Farmers' Awareness and Nutrient Management Practices among Calamansi Growers in Bayugan City, Agusan del Sur, Philippines

Mark Joil Joy P. Sanipa*, Myrna G. Pabiona, PhD, Chelly S. Alovera, MsC***, Andrew B. Melencion, PhD******

Department of Soil Science, Central Mindanao University, Musuan, Bukidnon, Philippines
Department of Horticulture, Central Mindanao University, Musuan, Bukidnon, Philippines

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***Abstract*—**Understanding how farmers recognize nutrient problems and make fertilizer decisions can inform locally appropriate support for calamansi production. This study characterized farmers' demographic and farm characteristics, reported awareness, and nutrient-management practices in Bayugan City, Agusan del Sur, Philippines, and assessed the interpretability of their reported harvest performance. A cross-sectional survey was conducted in January 2026 among 34 calamansi growers recruited through availability-based convenience sampling in four purposively selected barangays: Calaitan, Claro Cortez, Canayugan, and Mabuhay. Data collected through face-to-face interviews and self-administered questionnaires in English and Bisaya were summarized using frequencies and percentages. Most respondents were male (64.71%) and reported high school education (61.76%); all operated owner-managed, rainfed farms. All respondents reported using inorganic fertilizers, making their own fertilizer decisions, and applying fertilizers three to four times annually. Broadcasting predominated (94.12%), and fertilizer expense was a universal concern. Although all respondents recognized yellowing leaves, poor fruiting, and weak growth as possible nutrient-deficiency indicators, none reported soil testing or fertilizer-management training. "Self" (82.35%) and fellow farmers (44.12%) were the most frequently selected soil-information sources. All respondents perceived increased production following fertilizer use; however, unstandardized bag weights, inconsistent reporting periods, and buyer-driven harvesting prevented a defensible assessment of nutrient-management–production relationships. The findings document reported symptom awareness alongside limited diagnostic and training engagement, supporting priorities for accessible soil and plant diagnostic services, practical fertilizer guidance, and standardized harvest recording. Conclusions are restricted to the participating growers.

Index Terms: calamansi, nutrient management, farmer awareness, fertilizer practices, agricultural extension

I. INTRODUCTION

Calamansi (*Citrus microcarpa*) connects Philippine orchard production with fresh-fruit and processed-product markets, making sustained production relevant to both growers and downstream enterprises. Philippine studies nevertheless show that maintaining production involves more than supplying a marketable fruit: growers manage fertilizer inputs within farming systems exposed to water limitations, pest and disease problems, and seasonal price fluctuations [1]. These interacting concerns make nutrient management an important entry point for understanding farm performance, while also requiring attention to the circumstances in which farmers select and implement cultivation practices.

In perennial citrus systems, nutrient management involves coordinating fertilizer source, rate, timing, and placement with tree requirements, soil conditions, and water availability. A global meta-analysis identified significant interactions between water and nitrogen inputs in citrus production, indicating that their relationships with yield cannot be adequately understood in isolation [2]. Experimental evidence from 'Ambersweet' orange further demonstrates that responses to fertilizer application methods can differ between young and maturing trees [3]. Nutrient diagnosis and soil-specific interpretation therefore provide a stronger basis for management than fertilizer choice alone [4]. Similarly, a Chinese meta-analysis found benefits from optimized nutrient management but also differences among citrus groups and management approaches [5]. These findings establish relevant agronomic principles; they do not establish equivalent responses or fertilizer requirements for calamansi under Bayugan conditions.

Nutrient management is also a farmer decision-making process in which technically available options must be evaluated against perceived benefits and practical feasibility. In Oriental Mindoro, calamansi growers varied fertilizer materials and applications according to available resources, illustrating that recognition of fertilization's importance can coexist with substantial differences in practice [6]. More broadly, management decisions involve learning, perceived advantages, and compatibility with farmers' goals and circumstances [7]. A meta-analysis of agricultural technology studies likewise found that education, farm size, tenure, organizational membership, and access to extension were associated with agricultural technology use, although relationships varied considerably across technologies and locations [8]. These findings justify examining local resources, information access, and reported constraints without assuming that the same factors necessarily explain calamansi management in Bayugan City.

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Within this decision process, reported awareness must be distinguished from implementation. Research on mineral fertilizer use in eastern Democratic Republic of the Congo separated awareness, initial experimentation, and continued use, showing that these stages involved different informational and resource constraints [9]. Philippine evidence from onion production also indicates that farmer field schools can influence input decisions, although findings concerning pesticide management cannot be treated as evidence of fertilizer effects in calamansi [10]. Moreover, systematic-review evidence suggests that training benefits depend on implementation and context, with limited support for assuming sustained effects or automatic diffusion to nonparticipants [11]. Accordingly, information sources, training participation, perceived nutrient problems, and reported management practices warrant separate examination; none alone establishes comprehensive technical knowledge or consistent implementation.

Farm and household characteristics provide the context needed to interpret these practices. Differences in land access, farm scale, experience, and organizational participation may coincide with different opportunities to obtain inputs, information, or labor, but their relevance requires local assessment rather than presumption [8]. Agronomic conditions are equally important. The Guimaras calamansi survey documented predominantly rainfed production and grower-reported drought and pest-management constraints, demonstrating that fertilization occurs within a broader cultivation system [1]. Related citrus research also shows that tree development and water supply condition production responses [3][2]. Examining nutrient-management practices alongside farm conditions and other cultivation practices is therefore necessary to avoid attributing differences in production solely to fertilizer use.

Yield performance provides a meaningful production outcome against which to examine nutrient-management practices, but observational relationships require careful interpretation. Fertilizer practices may coincide with differences in water access, tree condition, and overall management, while citrus research demonstrates that nutrient–yield relationships vary across production environments [2]. Yield measurement introduces an additional consideration: research in smallholder maize systems found substantial discrepancies between farmer-reported and harvest-based estimates, illustrating how measurement approaches can affect productivity analysis [12]. For calamansi surveys, farmer recollections and documented farm records should consequently remain identifiable as distinct information sources, with comparable reporting periods and production units. Associations between practices and yield can identify patterns for further investigation, but cannot independently establish fertilizer responses or confirm farmers' perceived production improvements.

Existing Philippine calamansi research provides an important descriptive foundation. The Guimaras study characterized growers, cultivation practices, and production constraints, while the Oriental Mindoro assessment examined production within a wider system of resource limitations and market requirements [1][6]. However, these geographically specific findings do not establish how reported nutrient-management awareness, current fertilizer practices, farm circumstances, and yield performance are related among growers in the selected Bayugan communities. The resulting research need is a locally grounded assessment that brings these dimensions together, rather than an assumption of deficient awareness, inappropriate fertilization, or a uniform relationship between fertilizer use and yield.

This study therefore examines farmers' reported awareness and nutrient-management practices in calamansi production in Calaitan, Claro Cortez, Mabuhay, and Canayugan, four purposively selected calamansi-producing barangays in Bayugan City, Agusan del Sur, Philippines. Specifically, it aims to: (1) describe the demographic and farm characteristics of calamansi farmers in the study area; (2) characterize their current cultivation and fertilization practices, particularly those relevant to nutrient management; and (3) examine associations between nutrient-management practices and calamansi yield performance using farmer-reported information and, where available, documented farm records. By interpreting these practices alongside reported awareness, perceptions, and production circumstances, the study can inform priorities for local extension, soil-fertility advisory services, farmer training, and subsequent diagnostic or experimental research.

II. MATERIALS AND METHODS

Study Design, Area, and Participants

A cross-sectional farmer survey was conducted in January 2026 in Calaitan, Claro Cortez, Canayugan, and Mabuhay, Bayugan City, Agusan del Sur, Philippines. The barangays were purposively selected because calamansi growers were present. Respondents were recruited through availability-based convenience sampling according to their availability and willingness to participate. Thirty-four farmers participated: one from Calaitan, 11 from Claro Cortez, 16 from Canayugan, and six from Mabuhay. The survey characterized farmers and farms, cultivation and nutrient-management practices, and reported harvest performance. The small, unevenly distributed, nonprobability sample limited generalization beyond participating farmers, and the observational design did not establish causal relationships.

Questionnaire and Data Collection

Data were collected through face-to-face interviews and self-administered questionnaires in English and Bisaya. The questionnaire covered demographic characteristics, farming experience, farm area and tenure, organizational membership, family labor, cultivation practices, water availability, and environmental constraints. Nutrient-management items addressed fertilizer materials, application methods and frequency, fertilizer decision-making, soil testing, information sources, training, and perceived constraints. Additional questions concerned pruning, weeding, irrigation, mulching, pest management, and harvest performance.

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Awareness-related responses were interpreted as reported awareness and perceptions rather than objectively tested technical knowledge.

Harvest Measurement and Interpretation

Harvest information covered mostly January–December 2025 and consisted of monthly quantities or period-total estimates obtained through farmer recall, recorded in sacks of approximately similar size. Respondents reported approximately 10 months of harvesting per year, excluding April and May, when calamansi trees reportedly produced little to no fruit, potentially due to unfavorable weather conditions affecting fruit production; this did not establish zero biological production. Harvesting also depended on buyer orders, with some farmers stopping after collecting the requested sacks while fruit remained on the trees. Consequently, the outcome was termed reported harvested production, or recorded harvest quantity where supported by records, rather than total biological yield.

Data Analysis

Survey data were organized and summarized using descriptive statistics. Frequencies and percentages described farmer and farm characteristics, cultivation and fertilization practices, and awareness-related responses. Harvest information was summarized in its original recorded units, with attention to the reporting period and whether quantities came from farmer recall or written records. Descriptive comparisons between nutrient-management practices and harvested production were limited to observations with comparable units and reference periods. These comparisons were interpreted as exploratory patterns rather than evidence that fertilizer practices caused differences in production. Findings were restricted to the participating farmers.

III. RESULTS

Demographic and Farm Characteristics

The survey included 34 calamansi farmers. The largest age group was 51–55 years (29.41%), followed by 35–40 and 46–50 years (20.59%). Most respondents were male (64.71%) and married (91.18%). High school was the most frequently reported educational level (61.76%), followed by elementary (26.47%) and college (11.76%). General farming experience was most commonly within 28–36 years (35.29%). Calamansi-growing experience was concentrated in the 2–8-year and 9–15-year categories, each accounting for 44.12% of respondents. The largest proportion of respondents belonged to the lowest recorded farm-size category (41.18%). All respondents reported owning their farms, and none reported membership in a farmers' association or cooperative. Four was the most frequently reported family-labor count (38.24%), while counts of two and three each accounted for 26.47%. Sandy soil was reported by 55.88% of respondents, clay by 41.18%, and loam by 2.94%. Most respondents described their soil reaction as neutral (97.06%); one reported acidic soil (2.94%). These classifications reflected farmers' reports rather than laboratory measurements. All farms were reported as rainfed, and all respondents selected "No" for the combined flood-and-drought occurrence item.

Table 1. Demographic and Farm Characteristics of participating Calamansi Growers (N=34.)

Characteristic	n	Percentage (%)
No. of Years in Growing Calamansi		
2-8 years	15	44.12
9-15 years	15	44.12
16-22 years	2	5.88
23-29 years	0	0
30-36 years	2	5.88
Size of Calamansi Farm		
.06-0.35 ha	14	41.18
.36-.65 ha	7	20.59
.66-.95 ha	2	5.88
.96-1.25 ha	10	29.41
1.26-1.55 ha	1	2.94
Family Labor		
1 member	3	8.82
2 member	9	26.47
3 member	9	26.47

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4 member	13	38.24
Soil Type		
Sandy	19	55.88
Clay	14	41.18
Loam	1	2.94
Soil Reaction		
Acidic	1	2.94
Neutral	33	97.06

Percentages were calculated using 34 respondents as the denominator and may not total exactly 100% because of rounding. Age and farming experience are expressed in years. Soil type and soil reaction were reported by farmers and were not laboratory verified.

Cultivation and Nutrient-Management Practices

Land preparation was predominantly manual (97.06%), with one respondent reporting tractor use (2.94%). All respondents used air-layered planting materials. The recorded planting-distance categories of 3 × 3 and 3 × 4 were equally represented, each accounting for 50.00% of respondents. All respondents reported using inorganic fertilizers, with none reporting organic fertilizer use. Complete fertilizer, Muriate of Potash (MP), Ammonium Phosphate (AP), and urea were each selected by all 34 respondents. These selections were nonexclusive and did not specify whether the materials were applied together. All respondents reported three to four fertilizer applications every year within application-frequency category. Broadcasting was the predominant application method (94.12%), while two respondents used ring application (5.88%). No respondent reported fertigation or foliar spraying. All respondents identified themselves as the fertilizer decision-maker, and none reported practicing soil testing. Responses differed between the two soil-amendment items: all respondents answered affirmatively to general soil-amendment use, whereas all answered negatively to using amendments specifically to improve fertilizer efficiency. Weeding was reported by all respondents, pest control by 94.12%, and pruning by 64.71%. No respondent reported irrigation or mulching.

Characteristic	n	Percentage (%)
Land Preparation		
Manual	33	97.06
Tractor	1	2.94
Planting Distance		
3X3	17	50
3X4	17	50
Types of Inorganic Fertilizer		
Complete	34	100
MP	34	100
AP	34	100
Urea	34	100
Fertilizer Application Method		
Broadcasting	32	94.12
Ring	2	5.88

Table 2. Reported Cultivation and Nutrient-Management Practices among Calamansi Growers (N=34)

Characteristic	n	Percentage (%)
Age		
35-40 years	7	20.59
41-45 years	4	11.76
46-50 years	7	20.59
51-55 years	10	29.41
56-60 years	5	14.71
61-65 years	1	2.94
Marital Status		
Single	3	8.82
Married	31	91.18
Sex		
Male	22	64.71
Female	12	35.29
Educational Attainment		
Elementary	9	26.47
High School	21	61.76
College	4	11.76
No. of Years as Farmer		
10-18 years	9	26.47
19-27 years	8	23.53
28-36 years	12	35.29
37-45 years	4	11.76
46-54 years	1	2.94

Percentages were calculated using 34 respondents as the denominator. Multiple responses were recorded for inorganic fertilizer types; therefore, percentages within this item exceed 100% when summed. All practices were self-reported.

Awareness-Related Responses, Information Sources, and Constraints

All respondents identified yellowing leaves, poor fruiting, and weak growth as indicators of possible nutrient deficiency; none selected “I don’t know.” No respondent reported attending fertilizer-management training. For sources of soil information, “Self” was the most frequently selected response (82.35%), followed by fellow farmers (44.12%) and agricultural supply dealers (20.59%). Agricultural technicians and Facebook or the Internet were each selected by 5.88%, while no respondent selected radio or television. Multiple sources were reported, so the percentages exceeded 100% when combined. All respondents preferred inorganic fertilizers and identified fertilizer expense as a challenge. None selected difficulty obtaining fertilizers or lack of knowledge under the listed fertilizer-use constraints. These responses represented farmers’ stated preferences and perceived constraints.

Table 3. Farmer-Reported Indicators of Possible Nutrient Deficiency and Sources of Soil Information among Calamansi Growers (N = 34)

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Characteristic	n	Percentage (%)
Average Yield		
1-4 bags	2	5.89
5-8 bags	10	29.41
9-12 bags	7	20.59
13-16 bags	10	29.41
17-20 bags	5	14.7
Fruit Size and Production		
Big and many	7	20.59
Average	27	79.41
Observed Plant Problems		
Nutrient Deficiency	34	100
Small Fruit	34	100
Leaf Discoloration	34	100
Others (Flower, fruit, and leaf drop)	12	35.29

Percentages were calculated using 34 respondents as the denominator. Multiple responses were permitted for both items; therefore, percentages within each item may exceed 100% when summed. Deficiency indicators reflect farmers' reported recognition of possible symptoms rather than laboratory-confirmed nutrient deficiencies.

Reported Harvest Performance and Crop Problems

All respondents reported a harvesting period of approximately 10 months. Within the item labeled "Average Yield," the 5–8 and 13–16 bags were jointly the most frequent, each accounting for 29.41% of respondents. The 9–12 bags accounted for 20.59%, followed by 17–20 (14.71%) and 1–4 (5.89%). All respondents rated their production as average and perceived that fertilizer use had increased production. For the combined fruit-size and production item, 79.41% selected "Average," while 20.59% selected "Big and many." None selected "Small and few." In the separate plant-problems item, all respondents reported perceived nutrient deficiency, small fruit, and leaf discoloration. Twelve respondents (35.29%) additionally reported flower, fruit, or leaf drop. These responses described farmers' observations and perceptions; they did not establish diagnosed nutrient deficiencies or experimentally measured fertilizer responses.

Table 4. Harvest Quantities, Fruit Size and Production Ratings and Crop Problems among Calamansi Growers (N = 34)
Percentages were calculated using 34 respondents as the denominator and may not total exactly 100% because of rounding. Harvest quantities were reported in bags of none standardized weight and covered varying reporting periods; they therefore do not represent standardized crop yield. Fruit size, production ratings, and crop problems reflect farmers' reports rather than independent measurements or confirmed diagnoses.

Characteristic	n	Percentage (%)
Indicators of Possible Nutrient Deficiency		
Yellowing Leaves	34	100
Poor Fruiting	34	100
Weak Growth	34	100
Source of Soil Information		
Agricultural Technician	2	5.88
Fellow farmers	15	44.12
Facebook/Internet	2	5.88
Dealers	7	20.59
Self	28	82.35

IV. DISCUSSION

The findings characterize a group of calamansi growers whose nutrient-management decisions were largely self-directed despite substantial farming experience. Universal farm ownership and the absence of association or cooperative membership describe their operating circumstances, but neither explains fertilizer choices without further analysis. A calamansi value-chain study in Nueva Ecija likewise identified training and institutional coordination as development priorities, although it did not establish the effectiveness of particular extension interventions [13]. Locally, extension activities should therefore engage farmers outside formal organizations while recognizing their existing practical experience. These findings do not establish that experience or ownership ensures technically appropriate nutrient management.

Universal inorganic fertilizer use and preference coexisted with fertilizer expense as a shared constraint. This combination indicates that continued use did not eliminate affordability concerns. Experimental research among Kenyan maize farmers demonstrated that fertilizer purchasing responded to acquisition costs and the timing of purchase opportunities, illustrating that financial and decision-making circumstances can influence input use [14]. Those mechanisms were not tested in Bayugan, but they support examining costs alongside technical advice. Broadcasting and three to four annual applications described common practices;

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their prevalence does not demonstrate agronomic suitability. The reported selections do not establish nutrient quantities, seasonal allocation, or whether products were used together.

Recognition of yellowing leaves, poor fruiting, and weak growth indicates awareness of visible crop problems, but does not establish accurate identification of their causes. This distinction is particularly important because no respondent reported soil testing, while nearly all described their soils as neutral. Soil-reaction descriptions therefore cannot justify conclusions about measured pH or amendment requirements. Research on integrated soil fertility management in fruit crops emphasizes interpreting nutrient inputs within broader soil, plant, and management conditions [15]. Moreover, citrus huanglongbing can produce symptoms resembling nutritional disorders, demonstrating the limitations of symptom recognition alone [16]. This does not imply that the surveyed farms had huanglongbing; it supports diagnostic assessment before attributing symptoms to nutrient deficiency. The conflicting soil-amendment responses preclude a firm interpretation of amendment practices.

The entirely rainfed production setting further qualifies interpretation of fertilizer practices. A multiyear experiment in mature sweet orange demonstrated the importance of coordinating nitrogen management with irrigation scheduling, including fertilizer timing and placement [17]. Although those findings came from irrigated orchards on sandy soils in Florida, they support considering water conditions when interpreting nutrient management rather than transferring experimental rates directly to Bayugan calamansi. Likewise, respondents' negative answers to the flood-and-drought item do not establish consistently adequate root-zone moisture throughout the production cycle. Advice on application timing and placement should consequently consider actual soil-moisture conditions alongside nutrient requirements.

The information-source pattern identifies a practical route for advisory engagement. "Self" and fellow farmers were more frequently selected than agricultural technicians, while no respondent reported fertilizer-management training. Research among pineapple growers in Ghana demonstrated that farmers adjusted input decisions in response to information about other farmers' experiences, supporting the relevance of social learning in crop management [18]. This provides a rationale for evaluating farmer-to-farmer demonstrations locally, but does not establish that information exchanged among the surveyed growers was accurate. Similarly, infrequent selection of technicians does not demonstrate that extension services were unavailable.

Participatory training is a reasonable approach to evaluate, rather than an intervention whose benefits can be assumed. An East African evaluation reported benefits from farmer field schools for agricultural production and income [19]. However, Philippine onion research found reduced insecticide expenditure without a statistically significant yield effect, illustrating that training outcomes can differ across management objectives [20]. A broader review also identified potential benefits alongside the need for quality assurance and more balanced evaluation [21]. For the participating calamansi communities, training could therefore combine practical diagnosis, fertilizer-label interpretation, application decisions, and cost recording, with subsequent assessment of changes in practice and expenditure.

The production findings establish farmers' positive perceptions of fertilization, but cannot establish its relationship with harvested production. Several fertilizer variables were identical across respondents, leaving no observed between-group contrast, while application-method groups were highly unequal. More fundamentally, unstandardized bag weights and differing reporting periods prevented equivalent interpretation of the recorded quantities. Buyer-driven harvesting also meant that collected fruit did not necessarily represent all fruit produced. Research in Ugandan maize systems showed that conclusions about productivity relationships changed according to the production-measurement method [22]. That evidence reinforces the need for standardized measurement without quantifying reporting error in this calamansi sample.

Interpretation is additionally limited by the small, unevenly distributed convenience sample and reliance on self-reported practices, observations, and recollections. The aggregate tables do not permit assessment of individual practice–production relationships or adjustment for farm area, tree condition, and other management differences. Nevertheless, the survey provides a useful local baseline: it identifies reported fertilizer routines, diagnostic practices, information sources, and perceived costs that can guide targeted follow-up with participating communities.

V. CONCLUSION

The surveyed calamansi growers operated owner-managed, rainfed farms and reported predominantly self-directed nutrient-management decisions. Inorganic fertilizer use was universal, broadcasting predominated, and fertilizer expense was a shared concern. Farmers recognized possible deficiency symptoms, but reported no soil testing or fertilizer-management training; these findings establish reported symptom awareness rather than verified diagnostic competence. Although respondents perceived production benefits from fertilization, inconsistent harvest units and reporting periods prevented a defensible assessment of practice–production relationships. Local extension priorities include accessible soil and plant diagnostic support, practical fertilizer guidance, and cost recording. Follow-up research should use weighed harvests over common periods, document fertilizer quantities and application dates,

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and distinguish harvested fruit from fruit remaining on trees. Conclusions apply to the participating farmers rather than all calamansi growers in Bayugan City.

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AUTHORS

First Author – Mark Joil Joy P. Sanipa, Graduate Student, Master of Science in Soil Science, Department of Soil Science, College of Agriculture, Central Mindanao University, Philippines. Email: markjoiljoy23@gmail.com

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Second Author – Myrna G. Pabiona, PhD, Department of Soil Science, College of Agriculture, Central Mindanao University, Philippines.
Third Author – Chelly S. Alovera, MsC, Department of Soil Science, College of Agriculture, Central Mindanao University, Philippines.
Fourth Author – Andrew B. Melencion, PhD, Department of Horticulture, College of Agriculture, Central Mindanao University, Philippines.

Correspondence Author – Mark Joil Joy P. Sanipa, markjoiljoy23@gmail.com, s.sanipa.markjoiljoy@cmu.edu.ph

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