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Economic Analysis of Acid Lime Production and Marketing in Nepal: A Benefit-Cost Perspective from Nawalpur East District

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Abstract: Acid lime plays a crucial role in the livelihoods of many Nepali farmers and holds substantial promise for local economic development. This study analyzed the economic aspects of acid lime production in three municipalities of the Nawalpur East district of Nepal: Madhyabindu, Bulingtar, and Bungdikali, and sought to identify the concerns and potential related to acid lime marketing and manufacturing. Data were gathered from 96 acid lime producers using a semi-structured questionnaire from May 2022 to July 2022. The average areas of acid lime cultivation and productivity were 0.387 ha and 3.061 mt ha^{-1}, respectively. The production cost of acid lime was Rs. 104.82 kg^{-1}. The rental values of land and labor costs ($p=0.30$) were the highest influencing elements at 35.99% and 19.71%, respectively. Other analyzed factors included the cost of fertilizer ($p=0.20$), plant protection ($p<0.01$), Bordeaux-micronutrients ($p=0.35$), and farm management ($p=0.18$). Benefit-cost analysis revealed a ratio of 0.80 and mean gross margin of Rs. -19.82 for acid lime production. The major problem for the production of acid lime was the lack of irrigation, whereas the lack of storage was found to be a major market problem and thus needed careful attention from the relevant authorities. This examination indicated that acid lime production is a practical choice for Nepali farmers in the countryside; however, there is a need for improvement in production management. This also suggests that acid lime farming has the potential to become a successful export-focused business in the long run in the Nawalpur East district of Nepal.

Keywords: *Benefit-cost ratio, Bordeaux, enterprise, gross margin, scaling*

Introduction

Citrus aurantifolia Swingle, commonly known as acid lime, is a member of the Rutaceae family and is believed to have originated in the southern slopes of the Himalayas and northeastern regions of India (Asati et al., 2020). This tropical and subtropical fruit is of significant importance, particularly in Nepal, where it ranks as the third most prominent citrus crop after mandarins and sweet oranges (MOALD, 2020). Acid lime thrives in climates ranging from tropical to subtropical, with cultivation extending up to altitudes of 1200 meters above sea level (Thirugnanavel et al., 2007). Owing to its health benefits, acid lime is preferred for its appetizing qualities, stomachic properties, and antioxidant attributes (Thirugnanavel et al., 2007). Furthermore, lime peel oil and peel powder have extensive applications in soap and cosmetic industries (Debaje & Ingale, 2011).

Citrus cultivation in Nepal is a high-value agricultural activity that is the highest priority of the Master Plan for Horticulture Development (Shrestha et al., 2012). Acid lime cultivation prevails from the fertile terai plains to the lofty highlands, and from the eastern to western regions of Nepal. Lime cultivation occupies 8,587 hectares, yielding a total production of 46,118 tons and a productivity rate of 8.47 mt ha^{-1} (NCFD, 2020). Notably, in the eastern region of Nawalpur, 20 ha are dedicated to acid lime cultivation, with a productive area of 12 hectares, a production output of 310 mt, and a productivity rate of 25.83 mt ha^{-1} (MOALD, 2020).

However, despite the persistent efforts of the government and promising prospects for mid-hill citrus production, farmers in this sector face a multitude of challenges. These challenges include inadequate marketing infrastructure, limited access to market information, insufficient physical facilities, and a lack of marketing extension services (Chhetri & Ghimire, 2023a; Chhetri & Ghimire, 2023b). Additionally, price volatility and small-scale production concerns further compounded these difficulties (Ghimire et al., 2023). Disorganization among farmers exacerbates their predicament, rendering them vulnerable to exploitation by intermediaries seeking to maximize their profits (Sharma, 2006). In contrast to cereals, the marketing of horticultural commodities, such as fruits and vegetables, presents unique difficulties owing to their perishability, seasonality, bulkiness, and specialized handling requirements (Gandhi & Namboodiri, 2002; Ghimire & Chhetri, 2023a). Notably, Nepalese citrus has a limited market presence, spanning only 3-4 months. Research conducted by MDD (2001) underscores the challenges faced by high-hill farmers in acid lime production, which has led to declining interest among them. In light of these circumstances, it is imperative to assess the viability of acid lime farming by acquiring comprehensive information on production costs, marketing margins, gross margins, benefit-cost ratios, and overall profitability. This study primarily examines the economic aspects of acid lime production and marketing. The datasets derived from this study provide invaluable insights to a range of stakeholders, including farmers, entrepreneurs, investors, insurance agencies, and policymakers. This research has the potential to contribute valuable knowledge to both the academic and practical aspects of acid lime cultivation in Nepal.

In the subsequent sections, we delve deeper into the various facets of acid lime production and marketing. In Section 2, we provide detailed information about the methodology of the study, study site, and its relevance to acid lime cultivation. Section 3 explores the results and discussion of the study highlighting production processes and associated costs, shedding light on the economic aspects of acid lime farming and the marketing landscape, including price volatility and market dynamics. Finally, in Section 4, we summarize our findings, highlight their implications for the stakeholders mentioned earlier, and reveal their limitations and future research possibilities.

Materials and Methods

Study site

The research was carried out in citrus blocks in three municipalities (Bulingtar and Baudhikali rural municipalities and Madhyabindu municipality) of the Nawalpur East district (Figure 1), from May 2022 to July 2022, based on the recognized production site for acid lime through the Prime Minister Agriculture Modernization Project (PMAMP) database. It is located at 27°19′ N latitudes and 83°24′E longitudes.

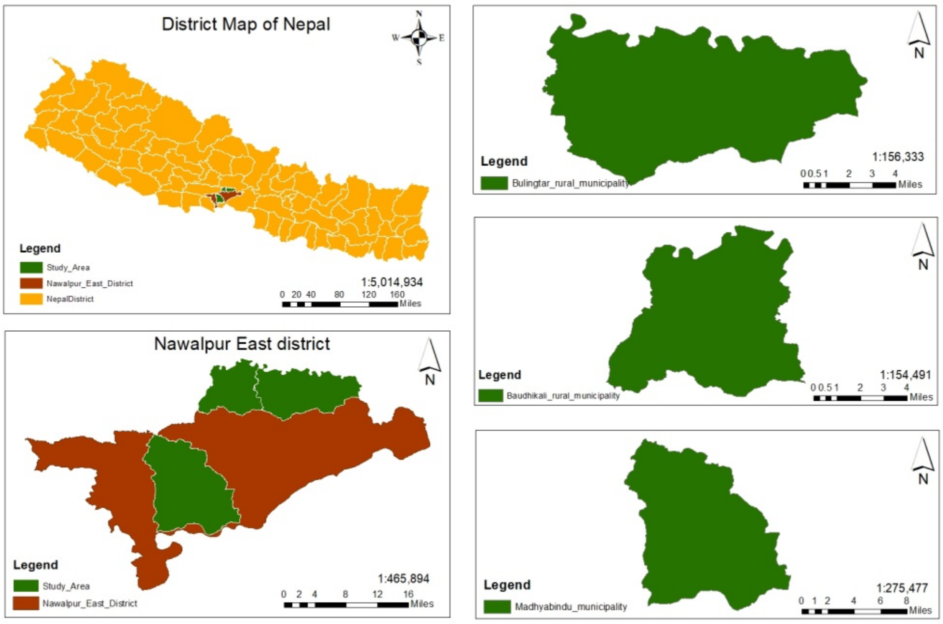

Figure 1 - Map of Nawalpur East district showing the study area

Sampling and data collection method

Among all the farmers who grew citrus, 32 acid lime-growing farmers were selected from each municipality. A straightforward random sampling technique was applied to obtain necessary data from the area. A semi-structured questionnaire was created and administered to each individual grower to collect primary data for the study, as described by Ghimire and Chhetri (2023b) and Ghimire and Gyawali (2023). To ensure the reliability and validity of the questionnaire, it was pretested before the field survey. After administering the questionnaire to 5% of the farmers in the nearby area, necessary adjustments were made as required.

The primary data were collected from the farmers of the site who have been experiencing the citrus situation for many years (Subedi & Timsina, 2023). The primary method used for data collection involved engaging with farmers to gain insights into their experiences, gathering up-to-date information on acid lime, and identifying the actual problems faced by citrus farmers. To collect primary data, a combination of methods was employed, including questionnaires, key informant interviews, and focus group discussions (Ghimire & Chhetri, 2023b).

To collect information and share knowledge, experience, and perceptions of acid lime farming, interviews were conducted. The target groups, namely the farmers, were asked a series of questions that were a combination of open-ended and closed-ended formats that could be helpful in collecting useful data and information on acid lime production and commercialization (Ghimire & Chhetri, 2023b). It assessed farmers' willingness to participate in acid lime farming and the factors affecting them. Experienced leaders of the village who had lived in the village for years were identified. Key informants such as local leaders, zone officers, mobilizer groups, and VDC officers were asked a series of questions about the present scenario of acid lime farming in the area, current yield statistics, number of people involved in acid lime farming, and economics associated with acid lime cultivation and marketing. Before conducting the field survey, using a checklist to verify the results obtained, three comprehensive FGDs (one in each municipality) were conducted. These discussions aimed to gather information on various factors related to the marketing channel and the problems faced by farmers in acid lime production and marketing (Ghimire & Gyawali, 2023). The FGD was conducted with zone committee members. The participants in the FGD included local citrus growers from different ethnic groups, comprising both male and female members. Several observations have been made regarding marketing systems and different farm activities. In addition, visits were made to market areas and farmer areas to observe different related activities. Secondary data were obtained from published and unpublished sources. To collect secondary data, information, shared knowledge, experience, and perception of citrus farming in various annual reports, newsletters, bulletins, and relevant articles, and information from the office were collected.

Methods and techniques of data analysis

Once the necessary data were collected, they were coded and entered into a computer for the analysis. The data were analyzed using various statistical tools, such as the Statistical Package for the Social Sciences (SPSS) (IBM Statistics 28; New York, USA) and Microsoft Excel 2010 (Microsoft Corp., Washington, USA). Different techniques, such as mean, standard deviation, frequency, percentage, regression, t-test, and scaling, were utilized to derive the necessary inferences. The qualitative data collected from the field survey were subjected to qualitative analysis, while the quantitative data were analyzed using both descriptive and analytical statistics.

Cost of production

All variable inputs, such as human labor, operation, irrigation, plant protection, and organic manure, were considered major factors of production and were valued at current market prices to calculate the cost of production.

$$\textit{Total variable cost (Rs ha}^{-1}\textit{)} = C_{labor} + C_{bdx+nut.} + C_{prot.} + C_{manure} + C_{oper} + C_{land}$$

Where, C_{labor}= Cost of human labor used, $C_{bdx+nut}$= Cost of Bordeaux and micronutrients, C_{land}= Cost of the rental value of land, C_{prot}= Cost of pesticides, C_{manure}= Cost of organic manures, C_{oper} = Cost of various operational tools.

Benefit-cost analysis

The benefit-cost ratio (BCR) serves as a financial compass guiding decision makers through the intricate terrain of project evaluation (Wijayanto et al., 2021). In essence, it transforms a complex array of data into a singular numeric expression, revealing whether an investment promises a bountiful harvest or a barren landscape. When the BCR for acid lime production is greater than 1, it signals bountiful orchard brimming with economic promise (Kamei & Singh 2021). This signifies that the anticipated financial returns from the cultivation of acid lime exceed the resources poured into their production, akin to a citrus grove laden with ripe marketable fruits. Conversely, a BCR dipping below 1 raises caution flags akin to a grove suffering from neglect or disease (Chabba et al., 2022). This serves as a stark reminder that the costs incurred in lime production may outweigh the expected returns, prompting a reevaluation of cultivation methods or market strategies. The cost of producing acid lime and the resulting gross return were utilized to determine the benefit-cost ratio (Subedi & Timsina, 2023), which was calculated using the following formula:

$$\mathrm{BCR} = \frac{\text{Gross return (Rs.)}}{\text{Total cost (Rs.)}}$$

Adhikari (2011) and Amgai et al. (2016) employed a comparable formula to evaluate the benefit-cost ratio as part of their respective assessments of cost-benefit analysis. To calculate the gross return, the income generated from the sale of the product was considered. On the other hand, the total cost of producing acid lime was calculated by adding up the variable and fixed costs associated with its production.

Marketing margin and producer's share

$$\text{Marketing margin} = \text{Retailer's price (Pr)} - \text{Farmer's net price (Pf)}$$

Where,

$$\text{Farmer's net price} = \text{Sale price} - \text{Marketing cost}$$

$$\text{Producer's share (Ps)} = \text{Farmer's price (Pf)} * 100/\{\text{Retailer's price}\}\ (\text{Pr}\ )$$

$$\text{Trader's share (Pmi)} = \text{Pri} - (\text{Ppi} + \text{Cmi}) * 100/(\text{Pri})$$

Indexing

Production- and market-related problems and possible causes of factors governing prices were ranked using the index. Scaling approaches that showed the respondent's attitude toward any impression in terms of direction and extremeness were used to construct the index (Miah, 1993; Subedi et al., 2019). The severity of production and marketing challenges encountered by acid lime producers were determined using ten-point and six-point scaling techniques, respectively. Respondents were provided with the option to select whole numbers on the scale rather than decimal values (Subedi et al. 2019). The factors influencing the price of acid lime were categorized into seven groups through scaling, and the formula used to calculate the index for measuring the intensity of production, marketing problems, and the factors that influence the price of acid lime were mentioned by Subedi et al. (2019) and Sharma et al. (2016).

$$\text{Is} = \sum \frac{S_i f_i}{N}$$

Where, I_s = index $0 \angle I \angle 1$, S_i = i^{th} intensity scale value, f_i = i^{th} response frequency, and N = Overall number of interviewees.

SWOT analysis

The acid lime market chain was evaluated using the SWOT analysis technique to identify its internal strengths, weaknesses, and external opportunities and threats.

Results and discussion

Socio-demographic characteristics of the interviewees

The analysis revealed that the average age of the interviewee was 50.52, with a standard deviation of 9.441. The respondents were aged between 30 and 75 years (Table 1). The total population of the study area was 372, with an average family size of 3.87 members, which is slightly lower than the national average of 4.6 (CBS, 2016). The family size of the sampled households ranged from a minimum of 1 to a maximum of 8. The overall number of people actively involved in acid lime cultivation was 130, with an average actively involved in acid lime of 1.35 members.

Table 1 - Age and family size of the respondents

Variable	Minimum	Maximum	Mean	Sum	Std. deviation
Average age of the respondents					
Age of Respondent	30	75	50.52	-	9.441
Family size and members involved in agriculture					
Total family size	1	8	3.87	372	-
No. actively involved in acid lime cultivation	1	2	1.35	130	-

The study showed that a higher percentage (88.5%) of the respondents were male and 11.5% were female, who were involved in acid lime farming (Table 2). This suggests a gender imbalance in resource ownership and decision-making authority at the household level, with males having a dominant position over females. The improvement of agricultural output depends on education, as formal education expands the farmer's knowledge base (Ghimire & Chhetri, 2023b). From the study, 25% of the respondents were illiterate and 75% were literate. Of the respondents, 32.3% depended only on agriculture, 34.4% were engaged in services, and 11.5% were dependent on remittances.

Table 2 - Gender, educational status, and income source of the respondents

Variables	Frequency	Percent
Gender		
Male	85	88.5
Female	11	11.5
Educational status		
Illiterate	24	25
Primary	30	31.3
Lower Secondary	35	36.5
Higher Secondary	7	7.3
Source of family income		
Agriculture	31	32.3
Service	33	34.4
Business	21	21.9
Remittance	11	11.5

The average age and education average were 50.52 and 1.26, respectively, which were 5% and 1% levels of significance, respectively, according to ethnicity composition. The average annual household income and family size average were 611052 and 3.38, respectively, which were not statistically significant (Table 3).

Table 3 - Socio-demographic characteristics by ethnicity composition

Variable	Brahmin/Chhetri	Janajati	Dalit	Overall (N=96)	F-value	P value
Age	53.87^{b}	47.83^{a}	50.79^{ab}	50.52	3.845**	0.025
Education	0.94	1.41	1.42	1.26	2.971*	0.056
Family size	4.03^{b}	4.20^{b}	3.13^{a}	3.38	4.616**	0.012
Income	633967	619804	566500	611052	0.609	0.546

*Note: *, **, and *** indicate significance at the 1 %, 5 %, and 10% levels, respectively.*

Farm characteristics

Land holding of the interviewees

Respondents had an average land ownership of 0.92 ha of which 0.35 ha land on an average was used by individual farmer for acid lime cultivation. Maximum acid lime cultivation was done in 2.54 ha and a minimum of 0.10 ha was used for the cultivation (Table 4).

Table 4 - Total land holding and acid lime cultivation area

Description	Minimum	Maximum	Average	Std. deviation
Total land holding in hectare	0.10	3.56	0.92	10.84
Total land used for acid lime production in hectare	0.10	2.54	0.35	0.737

Number of trees according to age

It is noteworthy that the introduction of grafted plants into the agricultural landscape of the study site was relatively recent, spanning only a period of six years. This introduction carries with it significant economic considerations. Grafted trees, although more expensive to acquire upfront for Rs. 150 plant^{-1}, demonstrate a remarkable boost in productivity, contributing an additional 10 metric tons ha^{-1} compared to non-grafted counterparts. This heightened productivity implies that the return on investment can be expected within approximately 1 year, as the return on investment is 1%, which means it will take one year for the grafted plants to recoup their additional cost of Rs. 50 plant^{-1} compared to non-grafted plants, assuming the yield difference and market prices remain constant. Grafted acid lime trees are often preferred in commercial citrus orchards because they tend to be more disease-resistant and can produce higher yields compared to non-grafted trees (Hayat et al., 2022), which cost Rs. 100 plant^{-1}. On average, grafted acid lime trees can yield around 25 metric tons per hectare under ideal conditions. However, this yield can vary significantly based on factors such as the age of the trees, the variety of acid lime, and the level of care and maintenance. Non-grafted acid lime trees are typically less productive than grafted ones, primarily due to their increased susceptibility to diseases and environmental stress (Bar-Joseph et al., 2023). Non-grafted acid lime trees may yield around 15 mt ha^{-1} on average (Table 5).

In our study, it was found that grafted plants accounted for only 31.29% of the total plant population. This suggests that while grafted trees offer promising economic benefits in the long run, a majority of farmers still rely on traditionally seed-planted trees. Among the plants surveyed, 42.08% were in the bearing stage (Figure 2), poised for productive output, while the remaining 57.92% were nonbearing, indicating a potential for increased productivity in the future.

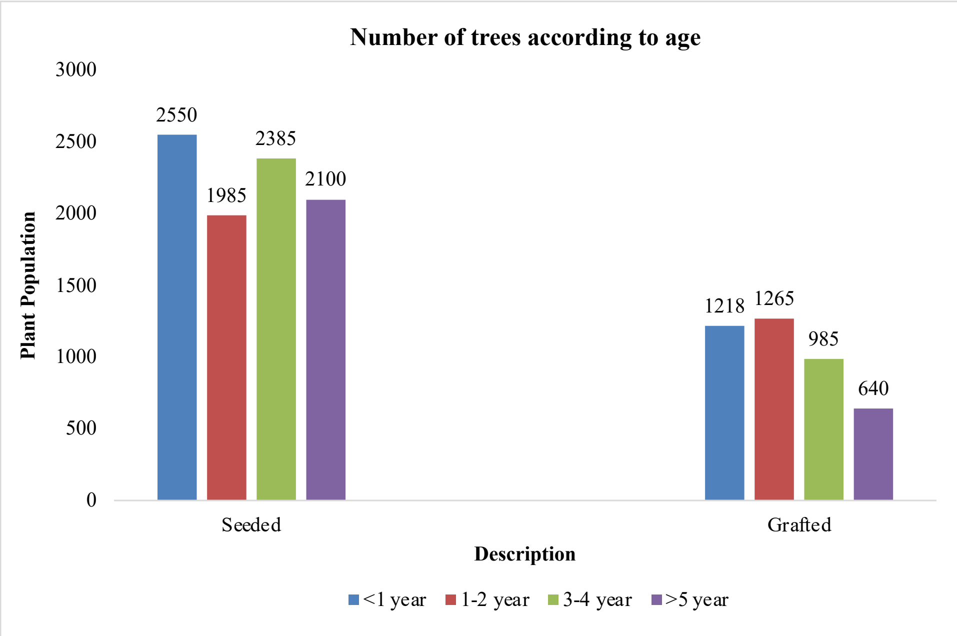

Figure 2 - Total tree according to age and planting material

Table 5 - Economic aspect of grafted acid lime plant

Variables	Price plant^{-1} (Rs.)	Yield ha^{-1}	Return on investment
Grafted	150	25	1% (1 year)
Non-grafted	100	15	-

Management and institutional characteristics

Grading of acid lime

Grading acid limes can help ensure that only high-quality fruits reach the market, leading to better marketability and reduced waste (Sawicka et al., 2023). However, it can be labor-intensive and require equipment and resources (Elkaoud & Elglaly, 2019). Growers must weigh the benefits against the costs and consider market demands and production volume when deciding whether to implement a grading system. Grading of acid lime was essential for effective marketing. From the survey, 25% of farmers were found to do the practice of grading, and the rest 75% of farmers were not found to do the practice of grading (Figure 3).

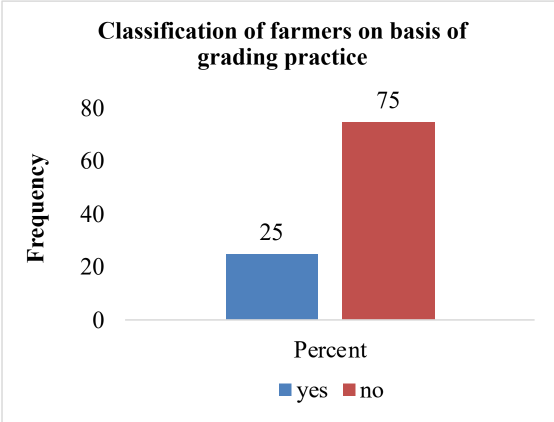

Figure 3 - Grading practice performed by the respondents

Role of different agencies in marketing

Table 6 encapsulates pivotal findings related to the factors influencing marketing, highlighting the perspectives of various stakeholders. These factors, comprising cooperatives, contract agencies, government entities, and farmers themselves, were assessed and categorized based on their perceived importance, falling into four distinct categories: highly important, important, moderately important, and least important. The role of farmers themselves was found to be of great significance, with a substantial 47.91% considering it highly important (Table 6). Additionally, 40.625% found it important, while only 11.45% thought it was moderately important, and none considered it least important. Government agencies were seen as highly important by 29.16% of respondents, with 31.25% rating them as important. On the other hand, 22.91% viewed them as moderately important, and 16.66% rated them as least important. Respondents recognized co-operatives as having varying degrees of importance. While 22.91% considered them highly important, 18.75% found them important, 33.33% deemed them moderately important, and 25% regarded them as least important. Interestingly, no respondents rated contract agencies as highly important. However, 9.375% found them important, 32.29% considered them moderately important, and a majority of 58.33% categorized them as least important.

Table 6 - Influence of different factors in marketing

Agency	Highly important	Important	Moderately important	Least important
Co-operatives	22 (22.91%)	18 (18.75%)	32 (33.33%)	24 (25%)
Contract agencies	0 (0.0%)	9 (9.375%)	31 (32.29%)	56 (58.33%)
Government agencies	28 (29.16%)	30 (31.25%)	22 (22.91%)	16 (16.66%)
Self	46 (47.91%)	39 (40.625%)	11 (11.45%)	0 (0.0%)

Contract farming

From the study, out of the total respondents, none of the farmers practiced contract farming. They had no idea what contract farming was about due to less market information.

Packaging during marketing

Packaging was found to be done either using a plastic bag or by *doko*. The majority of the farmers (46.9%) used plastic bags while transporting acid lime, 45.8% used *doko*, whereas only 7.3% used plastic crates (Table 7). This might be due to the high price of crates and easy availability of plastic bags and *doko* locally.

Table 7 - Packaging material while transporting of acid lime

Packaging material	Frequency	Percent
Plastic bag	45	46.9
Doko	44	45.8
Plastic crate	7	7.3

Economics of acid lime farming

Cost of acid lime production

The overall cost relating to acid lime was calculated by aggregating the cost incurred for labor, organic manure, and Bordeaux components along with micronutrients, plant protection, and other management costs. From the study, the majority of the production's expenses were contributed by labor costs excluding the land rent which was found similar to the previous reports of Kaysar et al. (2017) in which the cost of labor accounted for around 67% of the cost of production of acid lime including land revenue, labor cost contribute 12.5% and land rent contribute 20.3% which was highest among other cost in Palpa district. Thus, indicating that the production of acid lime was very labor-intensive and land occupying.

35.99% of the total production cost was used in land revenue which was the highest of all other costs. The second highest cost of production was labor which covered 19.71%. Human laborers were paid based on working days. The cost per day of labor used ranged from Rs. 250 to 400. Mainly labor was used in intercultural operations, manuring and harvesting while other works like irrigation, application of nutrients, and training pruning were done by family members. The average cost of labor was 26,713.46 Rs. ha^{-1}. Of the overall production cost, 10.9% was used in manure (Figure 4). In the study site, FYM was mainly used as a source of nutrients. FYM was used based on *doko* and the cost per *doko* ranged from Rs.40 to Rs.50. Chemical fertilizer was not used. On average 14,772.22 Rs. ha^{-1} was used for buying FYM. Rs. 9351.97 and Rs. 10571.11 were used per hectare on the Bordeaux component along with micronutrients and on insecticide and protection measures, respectively. Citrus leaf miners and oriental fruit flies were major insects and sooty mold and citrus canker were major diseases. Other costs of production like transportation, tools buying, and management along with packaging were included under the heading management cost which included 18.7% of the total cost.

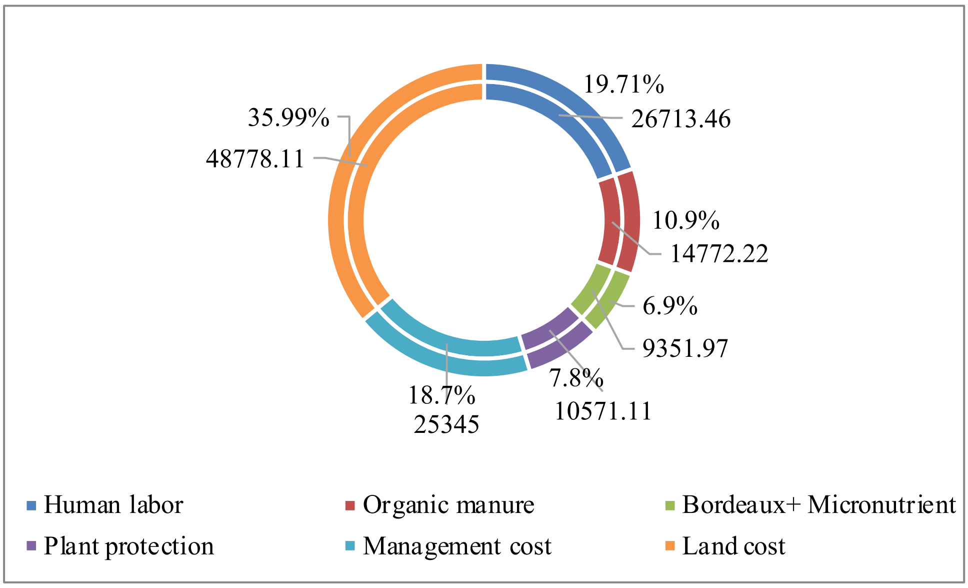

Figure 4 - Distribution of various cost involved in acid lime farming

Return from the acid lime production

Farmers cultivated acid lime in 0.387 ha of land and the productivity was about 3.061 mt ha^{-1} which fell far below the national yield which was 9.44 mt ha^{-1} (MoAD, 2018). The low yield obtained is attributable to different management practices as obtained from the above discussion. The price per kg of acid lime was Rs. 85 and the total return from the product was Rs. 102,666 ha^{-1}. The total production cost was Rs. 135,535 ha^{-1} and the average cost of production per kg was Rs. 104.82 ha^{-1}, gross margin was estimated at Rs. -19.82 (Table 8). The negative sign indicates that acid lime is a perennial tree, and it has just been 2-3 years since the fruit has come to the bearing stage or marketing stage and it takes 7-8 years for the tree to be at the best production stage. The benefit-cost ratio for acid lime production was calculated for the particular year 2021/22 excluding the fixed cost owing to the scarcity of information from the farmer about the investment phase and was found to be 0.8 which concluded that the acid lime production practice may show financial feasibility in a long run. The use of no extra supplement has lowered the production cost and the involvement of middlemen and competitive markets has made the farmer supply the product at lower cost. The Dailekh district of Nepal reported a benefit-cost ratio of 1.62 for mandarin production, according to Regmi (2020). Additionally, sweet orange production in the Sindhuli district of Nepal, as estimated by Parajulee et al. (2021), yielded a benefit-cost ratio of 2.81. Subedi and Timalsina (2023) reported a BCR of 2.2 for acid lime in Nepal which included four districts (Morang, Sunsari, Chitwan, and Nawalparasi). To enhance the BCR for acid lime production, several strategies can be employed. First, there is a need to reduce production costs by optimizing resource usage and adopting efficient farming techniques. Investing in modern agricultural technology, such as drip irrigation and precision farming, can boost yield while lowering input expenses (Afzal & Bell, 2023). Additionally, accurate recording of fixed costs is essential for a more precise BCR assessment. Exploring direct marketing channels and value-added products, like lime-based derivatives, can improve revenue. Access to affordable credit, ongoing training, and market research are vital to supporting farmers in making informed decisions. Lastly, adopting a long-term perspective when evaluating financial feasibility can provide a more comprehensive understanding of the potential benefits of acid lime production.

Table 8 - Economic statement of acid lime production

Measuring criteria	Value
Area of citrus cultivation (ha)	0.387
Productivity (mt ha^{-1})	3.061
Total revenue (Rs. ha^{-1})	102,666
Average revenue (Rs. kg^{-1})	85
Total cost (Rs. ha^{-1})	135,535
Average cost (Rs. kg^{-1})	104.82
Average gross margin (Rs. kg^{-1})	-19.82
Benefit cost ratio for current year (2021/22)	0.80

Factor affecting gross income of acid lime producer

In order to determine the effects of various factors on the gross revenue of acid lime producers, a Cobb-Douglas production function was applied based on cross-sectional data. Human labor, manure (FYM), plant protection costs, various micronutrients, and Bordeaux components utilized in the running year 2022 were all explanatory factors that were included in the models.

The coefficient of multiple determinations (R2) is a comprehensive measure that indicates how accurately the sample regression line aligns with the data. The model's explanatory power was revealed to be the best fit, with an R2 value of 0.66, indicating that 66% of the variation was explained by the variables present in the model. The adjusted R2 value was also 0.66, indicating that after taking into account the degree of freedom (df), 66% of the variation in the dependent variable was explained by the explanatory factors incorporated in the model. The overall significance of the estimated regression F-value was 182.51, which was significant at a 1% level of significance, thereby confirming the model's suitability. The estimated coefficient for the cost of fertilizer, plant protection, Bordeaux component, and other management costs showed no significant impact on the gross income generated from acid lime production. The regression coefficient for plant protection was 1.31, indicating that a 100% increase in the cost of plant protection could lead to a 131% increase in gross income. Table 9 presents the regression output obtained for gross income from acid lime production.

Table 9 - Regression estimation of variables influencing gross income of acid lime grower

Variables	Coefficient	Standard error	T-value	P-value
Human labor	-0.15	0.27	-1.041	0.301
Organic manure	-0.278	0.26	-1.271	0.207
Bordeaux + micronutrients	-0.504	0.21	0.939	0.350
Plant protection	1.312	0.24	13.510**	0.01
Management cost	-0.401	0.26	-1.334	0.186
No. of sample			96	
F-value			182.51	
Probability>F			0.00	
R^2			0.66	
Adjusted R^2			0.66	

*Note: ** refers to significant at 5%.*

Market channel analysis of acid lime

An effective marketing information system may manage product delivery on time, lower marketing expenses, boost output and productivity and maintain a clean and safe market area (Awasti, 2007). From the study, farmers were found to be not aware of market information. Only certain farmers had access to market information and were not satisfied with the price. Some participants can unfairly take advantage of other participants in the market chain due to the lack of marketing details and coordination (Lundy et al., 2007). Regarding market channels, the most common channel was through producer to consumer (Table 10). 49% of the farmers did follow this channel because farmers were scattered. The major problem in following the best contract system was due to low production by farmers. The major markets of the acid lime were within the district, and Chitwan, although no farmers had direct market access to these areas.

Table 10 - Different marketing channel

Marketing Channel	Frequency	Percent
Producer-Consumer	47	49
Producer-Trader-Consumer	1	1
Producer-Wholesaler-Retailer-Consumer	20	20.8
Producer-Retailer-Consumer	28	29.2

Major problems associated with acid lime production and marketing

Ranking problems of production

Major issues with the district's production of acid lime were recognized and included in the interview schedule based on direct field observation and conversation with the main authorities of the citrus zone. The major ten problems were high price input, unavailability of input in time, lack of irrigation, technical constraints, incidence of diseases, insects, lack of good quality saplings, environment constraints, shortage of labor, and lack of credit facilities (Ghimire & Gyawali, 2023). These issues were ranked by farmers. Scaling was done using forced ranking systems, with 1 representing the worst problem and 10 representing the least serious issue. After obtaining the index value, rankings were determined using high index values as described by Subedi et al. (2019).

Nawalpur East falls in the rain shadow area, which itself indicates that it suffers from water scarcity during peak requirements (Kharel & Basnet, 2022). Subsequently, the sloppy land topography does not favor irrigation in a noteworthy way which results in difficulty to use irrigated water for farm consumption. The majority of farmers stated that inadequate irrigation supplies were the main challenge to producing acid lime. The index value of this problem was highest (0.60) and was ranked as the most serious problem in the area (Table 11). The second major problem was the incidence of insects with index value of 0.55 which has resulted in low production and post-harvest loss. Disease incidence was ranked as the third major problem with a 0.54 index value. The high price of input was the fourth problem with a 0.31 index value. Human labor and manure made up a large portion of the cost of producing acid lime, and because these inputs were not readily accessible at an affordable price, farmers were compelled to pay higher prices, which increased the expense of production (Subedi & Timalsina, 2023). With a 0.23 index score, the lack of high-quality saplings was placed as the fifth issue. Farmers had to visit nurseries by themselves to buy saplings which in their opinion should have been done by local agro-vets of farmer cooperatives, and zones. The advantages of grafted saplings were not imparted to the respondents, it was also discovered. Likewise, the unavailability of input was ranked as the sixth problem with a 0.15 index value. Lack of credit facilities was ranked as the seventh problem with an index value of 0.11. Although the zone and NGOs have provided subsidy inputs and orchard establishment it was not enough for the farmers. Technical constraints were the eighth problem with a 0.09 index value. The farmers were found to be ignorant about the planting distance and use of adequate fertilizers at appropriate times. Likewise, grafting material use was also often neglected. Shortage of labor was ranked as the ninth problem with a 0.08 index value. The last ranked problem was environmental constraints with a 0.07 index value. Yearly a smaller amount of the product was damaged due to hailstone and frost.

Table 11 - Farmer`s perception on intensity of problem to acid lime production

Problems	Index	Rank
Lack of irrigation materials	0.60	I
Insects	0.55	II
Disease	0.54	III
High price of inputs	0.31	IV
Lack of good quality saplings	0.23	V
Unavailability of input in time	0.15	VI
Lack of credit facilities	0.11	VII
Technical Constraints	0.09	VIII
Shortage of Labor	0.08	IX
Environmental Constraints	0.07	X

Ranking problems of marketing

Responses regarding various constraints in the marketing of acid lime were recorded and analyzed during the field study (Table 12). The interviewees were asked to rank the various constraints in the marketing of acid lime that they had been facing in acid lime cultivation for a long period. The shortage of storage was identified as the main issue, with an index score of 0.8. Owing to the scarcity of a storage facility, the post-harvest loss was extreme resulting in a loss of production. With an index score of 0.65, lack of processing was identified as the second-most significant issue. The lack of possible industries and processing centers has resulted in a greater loss. Lack of grading, washing, and lack of proper exporting was ranked third with an index value of 0.53. Lack of a proper exporting mechanism was ranked fourth, volume of production was ranked fifth and lack of transportation was the last problem ranked with an index value of 0.22.

Table 12 - Farmers' perception on intensity of problem to acid lime marketing

Rank	Index	Rank
Lack of storage	0.80	I
Lack of processing	0.65	II
Lack of grading, washing and packaging	0.53	III
Lack of proper exporting mechanism	0.35	IV
Volume of production	0.29	V
Lack of transportation	0.22	VI

SWOT analysis

Acid lime production and marketing sector in Nawalpur East district has following strength, weakness, opportunity and threats (Table 13).

Table 13 - SWOT analysis of acid lime production in Nawalpur East

Internal factor	External factor
Strength	Opportunity
➢ The presence of very favorable weather conditions for the cultivation of acid lime ➢ Government different plans and policies have prioritized acid lime as a high-value crop ➢ Income-generating activity for marginalized people	➢ A substantial demand for the acid lime produced there ➢ Increased export opportunities to India ➢ A varied climate ➢ Utilization and protection of muddy land ➢ Job opportunity ➢ The Nepalese government places a strong emphasis on acid lime farming for economic purposes
Weakness	Threat
➢ Farmers are dispersed, and their productivity is modest since they employ few outside resources ➢ Input of poor quality ➢ Absence of government assistance ➢ Very little study has been done on the acid lime industry ➢ Few customers ➢ Significant post-harvest losses ➢ No collecting center	➢ Citrus decline ➢ Insects attacks ➢ High input cost ➢ Inclement weather ➢ Rising labor costs ➢ Political unrest ➢ Lack of coordination between production and commercialization ➢ Increase the availability of Indian acid lime in the Nepalese market

Conclusion

The potential for acid lime to contribute to both agricultural growth and economic development in Nepal is substantial. The analysis revealed that while acid lime cultivation is a viable option for Nepali farmers, there is room for improvement in production management. The study revealed the importance of addressing issues related to irrigation and storage facilities to enhance productivity and market access for farmers. Moreover, the benefit-cost analysis (0.80), demonstrated that there is a need for careful consideration of production costs and potential profit margins. Despite the challenges, the long-term prospects for acid lime farming in the Nawalpur East district appear promising, especially with a focus on export-oriented initiatives. However, it's crucial to acknowledge the limitations of this study, such as the relatively small sample size and the specific geographic focus. Future research endeavors could expand the scope by including a larger and more diverse sample and examining the broader implications of acid lime production on local economies and sustainability practices. In perspective, the results of this study offer valuable insights for stakeholders, from farmers and entrepreneurs to policymakers and investors. By addressing the identified challenges and building upon the findings of this research, stakeholders can work together to harness the full potential of acid lime cultivation and marketing in the region, ultimately benefiting the livelihoods of Nepali farmers and contributing to the growth of the local economy.

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