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Baseline Assessment of Performance Indicators among Mango Producers in Northern Côte d'Ivoire

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Abstract

A baseline assessment of mango producers in northern Côte d'Ivoire was conducted as part of the regional project to control fruit flies. The study encompassed a sample of 443 producers from the project area, covering the localities of Korhogo, Sinématiali, and Ferkessédougou, as well as 75 producers from the control area in Boundiali. Findings indicate that 99.3% of producers are male, predominantly native Sénoufo, with an average age of 48.9 years; women constitute less than 1% of the sample. The vast majority (97.6%) are married, with nearly equal proportions practicing monogamy (45%) and polygamy (53%). Households average 13 members, and producers have, on average, 20 years of experience in mango cultivation. Family labor predominates (87.4%), though 50.6% of producers also employ wage labor. Approximately 61.8% possess animal-drawn farming equipment, typically associated with cotton production. The average orchard size is 6.36 hectares, yet 65.9% of orchards are 5 hectares or less. The Kent variety is overwhelmingly prevalent, comprising 90% of homogeneous orchards. Most mango orchards were established between 1975 and 2005, with a subsequent decline in new orchard creation. Land tenure is largely secured, with 94.5% of producers being landowners—inheritance is the principal mode of land acquisition (93.7%). Land is perceived as scarce or very scarce by 95% of producers, although land disputes are infrequent (3.6%). From a technical perspective, only 3.3% of producers use fertilizers, whereas herbicides and insecticides are employed by 70.5% and 86.4%, respectively. Irrigation is virtually nonexistent (0.6%). The average per-hectare expenditure is 7682 CFA francs for inputs and 7965 CFA francs for maintenance, totaling approximately 15,500 CFA francs per hectare. Total export production is estimated at 16,513 tons, with 85% originating from orchards aged between 10 and 40 years. Large orchards (≥10 ha) account for 13% of holdings but contribute 48% of total production. The mean exportable yield is 1.15 tons per hectare, representing roughly one-third of the gross yield. Only 11% of producers hold certification, and 27% are affiliated with a producer group. Fruit flies inflict considerable damage: most producers lack knowledge of effective control methods, though over 90% recognize fruit flies as a major issue, alongside adverse climatic conditions and low purchase prices. Producers are thus aware of the detrimental impact of fruit flies but possess limited means to address the problem.

Keywords

Mangoes, Producers, Performance Indicators, Côte d'ivoire

1. Introduction

Mango ranks as the third most exported fruit from Côte d'Ivoire, with over 95% of production destined for the European market. Export volumes have risen significantly over the past four years, from 10,179 tons in 2011 to more than 20,475 tons in 2014 [1].

The growth of the mango sector plays a crucial role in mitigating rural exodus and supports national poverty reduction strategies by generating income for a wide range of stakeholders, including producers, exporters, packers, sorters, and both permanent and seasonal transporters. Despite its economic significance, mango production in Côte d'Ivoire is severely challenged by phytosanitary issues, particularly fruit flies, with the problem being aggravated by the presence of *Bactrocera dorsalis* [2] [3].

These phytosanitary challenges result in both a reduction in exportable mango volumes and a shortened harvest season. Due to fruit fly infestations, only 10% of total mango production is exported. The predominant pest species—*Bactrocera* sp., *Ceratitis* sp., and *Dacus* sp.—reach peak population levels during the mango production season [4] [5].

Similar to Côte d'Ivoire, fruit flies currently constitute the primary threat to mango production in West African countries. These pests compromise product quality and are consequently responsible for strict export restrictions on mangoes destined for the European Union and the United States. The competitiveness and market access of West African mango exporters to major international markets depend largely on their capacity to ensure a consistent supply of mangoes that meet prevailing regulatory standards. To address this challenge with sustainable and reliable solutions, CORAF/WECARD initiated a project selection process. The evaluation of submitted research proposals resulted in CORAF/WECARD approving funding for the project entitled "Fruit Flies Control Technologies Dissemination and Capacity Building of West African Fruits Value Chains Stakeholders," to be implemented across nine countries: Benin, Burkina Faso, Côte d'Ivoire, Ghana, Guinea, Mali, Niger, Nigeria, and Senegal. This project is part of the broader West Africa Fruit Fly Initiative.

To facilitate the effective implementation of this project, it was determined that each participating country would conduct a baseline survey in the principal mango-producing regions, enabling the subsequent assessment of the impact of disseminated fruit fly control technologies.

This article presents the findings related to the characterization of performance indicators in both the project intervention and control areas.

In this study, two zones are analyzed: the project intervention area and the control area, following an impact evaluation methodology based on the selection of a counterfactual or control situation. The intervention area is defined, according to the current administrative boundaries, as the Poro region around Korhogo and the Tchologo region around Ferké and Sinématiali. The Bagoué region, centered around Boundiali, serves as the control area.

2. Methodology

2.1. Sample Size Determination

In a stratified sampling design, the sample size is determined separately for each stratum, and the total sample size is the sum of the sample sizes across all strata. The calculation of the sample size for each stratum was performed using the formula proposed by [6]:

$$N = [Nz^2p\ (1 - p)]/[d^2\ (N - 1) + z^2p\ (1 - p)].$$

where:

N: the population size within each stratum

Z: the confidence interval

P: the proportion of the target population within the overall population

D: the required degree of precision

Assuming a 95% confidence level, a precision of 5%, and a prevalence of mango producers of 20% within the agricultural population, and incorporating a finite population correction factor (Naing *et al.*, 2006), the sample size was determined for each of the three strata. This enabled calculation of the total sample size, which was n = 443 for the project area (Korhogo 137 producers; Sinématiali 208 producers, and Ferké 98 producers) and n = 75 for the control area of Boundiali.

2.2. Data Collection and Analysis Methods

Data were collected through a formal survey utilizing a structured questionnaire, primarily centered on the producer module. Three enumerators conducted the data collection, with one assigned to each stratum within the project area. In the control area, two of the three enumerators were responsible for administering the survey.

Data analysis was performed using STATA software, version 13, with careful consideration of the survey's structure, particularly the sampling weights. Estimates of means, totals, and proportions were generated using the SVY prefix in STATA to specify that the data originated from a survey. Each point estimate was accompanied by its standard error and corresponding confidence interval.

2.3. The Impact Evaluation Method

Assessing the impact of an intervention involves addressing the following question: would the observed situation have been different had the intervention not taken place? In essence, this requires comparing outcomes with and without the intervention. However, the fundamental challenge lies in the impossibility of directly observing the counterfactual scenario—what would have occurred in the absence of the intervention. Consequently, impact evaluation techniques are designed to estimate as accurately as possible the situation that would have prevailed without the intervention, while the situation with the intervention is empirically measured during the evaluation process.

A range of methodological approaches is available to analysts. The most basic is the before-after estimator, also known as the simple difference method. This approach calculates impact as the difference between measurements taken before and after the intervention. However, this method is unreliable because, without a control group, it is impossible to ascertain whether observed changes are attributable to the intervention itself or to other unrelated factors. To address this limitation, evaluators often employ the double difference method (difference-in-differences). This approach involves identifying a control area comparable to the intervention area. The impact is then estimated as the difference between the changes observed in the intervention group and those in the control group over time. This method is based on the theoretical assumption that, in the absence of the intervention, the beneficiary group would have followed the same trajectory as the control group—an assumption that may not always hold perfectly in practice. Nonetheless, the potential bias associated with the double difference method is generally less severe than that introduced by the simple difference approach. For this reason, the double difference method is widely preferred among analysts and is the recommended approach in the present study.

3. Results

3.1. Demographic Characteristics of Mango Producers

The findings of this study reveal that mango production is overwhelmingly dominated by men, with women constituting less than one percent of the sample (**Table 1**). The average age of producers is under 50 years, indicating that the cohort is relatively young and within their most productive years (**Table 2**). Notably, female producers, with a mean age of 43, are significantly younger than their male counterparts (Table 3).

Marriage is the prevailing marital status among the producers, with over 97% reported as married, while singlehood and other forms of cohabitation account for less than 2% of the sample. These characteristics, particularly the extremely low percentage of cohabitants, suggest that Senoufo society is especially attentive to conventional forms of cohabitation (Table 4).

Table 1. Gender distribution of mango producers.

Producer Gender	Percentage	Standard Error of the Mean	95% Confidence Interval	
Male	99.33	0.3883	97.92	99.79
Female	0.6692	0.3883	0.2133	2.08
Total	100			

Table 2. Mean age of producers.

	Mean Age	Standard Error of the Mean	95% Confidence Interval	
Age	48.90	0.6499	47.62	50.18

Table 3. Mean age of producers by gender.

		Mean Age	Standard Error of the Mean	95% Confidence Interval	
Age					
	Male	48.94	0.65	47.66	50.22
	Female	42.69	5.89	31.10	54.28

Table 4. Marital status distribution among producers.

Marital Status	Percentage	Standard Error of the Mean	95% Confidence Interval	
Married	97.59	0.7229	95.68	98.67
Single	1.275	0.4928	0.595	2.713
Divorced	0.2667	0.2661	0.0374	1.874
Widowed	0.3346	0.2753	0.0662	1.672
Cohabiting	0.5335	0.3764	0.1329	2.116
Total	100			

Analysis of family structure among producers shows that just over half of the families are polygamous, while approximately 40% are monogamous, making monogamy the second most prevalent form of partnership. Single individuals of both genders comprise less than 3% of the sample. The marriages referenced are generally traditional, often accommodating polygamy. The near equivalence in the proportions of polygamous and monogamous couples points to a society in transition, gradually shifting from polygamous traditions toward monogamous modernity (Table 5).

The analysis of producers' social backgrounds reveals that over 99% are indigenous Senoufo, whereas migrants from other regions of Côte d'Ivoire constitute less than 1%. Notably, there are no foreign nationals among the producers, despite the geographical proximity and considerable presence of individuals from neighboring countries such as Burkina Faso and Mali, where mango cultivation is nonetheless relatively advanced (Table 6).

In terms of producers' origins, the data indicate that indigenous Senoufo producers are significantly older than their non-native counterparts. The age gap between these two social groups of producers is substantial, approaching a decade (Table 7).

Table 5. Distribution of producers by family type.

Family Type	Percentage	Standard Error of the Mean	95% Confidence Interval	
Monogamous	44.95	2.514	40.07	49.92
Polygamous	52.78	2.513	47.83	57.67
Single	2.274	0.7168	1.22	4.203
Total	100			

Table 6. Distribution of producers by social origin.

Social Origin	Percentage	Standard Error of the Mean	95% Confidence Interval	
Indigenous	99.06	0.4709	97.5	99.65
Non-indigenous	0.936	0.4709	0.347	2.5
Total	100			

Table 7. Mean age of producers by social background.

	Percentage	Standard Error of the Mean	95% confidence interval	
Native	48.98723	0.6544757	47.70076	50.27371
Immigrant	40.1296	3.12939	33.9783	46.2809

Table 8. Percentage distribution of producers by educational attainment.

Level of education	Percentage	Standard Error of the Mean	95% confidence interval	
Not in school	74.16	2.227	69.55	78.29
Primary	19.68	2.039	15.98	23.99
Secondary	6.093	1.201	4.118	8.926
Academic	0.0681	0.0681	0.0095	0.4846
Total	100			

Roughly three-quarters of the producers have not received formal education, with the remaining proportion exhibiting varying educational attainment. Specifically, approximately 20% of producers have completed primary education, 6% have attained secondary education (at the high school or college level), and less than 1% have reached tertiary education (Table 8).

The average household size among mango producers is 13 individuals (Table 9), and the household head typically possesses approximately twenty years of experience in mango cultivation (Table 10).

Table 9. Average household size among mango producers.

	Percentage	Standard Error of the Mean	95% confidence interval	
Household size	13.026	0.369	12.299	13.752

Table 10. Average number of years in mango production.

	Percentage	Standard Error of the Mean	95% confidence interval	
Number of years of experience	20.08	0.47	19.15	21.005

3.2. Productive Resource Endowment

3.2.1. Labor Input

Labor input is considered from a qualitative perspective. Due to constraints in time and data availability, the total quantity of labor devoted to a mango orchard is not estimated; instead, the focus is on analyzing the types of labor utilized by producers. The findings indicate that over 80% of mango producers rely on family labor. Approximately half of the producers employ hired labor, while a similar proportion do not engage in this form of labor (Table 11 and Table 12). Furthermore, nearly three-quarters of producers predominantly depend on family labor rather than wage labor (Table 13).

Table 11. Percentage distribution of mango producers utilizing family labour.

Use of family work	Percentage	Standard Error of the Mean	95% confidence interval	
Yes	87.39	1.638	83.8	90.27
Not	12.61	1.638	9.725	16.2
Total	100			

Table 12. Percentage distribution of mango producers employing wage labour.

Use of wage labour	Percentage	Standard Error of the Mean	95% confidence interval	
Yes	50.65	2.247	46.24	55.04
Not	49.35	2.247	44.96	53.76
Total	100			

Regarding labor modalities, almost two-thirds of producers possess animal-drawn farming equipment, which serves as a reliable indicator of their involvement in cotton cultivation (Table 14).

Table 13. Percentage distribution of mango producers predominantly utilizing one form of labor over another.

Increased reliance on work	Percentage	Standard Error of the Mean	95% confidence interval	
Family	76.38	2.157	71.88	80.36
Employee	23.62	2.157	19.64	28.12
Total	100			

Table 14. Percentage distribution of mango producers utilizing animal-drawn cultivation.

Has a carriage	Percentage	Standard error of the mean	95% confidence interval	
Yes	61.82	2.295	57.22	66.22
No	36.18	2.295	33.78	42.78
Total	100			

3.2.2. Land as a Factor

Table 15. Average orchard area (ha) within the project region.

	Average	Standard error of the mean	95% confidence interval	
Area	6.3603	0.467023	5.44	7.27

Table 16. Estimated total area of mango orchards within the project zone.

	Average	Standard error of the mean	95% confidence interval	
Area	14573.51	1076.834	12456.97	16690.05

Table 17. Distribution of orchards by area within the project zone.

Area group	Percentage	Standard error of the mean	95% confidence interval	
1 to 5 ha	65.94	2.376	61.12	70.44
5 to 10 ha	21.14	2.082	17.34	25.52
10 ha and above	12.93	1.667	9.988	16.57
Total	100			

The average size of a mango orchard is approximately 6 hectares, with the total area under mango cultivation in the project region estimated at 14,573.51 hectares (see Table 15 and Table 16). Analysis of orchard size classes reveals that over two-thirds of mango orchards occupy no more than 5 hectares, while 20% are in the 5 to 10 hectare range; only about 13% of orchards cover 10 hectares or more (see

Table 17).

3.3. Analysis of Plot Structure and Orchard Establishment Dynamics

3.3.1. Plot Structure

The findings reveal that over 90% of orchards consist of no more than two plots, with these plots predominantly located within the same physical area (see Tables 18-20). Furthermore, over 90% of these plots are homogeneous in terms of varietal composition. Specifically, the exploratory survey indicates that the Kent variety is overwhelmingly predominant, while the Keith and Amélie varieties are present only in minor proportions.

Table 18. Distribution of orchards within the project area by number of plots.

Number of plots	Percentage	Standard error of the mean	95% confidence interval	
1	62.28	2.48	57.3	67.2
2	29.64	2.33	25.27	34.42
3	6.741	1.277	4.625	9.727
4	0.8002	0.4611	0.2569	2.464
5	0.5335	0.376	0.133	2.114
Total	100			

Table 19. Distribution of orchards within the project area based on whether the plots are grouped or dispersed.

Location of plots	Percentage	Standard error of the mean	95% confidence interval	
Grouped	67.4	2.325	62.67	71.79
Scattered	32.6	2.325	28.21	37.33
Total	1000			

Table 20. Distribution of orchards within the project area according to the homogeneity or heterogeneity of mango varieties in the orchards.

Homogeneity of orchard varieties	Percentage	Standard error of the mean	95% confidence interval	
Homogenous	90.43	1.435	87.21	92.9
Composite	9.57	1.435	7.097	12.79
Total	100			

3.3.2. Dynamics of Mango Orchard Establishment

The average age of mango orchards in the project area is approximately 22 years. Half of the existing orchards are between 20 and 40 years old, while one third fall within the 10 to 20 year age range. The oldest (40 to 60 years) and youngest (3 to 10 years) orchard age classes each represent less than 10% of the total orchard area (see Table 21-23).

Table 21. Average orchard age in the project area.

	Average	Standard error of the mean	95% confidence interval	
Age	22.24	0.500	21.26	23.22

Table 22. Orchard distribution by age.

Age group	Percentage	Standard error of the mean	95% confidence interval	
40 to 60 years	7.988	1.351	5.704	11.08
20 to 40 years	52.43	2.565	47.38	57.43
10 to 20 years	31.6	2.407	27.07	36.51
3 to 10 years	7.983	1.395	5.636	11.19
Total	1000			

Table 23. Orchard distribution by area and age within the project zone.

Age group	Area group			
	1 to 5 ha	5 to 10 ha	10 ha or more	Total
40 to 60 years	5.792 (1.199) [3.838, 8.651]	1.91 (0.6916) [0.9337, 3.867]	0.3543 (0.2914) [0.0701, 1.77]	8.056 (1.366) [5.747, 11.18]
20 to 40 years	36.96 (2.466) [32.25, 41.92]	9.478 (1.491) [6.926, 12.84]	6.439 (1.239) [4.392, 9.346]	52.88 (2.565) [47.82, 57.87]
10 to 20 years	16.96 (1.956) [13.45, 21.16]	8.621 (1.434) [6.189, 11.89]	5.72 (1.225) [3.737, 8.66]	31.3 (2.412) [26.76, 36.22]
3 to 10 years	5.437 (1.182) [3.53, 8.288]	1.412 (0.6265) [0.5878, 3.353]	0.9191 (04935) [0.3187, 2.621]	7.769 (1.385) [5.446, 10.97]
Total	65.15 (2.46) [60.17, 69.82]	21.42 (2.151) [17.49, 25.95]	13.43 (1.745) [10.36, 17.25]	100

Two major periods of mango orchard establishment are evident: the first spans from 1975 to 1995, and the second from 1995 to 2005. Collectively, these periods account for over 80% of the current orchards in the project area. In contrast, orchard establishment at both age extremes—40 to 60 years and 3 to 10 years—has been significantly lower, each constituting less than 10% of total orchards. Specifically, the proportion of orchards established within these two extreme age categories is approximately 8% for each.

An analysis combining orchard size and age reveals that, irrespective of the size class, the majority of mango orchards were established between 1975 and 2005. Specifically, in the 1 to 5 ha size class—which accounts for 65.15% of all orchards—over 53% were created during this period. In the 5 to 10 ha category, which represents 21.42% of the total orchard area, 84.45% of orchards were established between 1975 and 2005. For the largest orchards, those exceeding 10 ha and constituting 13.43% of the total orchard area, 90.53% were established within the same timeframe.

In contrast, during the two extreme periods, the proportion of total orchard area established—regardless of size class—never exceeds 10%.

3.4. Analysis of Land Tenure

The vast majority of mango producers own the plots they cultivate, with only approximately 5% lacking ownership of the land they farm (**Table 24**). Inheritance constitutes the principal means of acquiring land, accounting for more than 93% of mango producers' access to property (**Table 25**). Land rental and purchase are extremely uncommon in the region, indicating that the land market remains at a nascent stage (**Table 26**).

Table 24. Breakdown of land ownership status among mango producers.

Ownership status	Percentage	Standard error of the mean	95% confidence interval	
Owner	94.53	1.108	91.9	96.34
Non-owner	5.47	1.108	3.66	8.102
Total	100			

Table 25. Percentage breakdown of mango producers by modes of land tenure.

Different forms of access to land	Percentage	Standard error of the mean	95% confidence interval	
Rental	1.07	0.5317	0.3991	2.821
Heritage	93.73	1.252	90.77	95.78
Buy	0.2667	0.2668	0.0372	7.584
loan	4.869	1.112	3.094	7.584
Other	0.0679	0.0679	0.0095	0.4833
Total	100			

Table 26. Modes of land acquisition.

Land borrowing terms	Percentage	Standard error of the mean	95% confidence interval
Against performance	0.3176	0.3176	0.0443 2.24
No counterparty	95.47	1.165	92.54 97.29
Other terms and conditions	4.209	1.137	2.462 7.105
Total	100		

Land is perceived as a scarce productive resource, with over 95% of producers reporting that land availability in the project area ranges from rare to very rare (**Table 27**).

Table 27. Percentage distribution of various forms of land availability.

Different types of land availability	Percentage	Standard error of the mean	95% confidence interval	
Very rare	50.45	1.559	47.38	53.5
rare	45.66	1.795	42.16	49.21
Normal situation	3.822	0.9124	2.382	6.079
Abundance of soil	0.0681	0.0681	0.0095	0.4816
Total	100			

Table 28. Percentage distribution of land by urban or agricultural classification.

Type of soil	Percentage	Standard error of the mean	95% confidence interval	
Urban	4.268	1.039	2.633	6.846
Agricultural	95.73	1.039	93.15	97.37
Total	100			

Table 29. Percentage distribution of land by topographical location.

Topographical position of the plot	Percentage	Standard error of the mean	95% confidence interval	
Plateau	68.44	2.298	63.76	72.77
Slope	21.42	2.022	17.71	25.66
Lowlands	10.14	1.54	7.489	13.59
Total	100			

Table 30. Frequency of land tenure disputes in the project area.

Frequency of land disputes	Percentage	Standard error of the mean	95% confidence interval	
Very frequent	1.072	0.4804	0.4427	2.572
Frequent	2.541	0.7603	1.406	4.55
Normal situation	63.8	2.399	58.97	68.37
Infrequent	32.58	2.349	28.15	37.36
Total	100			

Despite this scarcity, most mango plots are located on agricultural land rather than in urban domains (**Table 28**), and more than two-thirds are situated on flat terrain. Nevertheless, the findings show that approximately 20% of plots are on sloped land, while 10% are located in lowland areas (Table 29).

In spite of the pronounced scarcity of land in the project area, land disputes are infrequent; about 30% of surveyed producers consider land conflicts to be rare, and more than 60% regard the prevailing situation as normal, with no disputes arising (Table 30).

3.5. Production Analysis

3.5.1. Use of Chemical Inputs and Irrigation Practices

This section demonstrates that the use of fertilizer among mango producers is minimal, with only approximately 3% of producers applying this input (Table 31). In contrast, herbicides and insecticides are commonly used, with 70% and 86% of mango producers, respectively, applying these inputs (Tables 32-33).

Table 31. Percentage distribution of mango producers applying fertilizer.

Fertilizer application	Percentage	Standard error of the mean	95% confidence interval	
Yes	3.269	0.9143	1.878	5.63
No	96.73	0.9143	94.37	98.12
Total	100			

Table 32. Percentage breakdown of mango producers utilizing herbicides.

Herbicide application	Percentage	Standard error of the mean	95% confidence interval	
Yes	70.47	2.257	65.85	74.7
No	29.53	2.257	25.3	34.15
Total	100			

Table 33. Percentage breakdown of mango producers utilizing insecticides.

Insecticide application	Percentage	Standard error of the mean	95% confidence interval	
Yes	86.4	1.752	82.57	89.49
No	13.6	1.752	10.51	17.43
Total	100			

Table 34. Percentage breakdown of mango producers employing irrigation.

Use of irrigation	Percentage	Standard error of the mean	95% confidence interval	
Yes	0.6062	0.3851	0.1733	2.098
No	99.39	0.3851	97.9	99.83
Total	100			

Irrigation practices are also extremely limited among mango producers, as less than 1% utilize irrigation (**Table 34**).

3.5.2. Estimation of Production Costs

Regarding the costs associated with chemical inputs, the largest expenditures are allocated, in descending order, to herbicides, followed by insecticides, and then fertilizers (**Table 35**).

Table 35. Estimated average expenditures on chemical inputs (in FCFA).

Expense type	Average	Standard error of the mean	95% confidence interval	
Fertilizer expenditure	4060.387	1495.247	1121.447	6999.327
Herbicide expenses	29351.57	1946.085	25526.5	33176.65
Insecticide expenditure	15449.4	1870.223	11773.44	19125.37

On a per-hectare basis, the average expenditure per producer is 638.40 FCFA for fertilizers, 4614.80 FCFA for herbicides, and 2,429.04 FCFA for insecticides. Given the price of 19,000 FCFA for 50 kg of NPK fertilizer, these values suggest an average fertilizer usage of approximately 1.68 kg/ha. Overall, the average mango producer spends around 48,000 FCFA on chemical inputs for their orchard, which corresponds to 7,682.26 FCFA per hectare (**Table 36**).

Table 36. Estimated average total expenditure per orchard on chemical inputs (in CFA francs).

	Average	Standard error of the mean	95% confidence interval	
Average total input cost	48861.36	3623.036	41740.21	55982.52

Table 37. Estimated average expenditure on cultural operations (in CFA francs).

Expense type	Average	Standard error of the mean	95% confidence interval	
Weed control expenditure	27219.4	3123.534	21080.02	33358.78
Expenditure on pruning of mango trees	10239.07	1646.732	7002.382	13475.76
Expenditure on building and maintaining fences	8498.106	2226.452	4121.964	12874.25
Other maintenance expenses	4704.633	1537.024	1683.579	7725.686

With regard to the costs associated with orchard maintenance, the interventions considered primarily include weeding, pruning of mango trees, and other maintenance activities such as the construction or upkeep of fences. The findings indicate that, on average, producers allocate approximately 50,000 FCFA to various orchard maintenance tasks, equating to an average expenditure of 7965 FCFA per hectare (see Table 37 and Table 38).

Table 38. Estimated average total cost of cultural operations (in CFA francs).

	Average	Standard error of the mean	95% confidence interval	
Average total cost of cultivation	50661.21	5245.209	40351.63	60970.78

3.5.3. Estimation of Mango Quantities Collected by Harvesting Technicians for Exporters

On average, producers sold slightly more than 16,500 tons of mangoes to exporters (Table 39). Of this regional total, over 85% of the mangoes collected for export originated from orchards aged between 10 and 40 years, with 36% and 49% of the total volume coming from orchards aged 10 - 20 years and 20 - 40 years, respectively. The oldest orchards and the most recently established ones contributed 5.82% and 4.74%, respectively, to the total volume of mangoes collected for export (Table 40).

Table 39. Estimated total tonnage of mangoes harvested within the project area.

	Total quantity (in tons)	Standard error of the mean	95% confidence interval	
Total quantity of mangoes collected by harvesting technicians	16512.75	1696.011	13179.21	19846.3

Table 40. Estimated total quantity (in tons) of mangoes exported from the project area by orchard age.

Age group	Quantity	Standard error of the mean	95% confidence interval
40 to 60 years	961.0808	230.5731	[507.8011 1414.36]
20 to 40 years	8191.2	1348.469	[5540.268 10842.13]
10 to 20 years	5955.221	1166.402	[3662.212 8248.23]
3 to 10 years	783.265	214.5265	[361.531 1204.999]

Table 41. Estimated total quantity (in tons) of mangoes exported from the project area by orchard size.

Area class	Quantity	Standard error of the mean	95% confidence interval	
1 to 5 ha	4611.698	319.9739	3982.774	5240.622
5 to 10 ha	4035.797	526.3912	3001.15	5070.445
10 ha or more	7850.589	1717.115	4475.516	11225.66

The data indicate that approximately 48% of the mangoes collected by harvesting technicians were sourced from orchards of at least 10 hectares. Orchards sized between 5 and 10 hectares accounted for about 25% of the total, while those between 1 and 5 hectares contributed roughly 28%. Therefore, large orchards—those of at least ten hectares—are the primary suppliers of mangoes destined for export (**Table 41**).

Average yield was approximately 1.15 tons per hectare, which is significantly lower than the gross yield at the producer level: 3.5 tons per hectare for the Amélie variety, 5 tons for Keith, and 4 tons for Kent, the most prevalent variety in the project area. For Kent, the collected yield represents only 28.75% of the gross yield (**Table 42**). Results in **Table 43** reveal that yields are marginally higher in the oldest orchards compared to younger ones, although this difference is not statistically significant at the 5% level.

Yield analysis by orchard size shows that the highest yields were observed in orchards of 1 - 5 hectares, with yields in the other two size classes being of similar magnitude. Nonetheless, these differences were not statistically significant at the 5% level (**Table 44**).

Table 42. Mean yield (tonnes per hectare) of exported mangoes within the project area.

	Average	Standard error of the mean	95% confidence interval	
yield	1.1537	0.05415	1.047	1.26

Table 43. Mean yield (tonnes per hectare) of exported mangoes within the project area according to orchard age class.

Age group	Quantity	Standard error of the mean	95% confidence interval
40 to 60 years	1.182491	0.161577	[0.8648493 1.500132]
20 to 40 years	1.201786	0.0830887	[1.038443 1.365128]
10 to 20 years	1.08601	0.0939015	[0.9014105 1.270609]
3 to 10 years	0.9155955	0.1552327	[0.6104262 1.220765]

Table 44. Mean yield (tons/ha) of exported mangoes in the project region according to orchard size categories.

Area class	Quantity	Standard error of the mean	95% confidence interval	
1 to 5 ha	1.1659	0.072	1.024	1.3077
5 to 10 ha	1.12	0.1031	0.9173	1.3227
10 ha or more	1.1189	0.1141	0.8946	1.3432

3.5.4. Degree of Affiliation and Participation in Certification among Mango Producers in the Project Area

The overwhelming majority of producers are neither members of producer groups nor involved in any certification processes. Specifically, nearly three-quarters (73.01%) of producers lack affiliation with any group (see **Table 45**), while approximately four-fifths of producers do not hold any form of certification (see Table 46).

Table 45. Distribution of producers by level of group affiliation.

Affiliated with a group	Percentage	Standard error of the mean	95% confidence interval	
yes	26.99	2.201	22.89	31.53
non	73.01	2.201	68.47	77.11

Table 46. Distribution of producers according to certification status.

Certified	Percentage	Standard error of the mean	95% confidence interval	
yes	11.08	1.559	8.368	14.54
non	88.92	1.559	85.46	91.63

3.6. Production Constraints in the Project Area

3.6.1. Assessment of Biotic Constraints

In terms of biotic constraints, diseases pose a production challenge for approximately 85% of producers (Table 47), while pests—particularly fruit flies—represent a significant threat to production for nearly 97% of producers (Table 48).

Table 47. Assessment of diseases affecting mango trees as a constraint to mango production.

Do diseases represent a Constraint to mango production?	Percentage	Standard error of the mean	95% confidence interval
Yes	84.46	1.759	80.68 87.61
No	15.54	1.759	12.39 19.32
Total	100		

Table 48. Assessment of mango pests as a limiting factor in mango production.

Do parasites represent a Constraint to mango production?	Percentage	Standard error of the mean	95% confidence interval
Yes	97.26	0.832	95.06 98.5
No	2.735	0.832	1.498 4.943
Total	100		

3.6.2. Assessment of Socio-Economic Constraints

Regarding socio-economic constraints, the data presented in Table 49 and Table 50 show that the scarcity of agricultural labor constitutes a moderate to severe limitation for approximately two-thirds of producers. In contrast, the low purchase price is identified as an extremely severe constraint for nearly all mango producers.

Table 49. Assessment of labor availability as a constraint in mango production.

Is labor scarcity a constraint on mango production?	Percentage	Standard error of the mean	95% confidence interval
Yes	60.5	1.945	56.62 64.25
No	39.5	1.945	35.75 43.38
Total	100		

Table 50. Assessment of mango purchase price as a constraint in mango production.

Is the purchase price of mango a constraint on mango production?	Percentage	Standard error of the mean	95% confidence interval
Yes	99.2	0.4611	97.54 99.74
No	0.8002	0.4611	0.2569 2.464
Total	100		

3.7. Awareness of Fruit Flies and Their Damage in the Project Area

3.7.1. Assessment of Knowledge Regarding Flies, the Damage They Cause, and Solutions to Such Damage

Table 51. Classification of mango producers based on their capacity to recognize fruit flies on mangoes.

Can you identify mango flies?	Percentage	Standard error of the mean	95% confidence interval	
yes	21.01	1.854	17.6	24.89
non	78.99	1.854	75.11	82.4
Total	100			

Table 52. Qualitative assessment of losses attributable to fruit flies.

Do you lose a lot of money to flies?	Percentage	Standard error of the mean	95% confidence interval	
Yes. a lot	97.07	0.853	94.83	98.35
Not much	1.6	0.642	0.7244	3.498
Little	1.334	0.588	0.5583	3.152
Total	100			

An assessment of mango producers' knowledge regarding flies and the damage they inflict reveals that over three-quarters of producers acknowledge their inability to identify mango flies (**Table 51**). The overwhelming majority (over 97%) believe that flies cause significant damage to the fruit; more than 66% estimate that losses attributable to flies exceed 75% of total production, while approximately 20% assess these losses as falling between 50% and 75% (**Table 52** and **Table 53**). Only around 8.5% of producers report being aware of any endogenous solution (Table 54).

Table 53. Quantitative assessment of losses attributable to flies.

Percentage of production lost to flies	Percentage	Standard error of the mean	95% confidence interval	
>75%	66.77%	2.093	62.53	70.75
From 50% to 75% of sales	19.39%	1.795	16.1	23.16
Between 25% and 50% of sales	11.44%	1.574	8.686	14.91
<25%	2.41%	0.7205	1.335	4.315
Total	100			

Table 54. Assessment of the availability of indigenous solutions for the control of fruit flies.

Do you have endogenous methods for controlling fruit flies?	Percentage	Standard error of the mean	95% confidence interval	
Yes	8.54	1.321	6.277	11.52
No	91.46	1.321	88.48	93.72
Total	100			

3.7.2. Assessment of Producers' Training Level

Training constitutes the second essential step in combating fruit flies. The data presented in Table 55 show that fewer than 15% of producers state that they have received training in fruit fly control.

Table 55. Distribution of mango producers by whether or not they have received training.

Have you received training in fruit fly control?	Percentage	Standard error of the mean	95% confidence interval	
Yes	13.97	1.61	11.09	17.44
No	86.03	1.61	82.56	88.91
Total	100			

4. Discussion

4.1. Profile of Mango Producers

This study demonstrates that mango production in northern Côte d'Ivoire is predominantly undertaken by indigenous Sénoufo men, who are mostly married, possess limited formal education, and have, on average, approximately twenty years of experience (Tables 1-10). Such a demographic profile aligns with findings by [7], who indicate that traditional agricultural systems in West Africa are typically male-dominated, especially in the case of cash crops like mango.

The markedly low participation of women in this sector (less than 1%) stands in stark contrast to trends observed in other cash crop sectors [8], thereby underscoring a potential opportunity to enhance women's inclusion within agricultural value chains.

4.2. Productive Resource Allocation and Orchard Structure

Production is predominantly dependent on family labor (87%), although nearly half of producers also employ hired workers. This situation indicates a semi-commercial production structure, wherein family labor remains dominant but proves inadequate, especially during peak demand periods. Such findings are consistent with those reported by [9] regarding fruit crop production in West Africa.

The average orchard size is 6 hectares, with most producers operating on small plots (≤5 ha). However, 13% of orchards—often those owned by exporters—exceed 10 hectares and account for over 50% of total exported output (**Table 41**). This coexistence of small- and large-scale producers is a typical feature of agricultural value chains with significant export potential [10].

4.3. Dynamics of Orchard Establishment

The orchards have an average age of 22 years, with most being established between 1975 and 2005. The decline in new orchard creation observed since 2005 is attributed to the political crisis, competition from cashew cultivation, infestations by *Bactrocera dorsalis*, and increasing land pressure (**Table 23**). This reduction in investment activity aligns with widely reported impacts of conflict and state withdrawal on the sustainability of agricultural value chains [11].

4.4. Land Tenure Constraints and Access

Land tenure emerges as a major limiting factor: while 94% of producers own their land through inheritance (**Table 24** and **Table 25**), over 95% of survey respondents perceive land as highly scarce (**Table 27**). This paradox—widespread ownership yet pronounced scarcity—underscores the rigidity of the rural land market, as previously documented by [12]. Such scarcity directly constrains opportunities for orchard expansion or renewal.

4.5. Input Use and Intensification

The findings reveal a low to moderate level of intensification: fertilizer application remains marginal (3.3%), whereas herbicides (70%) and insecticides (86%) are extensively employed (see **Tables 31-33**). This reliance on plant protection products is attributable to severe pest pressure, particularly from fruit flies (*Bactrocera dorsalis*), which represents a major challenge in the region [13].

Furthermore, irrigation is nearly absent (<1%), significantly constraining productivity during drought periods. Despite this, existing literature on horticulture in the Sahelian context strongly advocates for the adoption of supplemental irrigation practices to ensure yield stability [14].

4.6. Productivity and Export Performance

The average export yield stands at 1.15 t/ha, representing approximately 30% of the gross yield observed for cultivated varieties (4 t/ha for Kent). This marked reduction is primarily attributable to the rigorous grading required by the phytosanitary standards of European markets. These findings corroborate those of [15], who emphasize the direct effect of fruit fly infestations on export rejection rates.

Certification is associated with a modest increase in yield (1.24 t/ha compared to 1.14 t/ha); however, this effect does not reach statistical significance, in part due to the limited uptake of certification in the region (11%) (**Table 46** and **Table 50**). These results align with the observations of [16], who demonstrate that the effects of certification are contingent upon producers' organizational structures and the availability of institutional support.

4.7. Production Constraints

Producers identify biotic constraints (such as fruit flies and parasites) as the most significant, followed by abiotic constraints (including strong winds and excessive rainfall), and finally economic constraints, particularly low purchase prices and a lack of organizational structure (**Tables 52-55**). This prioritization of constraints typifies the challenges commonly encountered in tropical export crop production across sub-Saharan Africa [17] (Affognon *et al.*, 2015).

5. General Conclusions

A baseline survey was conducted among mango producers in northern Côte d'Ivoire as part of a fruit fly control project funded by CORAF/WECARD.

Methodologically, two distinct areas were selected: the intervention area, or project zone (comprising Korhogo, Sinématiali, and Ferké), which would receive project interventions, and the control zone (Boundiali), which would not benefit from any project activities. In each area, a random sample of producers was drawn using a stratified sampling approach.

The baseline characterization encompassed nearly every aspect of mango production. This included an assessment of producer-specific characteristics, an evaluation of training levels related to fruit fly management, and analyses of plot structure, land tenure, and production. At each analytical stage, the most relevant performance indicator for project initiation was identified wherever possible for each level of analysis and in both zones. Consequently, a summary table of baseline performance indicators was produced for each zone, thereby enabling an evaluation of project progress and measurement of its impact at project completion.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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