respondents for checking the reliability and validity of interview schedule. The pre-testing was done on 10 percent respondent near to study area. The correction was made in the final interview schedule.

Questionnaire survey: The questionnaire survey was focused on the awareness of GAP among the farmers. The information about the household, socio-economic status, perception of farmers about GAP and the extent of GAP adopted if aware were collected. The questionnaire was used to collect information from the randomly selected registered farmers in Rainadevi Chahara and Ribdikot Rural Municipality of Citrus Zone, PIU Palpa.

Secondary data

The secondary data related to citrus production was obtained from different institutes and organizations such as Agribusiness Promotion and Marketing Development Directorate, Ministry of Agriculture and Livestock Development, Central Bureau of Statistics, Project Implementation Unit, Palpa, Fruit Development Directorate, Food and Agriculture Organization, etc. It comprised of statistical data which were previously reported by the above-mentioned organizations but is being repurposed to address the research objectives.

Data analysis technique: Data was entered in the Statistical Package of Social Sciences (SPSS-19) software and analyzed using SPSS-19 and Microsoft Excel-2019. Mean, standard error of mean, index of agreement, t- test were used to analyze the data.

Descriptive analysis: The farmers were categorized into two groups: Aware of GAP and Unaware of GAP. The data analysis and comparisons were made on these categories in order to derive results. Farmers that comply to at least seven of the given ten parameters were considered GAP aware and are illustrated in Table 1.

Table 1. Parameters for categorization of GAP aware and unaware farmers'.

Parameters	Criteria to be GAP aware
Planting materials	Practices of using disease free seedlings
Plantation method	Must dig pit of $1m^3$
Soil management and fertilization	Apply FYM and chemical fertilizers about 75% to 100% of recommended dose
Water management	Irrigate orchard at least in 3 stages: new growth and flowering, fruit setting, fruit harvest and early stage of fruit growth if the soil is dry and must manage drainage system
Crop protection	Integrate IPM system and knowledge of use of registered pesticides only
Other management practices	Carry out training pruning and weeding practices
Harvest and on-farm processing and storage	Must consider maturity indices, use ladder crates, bags during harvesting and must sort and grade fruits and store fruits in appropriate environment after harvesting
Hygiene and environmental management	Safe disposal of pesticides containers, separate decomposable and non-decomposable wastes and minimize non-recyclable wastes
Human welfare	Provide decent wages and appropriate working hours
Document and records	Maintain records of farm

Perception of farmers towards GAP

The farmers' perception towards GAP was analyzed by using different variables. The perception was analyzed on a scale of strongly agree, agree, neither agree nor disagree, disagree and strongly disagree. Perception towards GAP was analyzed by using an index of agreement. The frequency of agreement was calculated by the summation of frequency of response of scale as strongly agree and agree and frequency of disagreement calculated by the summation of frequency of response of scale as neither agree nor disagree, disagree and strongly disagree. Index of agreement was calculated by using formula:

Index of agreement= (Frequency of agreement- Frequency of disagreement)/ n

Where n= total sample size

The value of the index of agreement may range from -1 to 1. When the value of index of agreement is greater than 0.5 then the variable is considered to have positive perception whereas when the index of agreement is less than 0.5 then the variable is considered to have negative perception.

GAP application by farmers

A GAP framework for fruits and vegetables made by the United Nations Food and Agriculture Organization was used as a standard for evaluating the extent of GAP application by the aware citrus farmers. Descriptive statistics was used to evaluate the extent of GAP application in percentage. The extent of GAP application was analyzed under different categories: planting materials, plantation, soil management and fertilization, water management, crop protection, orchard management practices, harvest and on-farm processing and storage, hygiene and environmental management, human welfare and document and records.

RESULTS AND DISCUSSION

Awareness of farmers about GAP

Out of 64 respondents of study areas only 20 (31.25%) respondents were aware about good agricultural practices while 44 (68.75%) respondents were unaware about good agricultural practices. There is less awareness among farmers because specific GAP focused trainings were not conducted in the research area. Conducting GAP training programs in the future can significantly impact awareness and adoption rates by enhancing skills, and best practices, providing access to resources and support, promoting environmental sustainability, and showcasing the economic and social benefits of adopting GAP in citrus farming. To say that, Joshi *et al.* (2019); Sedhai *et al.* 2022 in their study also mentioned training as an another tool to aware farmers about new technology and thus as an effective role in motivating farmers to adopt GAP. Also, among GAP aware farmers approximately 90% were found to have learned through extension agents and rest through social media/newspaper which is similar to the findings of Joshi *et al.* (2019). Extension agents provide direct, personalized communication and guidance to farmers, addressing their specific needs and concerns. Additionally, farmers typically trust information coming from extension agents due to their expertise and established relationships, increasing the adoption rate of GAP. Dhital & Joshi, 2016 supported that educated farmers are more aware, exposed to technology and better understand and adopt them. Likewise, Bernier *et al.* (2015) emphasized in his study the necessity of better extension services and training for adoption of new innovation.

Table 2. Distribution of the socio-economic and demographic characteristics (continuous variable) of the sampled household with farmers' category.

Variables	Overall (n=64)	Farmers' category		Mean difference	t- value
		GAP aware (n=20)	GAP unaware (n=44)		
Age	46.58 (11.71)	47.60 (13.19)	46.11 (11.10)	1.49	0.47ns (p=0.64)
HH size	6.31 (1.69)	6.10 (1.55)	6.41 (1.77)	-0.31	-0.67ns(p=0.50)
Male members of HH	3.38 (1.13)	3.40 (0.94)	3.36 (1.22)	0.04	0.12ns (p=0.91)
Female members of HH	2.89 (0.89)	2.60 (0.75)	3.02 (0.93)	-0.42	-1.79ns(p=0.08)
Total land holding (ha)	1.16 (0.87)	1.18 (0.91)	1.15 (0.87)	0.03	0.152ns(p=0.8)
Total citrus production land (ha)	0.71 (0.50)	0.71 (0.52)	0.70 (0.50)	0.01	0.12ns (p=0.90)
Number of bearing trees	289.38 (196.42)	357 (260.26)	258.64 (153.29)	98.36	1.57ns (p=0.12)
Number of non-bearing trees	215.39 (214.83)	315.75 (322)	169.77 (122.36)	145.98	2.64** (p=0.011)
Price/kg	66.48 (5.54)	70.25 (6.78)	64.65 (3.84)	5.59	4.18*** (p=0.001)

Notes: Figures in parenthesis indicate standard deviation; p-values are the result of t-test, *** , ** indicates 1%, 5% level of significance respectively; Source: Field Survey, 2022.

Table 3. Means of perception of respondents towards GAPs (n = 20).

Statements	N	Mean	Std. Deviation
Assistance in obtaining government support	20	2.70	.801
Boosts farmers' earnings	20	3.70	.865
Demands time	20	3.90	.718
Fruits satisfies national and international standards	20	3.95	.605
Efficient at minimizing pests and diseases	20	4.00	.858
Improve the export potential of fruits	20	4.20	.696
The fruit has a better appearance and improved quality.	20	4.35	.587
Valid N (listwise)	20		

Source: Field Survey, 2022.

Table 4. Perception of respondents towards GAPs (n =20).

Statements	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)	Index of agreement
GAP						
Produced fruit have better appearance and improved quality	45.0	55.0	0.0	0.0	0.0	1
Demands time	15.0	65.0	15.0	5.0	0.0	0.75
Boosts farmers' earnings	15.0	50.0	25.0	10.0	0.0	0.55
Efficient at minimizing pests and disease	35.0	45.0	20.0	0.0	0.0	0.9
Assistance in obtaining government support	20.0	30.0	50.0	0.0	0.0	-0.3
Fruit satisfies national and international standards	65.0	35.0	0.0	0.0	0.0	1
Improves export potential of fruits	50.0	50.0	0.0	0.0	0.0	1

Source: Field Survey, 2022.

Perception of respondents towards GAPs

Perception of respondents toward GAP was analyzed by using a five-point Likert scale analysis. The five-point Likert scale was considered an interval scale. The mean was very significant. A score of at least 3.5 indicated positive reactions on a scale with values ranging from 1 to 5. From 1 to 1.8, the scale denoted a strong disagreement. The range 1.81 to 2.60 denoted disagreement. Neutral is denoted from 2.61 to 3.40; agree from 3.41 to 4.20; and strongly agree from 4.21 to 5 (Pimentel, 2010). The perception of farmers towards GAP was found to be positive. The entire respondents agreed to the fact that GAP awareness and adoption led to the production of fruits with better appearance and improved quality, demands time, boosts farmers' income, was efficient in reducing pests and diseases, fruits thus produced help meet national and international standards and enhances fruits export potential. About 97.0% respondents disagreed that GAP adoption helped them to get any incentives or government support (index= -0.3; Mean= 2.70). The findings were similar to the Sedhai *et al.* (2022) who reported 61.5% of disagreement. The government might be allocating its resources to other sectors like enhancing crop diversity, incentives on farm inputs, production and hence specifically GAP adoption might not have received a high priority. The lack of support for GAP adoption can lead to a widening gap in knowledge and skills among farmers. Farmers may miss out on modern farming techniques, innovative technologies, and best practices, hindering their overall growth and development. 55.0% respondents agreed that GAP increases farmers income (index=0.55; Mean= 3.70), which is in line with the study done in Malaysia where the income of large-scale farmers who adopted GAP was 1.7 times higher compared to farmers who did not practice GAP (Islam *et al.*, 2012). While, 75.0% respondents agreed that GAP practices are time consuming process (index= 0.75; Mean= 3.90).

Production practices of GAP aware farmers in accordance with GAP standards

Planting materials

Out of 20 GAP aware respondents, 75% of commercial citrus growers used both grafted and seedlings from seed that are completely disease free. However, only 25% exclusively use seedlings from seed as plant material. Farmers primarily use the side and cleft grafting technique since it is a very simple and effective grafting method. Furthermore, the vast majority of farmers (43.8%) said they purchase seedlings from private nurseries, while 20.3% said they operate their own nurseries.

Plantation

Out of 20 GAP aware respondents, all of them dug the pit of $1m^3$ for transplanting and practice appropriate planting time i.e., July -August (Asar-Shrawan). Pit digging before two months of transplanting the seedlings and leaving pit open for 15-20 days prior to fertilization, is therefore, practiced among the citrus growers in Palpa. Likewise, 70% of respondents have appropriately selected the orchard site. A good orchard site includes market accessibility, proper orientation (north-east facing), shorter distance from home, maximum sunlight hours received etc.

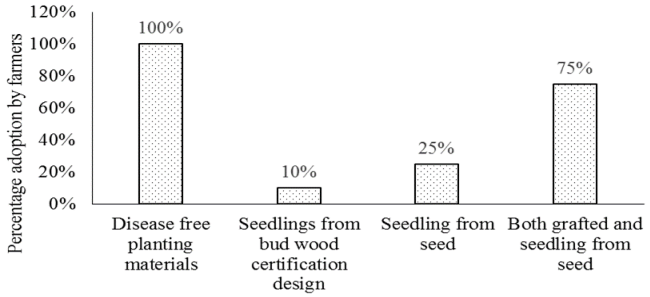

Figure 1. *Percentage of aware respondent farmers adhering to GAP related to planting materials. Source: Field Survey, 2022 .*

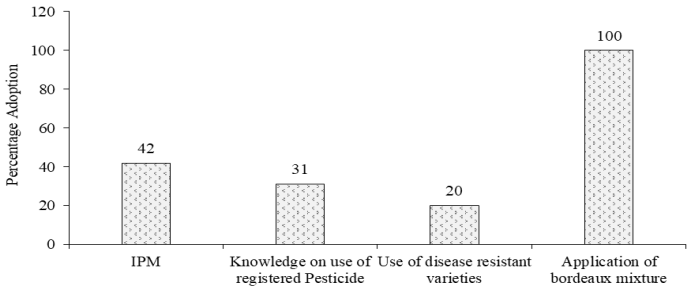

Figure 2. *Percentage of aware respondent farmers adhering to GAP related to crop protection (Source: Field Survey, 2022).*

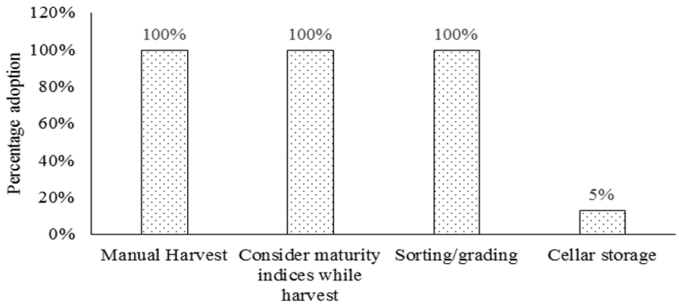

Figure 3. *Percentage of aware respondent farmers adhering to GAP related to harvest and storage (Source: Field Survey, 2022).*

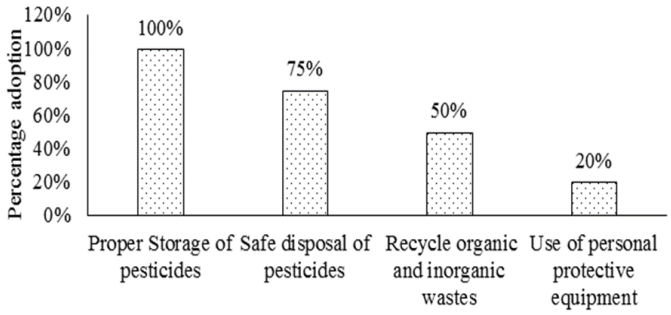

Figure 4. *Percentage of aware respondent farmers adhering to GAP related to hygiene and environment management (Source: Field Survey, 2022).*

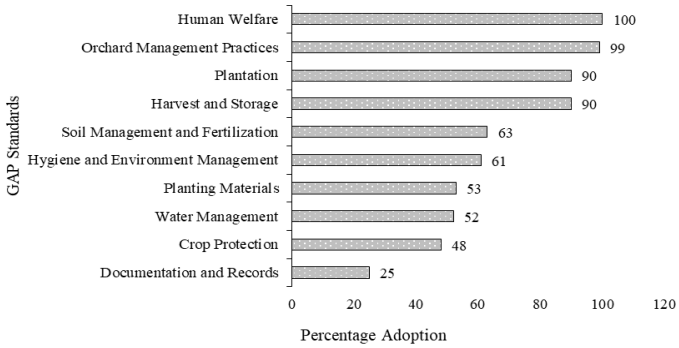

Figure 5. *Percentage adoption of GAP standards by GAP aware farmers (Source: Field Survey, 2022).*

Soil management and fertilization

Only 40% of the aware respondents used a recommended dose of chemical fertilizer i.e., 200 gm Urea, 200 gm DAP, 250 gm Potash per pit at the time of pit filling (2 months prior to transplanting). While 85% of them used organic manure to grow their citrus. Farmers generally prefer 2-3 bamboo basket of FYM, compost manure, ash 2 kg and bone meal 2kg per pit as an organic fertilizer to citrus trees.

Water management

The majority of aware responders (59%) rely on rainfed irrigation for their citrus orchards. The farmers' most pressing issue in Palpa district is the irrigation dilemma. For that reason, irrigation scheduling in the orchard is very important. Water requirement during peak period i.e., flowering, fruit setting, after harvest and during new growth is critical. Only 38% of them monitored soil moisture manually prior scheduling one. Likewise, 78% of the respondents followed water saving and recycling practices. They used plastic ponds, cement ponds and ferrocement jars for water harvesting. Few of the commercial farmers had year-round water supplies like streams, hand pumps, and drinking water, while majority of farmers only had seasonal water supplies like rainwater.

Crop protection

42% of GAP aware respondents reported use of Integrated Pest Management (IPM) approaches in the orchard. Practices often consist of; soil solarization of pit, intercropping, mulching, interculture, use of yellow sticky traps for black flies and citrus aphid control, use of pheromone trap against fruit flies, proper fertilization, chemical control, irrigation scheduling, proper site selection, collect and destroy infected twigs, leaves, fruits etc. Only 31% of them have a knowledge on use of registered pesticides or any form of chemical crop protection measures. 20% of the farmers use disease resistant varieties i.e., rootstock from trifoliate orange (*Poncirus trifoliata*), citrange (*Citrus sinensis* P. trifoliata*). Likewise, 100% of the respondents have a proper knowledge on use of Bordeaux mixture in the citrus trees for crop protection.

Orchard management practices

98% of respondents had used mulching. While, 100% farmers practice training- pruning and weeding in the citrus orchard. After weeding and manuring, they generally apply dry leaf mulch to a thickness of 8cm in the basin. Farmers mainly practice training/pruning on December-January by removing rootstock branches 3 feet long from the soil, use secateurs for the process and apply recommended dose of Bordeaux paste after the cut (100g copper sulphate: 150g lime: 1 liter of water).

Expansion of production area

Number of non-bearing trees for GAP aware farmers was found higher than unaware farmers. This difference can be attributed to the fact that farmers are expanding their production areas as part of PMAMP, PIU Palpa's effort to increase the citrus production area under the area expansion program. Several

seedlings are just planted or of age less than three. Therefore, they are non-bearing for now but as soon they reach to bearing age (3-5 yrs.), it is certain that they'll start giving the fruits. Expansion in production area therefore, offers an opportunity to promote sustainable farming practices to ensure long-term environmental health and productivity. Henceforth, the number of bearing and non-bearing trees in the orchard will also be determined by the grower's ability to properly maintain the orchard by adopting better management practices. Better management practices by farmers with respect to bearing trees was mentioned in the work of Waghmod *et al.* (2020).

Harvest and storage

100% of GAP aware farmers harvest citrus manually by the use of ladder, they consider maturity index prior harvesting and perform sorting and grading of fruits prior to selling. Maturity indices are based on fruit peel color, fruit size, weightiness and fruit aroma. Likewise, grading/sorting are based on size of fruits manually. Storage facility for precooling of fruits is not much available. Despite the fact that 5% of farmers had a cellar for storing their fruits, the majority of farmers typically stored their produce in their own homes. Citrus can be stored up to 3 months in cellar storage after the harvest.

Hygiene and environmental management

100% of the GAP aware farmers properly store the pesticides in the store room away from food and water source. They also make sure the pesticide is not in reach of the children. Likewise, 75% of the respondents disposed the containers they use for chemical control safely. Some share excess of pesticides to neighbors, wash properly the containers after use, dispose to landfill sites, while some keep it for next season crop. While 25% of respondents were found burning the cans after use. Only 20% of respondents use personal protective equipment while spraying fertilizers and pesticides. Majority of them preferred masks, gloves and leather boot which is more accessible. They try to minimize non-recyclable waste and recycle organic and inorganic waste. Organic trash is typically recycled by farmers into farm and household compost manure, while inorganic waste, such as plastic bottles are recycled to grow flowers.

Human welfare

All the aware respondents (100%) paid decent wages to the labor and defined acceptable working hours for labors with maximum of 7 hours of work per day.

Documents and records

25% of aware farmers only keep any form of farm and crop records while 75% of the farmers do not maintain records. Farmers who kept records of their farming activities said that doing so had aided them in monitoring their operations and making the necessary plans for the best outcomes.

Adoption level of GAP standards

The overall level of adoption of 10 standards among GAP aware commercial citrus growers in Palpa district reported 100 % compliance with the standards of human welfare. The least adopted standard is documentation and records (25%) followed by crop protection (48%), water management (52%), planting materials (53%), hygiene and environment sanitation (61%) and soil management and fertilization (63%). All in all, improving GAP awareness and adoption positively impacts farmers' income by increasing productivity, improving fruit quality, providing access to premium markets, and promoting sustainability which therefore, can make a huge difference in improving livelihood of citrus growers in Palpa. It also enhances the safety and quality of citrus production, meeting consumer demands for safe, healthy, and sustainably grown produce. Hence, further awareness on GAP adoption is required in the region.

Impact on fruit price

As a result of the nicer, disease-free appearance of fruits in terms of size and compactness, GAP adoption helped farmers earn a good price/kg—NRs.70.25/kg for GAP aware and NRs.64.65/kg for GAP unaware farmers. The study supports Verma *et al.* (2020) who mentioned GAP adopters earn roughly a third more than non-adopters. Also, study conducted by Aydın & Aktürk, (2018) in peach and cherry showed GAP resulted in increased relative profits. Danquah *et al.* (2015) also reported that implementing GAP increases the benefit-cost ratio of maize and cowpea by 36.1–72.8% and 11.1%–19.5%, respectively. As a result of better fertilization management practiced by GAP aware farmers and good price/kg demanded by GAP crops, financial situation of GAP adopting farmers can be enhanced. Laosutsan *et al.* (2019) in his findings also validates the similar conclusion. Consequently, farmers can be successful in increasing their income and overcoming the high production expense.

Challenges in GAP adoption

Farmers generally found difficult to manage the orchard, and stated that the process involves multiple steps and meticulous observation is required to obtain the significant results. Therefore, the study is similar to the findings of Joshi *et al.* (2019); Sedhai *et al.* (2022). Farmers mentioned following best practices for orchard management, including pruning, grafting, thinning, canopy management, keeping records and so on is very tiring specially for small holders' farmer who have to manage the orchard by their own.

Seedling certification

Despite the fact that 35.9% of respondents used seedlings from Citrus Development Centre (CDC); Palpa, there is minimal seedling certification and monitoring available at the field level. This is another reason why farmers still don't have their planting materials certified. It is to be noted that in the study area, the farmers use visual observation as the primary criteria to determine if seedlings are disease-free. They rely on specific visual indicators such as the absence of leaf curling, changes in leaf color, leaf spots, blight, and other visible signs of disease. If

seedlings do not exhibit these symptoms, the farmers consider them to be disease-free. Relying on visual indicators alone might result in underestimating the severity of a disease. Therefore, with an aim to distribute healthy seedlings CDC, Palpa has initiated a bud wood certification block. The utilization of certified budwood significantly decreases citrus pathogens, particularly highly damaging ones, across a region or nation (Vapnek, 2009). As a result, profitability increases with certified trees, and growers increasingly request them because thriving citrus orchards can endure for multiple generations. However, only 10% of GAP aware farmers in the Palpa are using seedlings that have been bud wood certified.

Conclusion

Although, farmers in the district are not specifically trained about good agricultural practices, majority of GAP aware respondents have adopted GAP standards to some level. Also, most of the GAP aware farmers have a positive perception towards it which implies they are obtaining good outcomes for employing good agricultural techniques. However, 97.0% respondents disagreed that GAP adoption helped them to get any incentives or government support. Therefore, awareness among the GAP standards and bud wood certification in high income crop like citrus is an important aspect that should come into consideration by government bodies and they should provide services accordingly. Since the majority of farmers in the region are focused on commercial citrus cultivation, it is important to note that their understanding of Good Agricultural Practices (GAP) is limited. Although, adoption of GAP standards by GAP aware farmers are positive in relation to human welfare (100%), orchard management practices (99%), plantation (90%), harvest and storage (90%), soil management and fertilization (63%), and hygiene and environment management (61%); many farmers are unaware of the benefits and implementation of these practices. To address this issue, it is crucial for relevant authorities to organize awareness programs and provide supplementary training sessions. Such initiatives can greatly enhance farmers' knowledge and adoption of GAP, resulting in improved market value for their citrus crops.

DECLARATIONS

Author contribution statement

Conceptualization: B.O.; Methodology: B.O and B.R.; Software and validation: B.O., B.R. and D.B.; Formal analysis and investigation: B.O.; Resources: B.O.; Data curation: B.R.; Writing—original draft preparation: B.O.; Writing—review and editing: B.R., B.O., and D.B; Visualization: D.B.; Supervision: D.B.; Project administration: B.O.; Funding acquisition: B.O. and D.B. All authors have read and agreed to the published version of the manuscript.

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