Working Paper Series

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Resource: A2.5 Research Analysis and Validation

Study focus – Impact assessment

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Summary

The purpose of this study is to examine the impact of three technical interventions on mango production – from cultivation to post-harvest – in order to reduce unnecessary costs and increase household income through improved fruit yield and quality, processing, and trade. We found that the fertiliser intervention increased household income for producers of Cat Chu variety mangoes by VND19 to 27 million/ha/year from the main harvest, due to reduced fertilisation costs; whereas the income increase for Cat Hoa Loc variety mangoes was around VND67 million/ha/year. However, some unexpected influence factors during the interventions – such as difference in age classes, varieties, or densities of mango plantations – must be taken into account when evaluating these impacts. The flowering experiment, on the other hand, did not provide the desired results due to unfavourable weather conditions. Although the sap burn intervention did not cause an economic impact on smallholder farms, as the experiment was conducted under a controlled supply chain environment, the longer ripening period and increased cosmetic value resulting from this treatment may provide an opportunity for farmers to obtain higher prices in future.

1 Introduction

This study performed impact assessments relating to three interventions in activities 2.1, 2.2 and 2.3 in the project.

Operational, financial, and socio-economic ex-post impact assessments were conducted for each of the interventions: fertiliser application, flowering manipulation, and sap burn treatment. The research team used the economic and financial templates developed for monitoring and evaluating the interventions. Furthermore, a semi-structured survey instrument was used for each intervention to collect in-depth information regarding the reasons for intervention impacts and the adoption challenges.

The project encompassed areas with a high concentration of growers and other supply chain participants (see Appendix 1 for a description of the intervention context). Collaboration with lead businesses in other areas of South Vietnam – particularly in the processing channel – also occurred. Such companies provide ideal opportunities for testing and promoting specific chain innovations. As a result, the selection of private sector partners was largely based on opportunity rather than location.

This study answers the following research questions:

- What are the impacts of each of the interventions on smallholder mango farmers?
- What are the challenges and barriers for farmers to adopt each of the interventions?

The report summarises the impact assessment outcomes from the interventions and presents recommendations to achieve broader market development – including financial benefits that could be allocated more equitably across the supply chain. The findings contribute to the mango value chain linkage building activities and training programs within the project.

2 Method

2.1 Research design

This study uses a qualitative evaluation method to gather information for the three interventions. The Southern Center for Agriculture Policy and Strategy (SCAP) and Southern Horticulture Research Institute (SOFRI) teams conducted semi-structured in-depth interviews from October 2021 to February 2022. It is important to note that the experiment must be deployed many months in advance (by the SOFRI technical team) in order for mango trees to complete a fruiting cycle from dormancy to flowering and harvesting before being fully evaluated. Normally, this takes between 3 to 4 months. The fertilising intervention occurred four times: firstly in March, secondly during flowering in June, with the last two interventions set according to farmer schedules. The sap burn experiments were evaluated in the garden as soon as the farmers finished harvesting. Furthermore, because the effects of sap burn intervention extend beyond mango farms, we interviewed pack houses and wholesale markets involved in supply chain trading of treated mangoes. Detailed information on the experiments is located in the Appendices.

2.2 Data collection

The study was completed by 12 farmers in Tien Giang and Dong Thap provinces, with four households for each of the interventions. Each intervention was implemented on 24 to 30 trees.

Fertilising experiment:

- Control experiment ao (conventional): 1 tree/1 exp, 5 replication (rep)
- Experiment a1: decrease 25% of N, keep P, K, Ca as usual: 1 tree/1 exp, 5 rep
- Experiment a2: decrease 50% of N, keep P, K, Ca as usual: 1 tree/1 exp, 5 rep
- Experiment a3: decrease 75% of N, keep P, K, Ca as usual: 1 tree/1 exp, 5 rep

Flowering experiment:

- Control experiment bo: conventional: farmers continued to operate as per normal (Paclobutrazol treatment): 1 tree/1 exp, 5 rep
- Experiment b1: Uniconazol: 1 tree/1 exp, 5 rep
- Experiment b2: Prohexadion: 1 tree/1 exp, 5 rep

Sap burn experiment:

- Control experiment co: conventional: farmers continued to operate as per normal: 1 basket (plastic basket, about 53 kg), 3 rep (equivalent to 3 baskets)
- Experiment c1: applied SIAEP1, 2.5g/litre water, submerge whole mango basket in the solute tank: 3 rep for 3 baskets of mango

Appendix 3 provides the checklist for the impact assessment data collection.

3 Results and discussions

3.1 Cost impact of fertiliser intervention

Cat Chu mango: On average, the cost of one hectare of mango cultivation under the project's fertilising intervention during the 2021 October season was VND105.2 million/hectare; whereas the cost of the traditional fertiliser application was VND107.2 million/hectare (Table 1).

Table 1. Cost of Cat Chu mango production of the October season, 2021 in Dong Thap

Item	Traditional cultivation		Project intervention[1]		Difference	
	VND mil/ha	%	VND mil/ha	%	VND mil/ha	%
Labour[a]	35.2	32.8	35.2	33.5	0	0
NPK fertiliser	6.65	6.2	4.64	4.4	-2.01	-1.91
Organic fertiliser + regulator chemicals	13.33	12.4	13.33	12.7	0	0
Plant disease chemicals	30	28.0	30	28.5	0	0
Other materials[b]	19.86	18.5	19.86	18.9	0	0
Other costs[c]	2.14	2.0	2.14	2.0	0	0
Total	107.18	100	105.17	100	-2.01	-1.9

Source: Surveyed result

Note: a: Common labour wages in the region are VND300,000 to 320,000 /day. Usually, this fee does not include the cost of meals - 2 meals/day; b: Bags of fruit, chemicals for flower treatment, electricity, gasoline; c: Equipment, tools, cheap equipment, transport)

The data in Table 1 shows that the total production cost of the experimental mango orchards using the project's fertiliser process was VND2.01 million/ha– less than that of the conventional (control) model, owing to savings in synthetic NPK (nitrogen, phosphorus, and potassium) fertiliser costs. Only the type and the amount of chemical fertiliser differed between the experimental mango trees and the control mango trees (farmers). The experimental mango trees were fertilised with single fertilisers such as urea (1.52 kg/tree/crop), phosphorus (3.44 kg/plant/crop), potassium (1.17 kg/tree/crop), and lime (0.32 kg/plant/crop); whereas gardeners use mixed fertilisers such as Yara 20-20-10 and Yara 20-20-15.

Hoa Loc mango: Unlike Cat Chu mango, Hoa Loc mango costs were calculated over 1 year. This is due to the fact that they are unable to split (or remember) the quantity of fertiliser required for each crop during the interview process, just the total amount they must spend on fertiliser for the entire year. Therefore, the overall cost was much higher than that of Cat Chu mango. The cost of labour and fertiliser, calculated using the project formula, decreased by 1.6 and 14.0 million VND/ha/year, respectively. Therefore, total production costs were reduced by 15.6 million VND/ha/year or 6.8%, when compared with traditional farming (Table 2). It should be noted that the labour calculated in this table includes both family and rented labour. Farmers claim that hired labour is scarce and that prices are rapidly rising, making mango production less profitable in recent years.

[1] This is the 50% NPK reduction scenario. (The other two experiments are 25% and 75% NPK reduction, control: 100% NPK)

Table 2. Annual cost of Hoa Loc mango production, 2021

Item	Traditional cultivation		Project intervention		Difference	
	VND million/ha	%	VND million/ha	%	VND million/ha	%
Labour	97.93	42.9	96.33	45.3	-1.60	-0.7
Fertiliser (both organic and NPK)	52.33	22.9	38.33	18.0	-14.00	-6.1
Plant disease + regulator chemicals	58.333	25.6	58.333	27.4	0.00	0.0
Other materials	17.17	7.5	17.17	8.1	0.00	0.0
Other costs	2.36	1.0	2.36	1.1	0.00	0.0
Total	228.12	100.0	212.52	100.0	-15.6	-6.8

Source: Author's analysis

3.2 Operational impact

Changes in growth stages

Fertilising intervention: Table 3 compares the results in each growth stage between the control and experimental plants. For both Cat Chu and Cat Hoa Loc mangoes, the evaluation results demonstrated no difference in dormancy between the control formula (including the experiment and neighbouring households) and the project intervention. Regarding the flowering stage, the project's experimental formula had a stronger effect on Hoa Loc mango, which obtained a flowering level 15 to 25% higher than traditional cultivation; whereas it had a weaker effect on Cat Chu mango, which had a flowering level of around 5% lower. Note that this lower rate occurred within just one household (Mr. Mach) in My Xuong commune, Cao Lanh district – the other household (Mr. Tung - Tan Thuan Tay commune, Cao Lanh City) obtained no flower at all. In terms of fruit development, there was an inverse relationship between the two mango varieties: the number of young fruit in the project's fertiliser formula was 10% higher than that of the conventional practice of Cat Chu mango; whereas the young fruit level of Hoa Loc mango decreased by 5 to 10%. However, at the harvesting stage, Cat Chu mango under intervention produced more uniform and larger fruit compared with the control group – approximately 50 g (17%) larger, resulting in a higher percentage of first-grade fruit (Table 3)[2].

For the Cat Chu fertilising experiment at Mr. Tung's household in Tan Thuan Tay commune (DT), during the current season (flowering began in December 2021), 6 out of 20 trees (30%) under the project treatment produced fruit; whereas only 15 out of 180 trees (8.3%) under the conventional practice bore fruit during the second harvest season. The fruiting rates (amount of fruit/number of flowers) were similar between the treated and conventional practices. The same farmer also predicted no yield discrepancy between the treated and untreated mango. Furthermore, Mr. Mach's household in My Xuong commune, Cao Lanh district witnessed a 100% flowering, fruit setting and harvesting of all trees under both experimental and conventional practices. This can be seen as a significant difference between the two Cat Chu mango gardens under the project experiment – despite the close proximity between the two locations (13 km).

[2] Farmers acknowledged that their estimates were approximate and may be subject to errors

Table 3: Difference in process changed of both mango varieties

Growth stage		Cat Chu Variety		Cat Hoa Loc Variety	
		Traditional cultivation	**Project intervention**	**Traditional cultivation**	**Project intervention**
Dormancy		-	Unobservable differentiation	-	Unobservable differentiation
Flowering		120/300 trees have flowers in the 1st season (40%) 135/300 trees have flowers in the 2nd season (19.8%)	5% more proliferation in the 1st season. 26/40 trees have flowers in the 2nd season (65%)	-	15 to20% more proliferation in the 1st season. Unobservable discrepancy in the 2nd season
Fruit development		120/300 have fruits in the 1st season 135/300 trees have fruits in the 2nd season (19.8%)	10% more proliferation in the 1st season. 26/40 trees bear fruits in the 2nd season	-	5 to 10% less proliferation in the 1st season. 10 to 15% more proliferation in the 2nd season
Harvesting	Season 1	Average weight: 350 gram/fruit	Fruit is 50gram (17%) bigger than traditional cultivation one, reach 400 gram/fruit, fruits are more uniform in size.	Grade 1[3]: 25% ---------- 2: 30% ---------- 3: 35% Bad grade: 15%	Grade 1: 40% --------- 2: 35% --------- 3: 15% Bad grade: 10%
	Season 2	Not harvested yet		31.7 kg/tree Fruit grade % are similar as in season 1st	36.4 kg/tree 14.8% higher yield Grade 1 is 10 to 15% higher than in season 1st (50 to 55%) Other grade % are similar as in season 1st

Source: Surveyed result

For Hoa Loc mango, fertilising increased the fruit rate of grade 1 (greater than 500 grams/fruit) to around 40% or 15% higher than traditional farming; while grade 2 (400 to 500 grams) increased only slightly, at 5% higher than the control (Table 3).

In the Tet season, 28 out of 40 trees under project treatment produced 1,020 kg of mango (36.4 kg/tree) compared with 1,650 kg from 52 out of 69 trees under the conventional practice (31.7 kg/tree) – resulting in an increase of 14.8% higher yield from fruited trees. It should be noted that this yield only increased by 1.3% when taking into account all trees (fruited and non-fruited). However, according to farmers, calculating additional yields based on individual trees is a more accurate reading, given each tree has its own fruiting cycle – one season good, the next bad. Farmers had not yet harvested at the time of the second survey in February 2022, but one farmer (Mr. Tiep) claimed that the fruit size of the current season under the project treatment was uniformly larger than that under conventional practice – predicting that the grade 1 percentage would be higher than 40% as observed in the last season (first survey), potentially up to 50 to 55%. Regarding yield for the following harvest, he predicted that 15 of the 20 trees under experiment would produce around 650 kg (43.3 kg/tree) and 10 of the 15 trees under the conventional

[3] Hoa Loc mango fruit classification: G1: >500gram, G2: 400 to 500gram, G3: 300 to 400gram, dạt: <=300 gram or cracked, black spots.

practice would produce about 300 kg (30 kg/tree), resulting in a 44.3% increase in mango yield under the project intervention. This prediction needs to be verified during the next harvest, in April to May 2022. The other farmer (Mr. Thuc) had no clear prediction about the fruit grade or discrepancies between treated/untreated mango trees. The difference, according to households engaged in the project, was due to: (i) the application of fertilisers using the new SOFRI formula based on testing soil samples, thereby knowing the lack and excess of trace elements in the soil, which was the foundation for fertilising with balanced nutrition as recommended by the project. In the case of the traditional method of fertilising, soil samples were not tested, so people relied solely on their own experience; and (ii) farmers' perceptions of organic fertilisers and manure for plants have shifted significantly in recent years, resulting in increased use of organic fertilisers and manure. This fundamental change not only causes the mango trees to grow more naturally, but also ensures the quality of fruit and reduces soil erosion. To minimise costs, all surveyed households stated they would reduce inorganic and increase organic, particularly processed organic, from available sources in the near future. For example, rotten mango, garlic, chilli, and wine soaked in water can all be used to irrigate plants – providing organic fertiliser while also eliminating pests. From years of farming experience, farmers believe that a sufficient amount of fertiliser must be applied, or else the tree will be degraded with respect to foliage ability, the degree of flowering, fruit setting, and fruit size.

Flowering intervention: The results of the evaluation of the flowering experiment in Table 4 showed that there was no difference between the project's flowering treatment formula and the traditional flowering treatment, with respect to the dormancy period for both mango varieties. Only one household cultivating Cat Chu observed 12.5% more flower proliferation.

The treatment of Uniconazole and Prohexadione on Cat Chu mango resulted in 10 out of 16 experimental trees developing fruit (62.5%); while in the control treatment (using Paclobutrazol, also known as PBZ), there were 10 out of a total of 29 trees, accounting for 35% (3 out of 8 trees produced fruit under the control experiment). For Hoa Loc mango, some trees under the project treatment did not produce flowers and fruit, while the traditional farming method showed about a 10% reduction in fruit setting for flowering plants. However, according to researchers and participants, the flowering experiments this time around have not been satisfactory because the flower treatments have encountered unfavourable weather (early and repeated rains), causing the experiment to be repeated, thereby reducing the experimental accuracy. Furthermore, according to one farmer (Mr Tiep), Hoa Loc mangoes failed this year, making it difficult to compare between trees in the garden and those from previous years. The weather factor is very important for flowering, because it is considered a crop loss if it rains for 3 to 4 consecutive days.

Table 4: Process changed of mango under flowering intervention

Change in stage	Cat Chu Variety		Cat Hoa Loc Variety	
	Traditional cultivation	Project intervention	Traditional cultivation	Project intervention
Dormancy	Unobservable differentiation		Unobservable differentiation	
Flowering	- 5/10 trees have flowers in the 1nd season (50%)	Unobservable differentiation 10/16 trees have flowers in the 1nd season (62.5%)	No flower on some trees.	No flower on some trees, but in general unobservable in the 1st season;
Fruit development	10/29 have fruits (34.5%) in the 1st season	Uniconazol: 10/16 trees have fruits (4 trees under Uniconazole and 6 trees under Prohexadione treatment) in the 1st season (62.5%).	Decreased 10% compared to the previous year	Crop loss, decrease 10 to 15% Unobservable differentiation in the 2nd season
Harvesting		Inconclusive yet	-	Inconclusive yet

Source: Author's analysis

In the second evaluation, only four trees across Mr. Chi's Cat Chu entire mango plantation obtained a 75% flowering rate and were thus fruiting under natural conditions (without treatment) – these were the same trees of the previous flowering treatment under the project. The rest of the garden only obtained 10 to 15% flowering on each tree, which led the farmers to abandon all of them in order to prepare for the new fruiting season. According to the farmer involved (Mr. Chi), the project is yet to determine whether the experiment has been successful or not.

For the Cat Hoa Loc mango only one household participated – with 14 trees planted under the project flowering intervention and seven trees planted under the traditional practice (PBZ pouring into stump or soil drench). However, during the blossoming season in June 2021, only 2 to 3 trees blooms appeared on the treated mango trees, whilst three trees under the conventional practice obtained only 30 to 40% blossom, as seen in neighbouring gardens of other households. This was due to the weather conditions in Hoa Hung commune, Cai Be district, claimed Mr. Tòng and Mr. Dan, mango growers in the same village within the project site. During the main harvest season (second survey in February 2022), the flowering had taken place naturally without flowering treatment. However, just two out of the 14 previously treated trees bloomed, whereas four out of the seven trees in the previous control group bloomed. Mr. Tiep observed that these six trees will produce an equal yield, of around 25 kg/tree during the next harvest in April 2022.

Sap burn experiment

Traditional treatment: Famers removed pedicels (3 to 5 cm long), clean off the sap of fruits before packing them into baskets (20 to 30 kg each) and delivering them to local buyers.

Project treatment: Picked mangoes were cleaned, pedicels were cut, they were weighed for the experiment, then soaked in cold and clean water for 10 to 15 minutes, dipped in solution (SIAEP 1) for 1 minute, before being taken out and dried.

The difference between the experiment using SIAEP1, concentration 2.5 g/litre, and the control (traditional), was that mangoes were stored for longer than 1 to 2 days at room temperature (Cai Be fruit shop in Cai Be district) – while the temperature in the supermarket (WinMart) was set by air-conditioning. Because the project treated mango had a more attractive appearance, it sold faster in the supermarket than traditionally treated mango. This makes it difficult to determine the exact percentage of mango required to extend the ripening time by 1 to 2 days (Table 5). Observations revealed after dipping mango and drying at the farm gate, the ripening stage was slower than wrapping mango with paper.

Table 5: Difference of traditionally treated and project's treated mangos

	Cat Chu Variety		Cat Hoa Loc Variety	
	Traditional treatment	**Project intervention**	**Traditional treatment**	**Project intervention**
Before treatment	The fruit is green, has a long pedicel, is sticky with sap, and has some stains, melasma, can be soiled, and can be stung by insects.	The fruit is green, pedicel is removed, is sticky with sap, and has some stains, melasma, can be soiled, and can be stung by insects.	Similar to Cat Chu mango, but fruit is bigger	
After treatment	The fruit is green, and clean, has a long pedicel	The fruit is green, and clean, shiny and beautiful, no sap coming out from pedicel		The fruit is green, and clean, shiny and beautiful, no sap coming out from pedicel
Ripening time	3 to 4 days (the least mature fruit)	4 to 6 days	4 to 5 days	6 to 8 days
Selling ability, price	Easy to sell, particularly for domestic consumption with pedicels	Difficult to sell (according to farmer's opinion), price unchanged to compare with traditionally treated mango	Easy to sell, particularly for domestic consumption with pedicels	Difficult to sell at the beginning, price unchanged to compare with traditionally treated mango

Source: Author's analysis

Mangoes treated under the project method, in general, differed from traditional treatment in that they had been washed, including any sap attached to the skin. Farmers believed that the chemical can dissolve and clean the mango sap in the treatment solution.

There were mixed opinions about mango treatment for a variety of reasons:

- Both households and local purchasing agents had never treated sap, thus they did not know what to expect, especially negative feedback from wholesale markets or supermarkets, if any.
- It was difficult for people to sell processed mangoes because buyers did not request them.
- According to one farmer, treated mangoes were almost entirely purchased by researchers and brought to Ho Chi Minh City, so the evaluation team did not have opportunity to evaluate the advantages of buying and selling.
- In another household, the farmer's processed mangoes was only sold to the local buyer within the commune, therefore he did not know where the product ended up, so it could not be assessed.

Adoption barriers for sap burn treatment included:

- According to farmers, if this experiment was carried out in the garden, a space of 10 to 15 square meters would be required with a minimum of 1 to 2 electric fans to dry the mango after solution dipping.
- It takes time and labour for the household – estimated at least 0.5 labour days/ton of treating mango.
- The household must purchase additional equipment such as an interlining canvas, dipping tank, trolley and electric fan. When asked if they would continue using the project method, households stated that they would only do so if local traders required it – households would satisfy local buyer requirements, provided that they consume all their mangoes without buying at higher prices.
- Mangoes have a high domestic demand; however most people prefer mangoes with pedicels – particularly pedicels with leaves – to make them more attractive to display at

worshipping events. Furthermore, mango with pedicels do not have sap bleeding and would feel like a freshly picked mango to the buyer (improving experience). As a result, treated mangoes with removed pedicels would generally not be preferred. It is interesting that consumers desire to keep the pedicel intact with the thin layer of white powder on the surface of the Cat Hoa Loc mango skin – but also like the beauty and shiny skin of mango from the project treatment method.

Yield and fruit quality

Fertilising

Productivity: The yield of Cat Chu mango was slightly lower than that of the traditional fertilisation method for the project's fertiliser formulations, particularly in the formulas with 75% and 50% reductions in NPK fertilisers. The application of the 25% NPK reduction formula, on the other hand, increased yield. There were some trees in particular that achieved a 4 to 5% increase, or an average of 20 to30 kg/tree, which is greater than that of traditional fertilised trees of the same age. This was largely because the project-fertilised tree's fruit was 50 grams/fruit larger than average. Furthermore, when compared to traditionally fertilised mangoes, which are only VND20,000 /kg at the time of evaluation, large-fruited mangoes are sold at a price VND1,000 to 3,000/kg higher (VND23,100/kg).

In the second evaluation, both the fertilising treatment and conventional practice appeared to have a very high fruiting rate for the Cat Chu variety in My Xuong commune. Due to weather conditions, farmers must consequently discard 20 to 30% of the fruits when covering them with bags, even if the fruits are qualified. This occurred throughout the garden, affecting both experimental and non-experimental trees equally.

Fruit colour: There was no difference between the traditional fertilisation method and the project method for both Cat Chu and Hoa Loc mango varieties. This may be partly because all the fruits were covered by paper bags in the same way.

Fruit size: Mangoes of both varieties produced fruit of roughly equal size. There was a significant difference when applying the project fertilising formula. The fruit was larger in Hoa Loc mango, at 15% and 5% for grade 1 and 2 fruits, respectively.

Sweetness: No tasting was undertaken; however farmers did not believe there would be any difference.

Flowering

Flowering is inconclusive at this moment. To date, there have been no positive indicators from the flowering trial in both experiments across two households: one household of Cat Chu mango in Dong Thap and another household of Cat Hoa Loc mango in Tien Giang There are three plausible explanations for this outcome:

- 2021 was the year of crop failure in some sub-climates in Dong Thap. This is evident when one household in Cao Lanh District had a very good harvest, while another household in Tan Thuan Tay commune (Cao Lanh city, about 13 km away) had consecutive crop failures – which was similar to another household in the same commune participating in the fertiliser treatment. This also happened on a large scale in the Cat Hoa Loc mango area of Hoa Hung, Cai Be, Tieng Giang communes. Thus, the intervention design of only one experiment per household at a single site is not sufficient for evaluation and replication.
- The selection of flowering experiments in the intercropping garden with Taiwanese mango at low density (4 m x 4 m, one row of Cat Chu mangoes and one row of Taiwanese mangoes) may affect the experiment and be difficult to evaluate, while most of the Cat Chu area in Dong Thap is mono cultivated.
- Finally, the experiment implementation was hampered by rain, making it difficult to assess the remaining effect, repeat the trials, and evaluate the impact.

3.3 Socioeconomic impacts

Impact on household income and economy

This section evaluates how household income changed as a result of fertiliser reduction costs, along with gains in mango price and productivity.

Fertilising

Although a productivity increase was not observed for Cat Chu mango, given the higher selling price of mango due to larger fruit achieved by project fertilisation, the income gain is expected to be in the region of VND2.0 to 3.1 million/ton. Assuming an annual yield of 7.5 tonnes/hectare, the total income gain is expected to be between VND15.0 and 23.3 million. Furthermore, the savings from fertiliser reduction are anticipated to be VND2.01 million/harvest season, or VND4.02 million across the whole year, resulting in a total income gain for households cultivating Cat Chu mango of VND19.0 to 27.3 million from the main harvest season.

Although total productivity for Hoa Loc mango was not observable, fruit grades 1 and 2 increased by 15% and 5%, respectively, due to the project's fertilisation intervention. The corresponding revenue gain would be VND51.0 million based on the weighted average revenue by selling price, according to our farmer interviews (grade 1 being VND50,000 and grade 2 VND40,000 (Table 7), assuming the average productivity is 12 tons/ha/year, as experienced in the region[4]). Furthermore, the savings from fertiliser reduction would amount to VND15.6 million per year (Table 6), making a total income gain of VND66.6 million/ha/year.

Table 6: Hoa Loc mango grades and their farmgate prices

Fruit categorisation	Traditional fertilisation	Project fertilisation	Selling price (VND/kg)	Turnover (Traditional) VND/ha	Turnover (Intervention) VND/ha
Grade 1	25%	40%	50 000	150 000 000	240 000 000
Grade 2	30%	35%	40 000	144 000 000	168 000 000
Grade 3	30%	15%	30 000	108 000 000	54 000 000
Bad grade	15%	10%	15 000	27 000 000	18 000 000
Total	100%	100%		429 000 000	480 000 000

Source: Author's analysis

Flowering

PBZ (conventional) treatment is simple and requires less labour (60 trees/day), whereas canopy spraying requires nearly double the work (30 trees/day). Initially, this intervention appears to increase inputs, resulting in higher costs for mango cultivation for smallholders. However, from a legal perspective PBZ use in plants is likely to be restricted by the government in the near future.

Sap burn

Despite seeing positive results such as the mangoes being shiny and more attractive, extending the ripening time of both Cat Chu and Hoa Loc mangoes, and storing them for a longer period in normal temperature conditions and supermarkets – there were mixed opinions on whether the treatment should be performed. However, because the selling price was not higher and local buyers did not require treatment, some households (Tan Thuan Tay commune) believed that mango should not be treated because this costs money in terms of materials and labour, as well as time in packaging and shipping. Even processed Chu mango was more affordable. Both farmers and researchers agreed the sap burn experiment was ineffective at the household level, but only viable at a concentrated scale with a higher volume – such as local buyers, agents, or processing factories. The question is

[4] The average yield of Hoa Loc mango in Cai Be district ranges from 11 to 15 tons per year.

whether, if processed in these locations, the transportation time from the farm will still make this sap burn treatment effective, in terms of the amount of sap extracted.

Impacts on the distributional channels

According to the fertiliser experiment, Cat Chu mangoes have larger and more uniform fruit in terms of size and are obtain a higher price (VND1,500 to 3,000 /kg) on average. Meanwhile, the fertiliser experiment with Cat Hoa Loc mangoes increased the rate of grade 1 and 2 mangoes by 15% and 5%, respectively. As a result, a greater proportion of mangoes will enter the fresh mango channel for domestic consumption and export. This also means that the percentage of mangoes of grades 2 and 3 will decrease, implying that the rate of mango going into the processed channel will be reduced.

A complete assessment of the sap burn experiment cannot be made due to the relatively small amount of mango in the experiments and the lack of accurate tracking of the product's flow. However, according to preliminary estimates, both Cat Chu and Hoa Loc mango varieties take 1 to 2 days longer to ripen. This has the potential to reduce losses during transportation and display on supermarket shelves, allowing farmers to negotiate higher prices in the future.

3.4 Environmental impact

The traditional method of fertilising has the disadvantage of (i) not fertilising based on soil testing results, but rather on farmer knowledge and the experience of others in the area and (ii) the amount of fertiliser is not balanced, causing evaporation, erosion, and washout horizontally and vertically, causing environmental pollution; and (iii) its tendency to produce clay (clay-pan), increasing pests and diseases. The project's intervention to reduce fertiliser content not only helps growers reduce production costs, but also assists in reducing environmental pollution caused by farmers' traditional use of chemical fertilisers. Furthermore, chemical residues in fruit are expected to decrease.

Regarding the experimentation of flowering and fruiting, it is related to the use of chemicals and obviously harmful to the environment. However, every time it rained after treatment was applied, farmers generally had to spray again. Therefore, in addition to selecting the right chemicals, it is important for farmers to have information about the weather to avoid waste and reduce pollution to the environment. The chemicals Tobajum and Paclobutrazol are used to treat flowering. Mr. Tiep, a farmer, stated that "in my opinion, these substances have a more or less negative impact on the environment." During the off-season mango treatment, other fruit trees planted near the mango tree treated with one of these chemicals exhibited the phenomenon of leaf curling, small leaves, damaged and rotten fruit. According to most households, these chemicals have a greater or lesser impact on the environment, particularly the groundwater that people rely on. According to SOFRI, if watered into the soil, this substance, unlike Paclobutrazol, will remain in the soil for nearly a year; whereas 02 SOFRIs (Uniconazole and Prohexadione calcium), sprayed on leaves under the influence of sunlight and rain, will decompose quickly – reducing environmental effects on the soil, water, air, etc.

Concerning the sap burn experiment, it is unclear if the solution after treatment is toxic to humans, livestock, or poultry. People currently only pour the solution into the common household wastewater system, rivers, and the surrounding environment. However, according to the SIAEP assessment, both TA18 and SIAEP1 are recommended by the manufacturer as having no harmful effects on the environment. According to the SIAEP Institute, a small amount is probably safe, but if it is excessive, a specific assessment is required.

3.5 Gender issue

In order to evaluate gender inequalities in mango growing, harvesting, processing, and trading in the mango value chain, a comparison was made between the project's technical interventions on the one hand and farming responsibilities on the other. Men commonly participate in harder tasks

such as spraying pesticides on trees and picking fruits that require climbing trees, whilst women often undertake lighter work such as weeding, watering, peeling fruit, and sorting mangoes. Therefore, the fertiliser and flowering interventions did not result in apparent changes in women's workload on the farm. Women can be more active in several aspects of the sap burn intervention, such as stem cutting, mango dipping treatment, and packaging. However, our interview with mango buyers (Kim Nhung company Cat Chu in Dong Thap, and Long Uyen Company in Tien Giang), suggested that sap burn treatment should be carried out at the aggregate level such as local buyers, or processing factories.

3.6 Challenges and barriers

Some initial observations:

- The project's proposed method of fertilising based on digging soil profiles and testing soil nutrient compounds is difficult for farmers to implement.
- The traditional flower treatment (Paclo) is to pour it into the stump, which is far more effective and less expensive than spraying it on the tree.
- Uniconazol costs VND300,000/kg and Prohexadion costs VND2,000,000/kg, much higher than the traditionally used PBZ, which costs around VND150,000/kg.

3.7 Assessment limitations

In general, there were many experiments, however the number of successful experiments was small. This could be due to one or more of the following factors:

- The density and age of trees in some experimental gardens was uneven. For example, one household in My Xuong had seedling mangoes planted in 1994 and grafted mangoes planted in 2000.
- Some households (for example, a household in Tan Thuan Tay) intercropped Cat Chu and Taiwan mango varieties, at very low density (4 m x 4 m), while the majority planted at the density of 8 m x 8 m or 6 m x 10 m.
- The flower treatment in some households was hampered by rain and crop failure, resulting in an unclear treatment efficiency. As a result, the possibility of the experiment being repeated, or the treatment chemicals being absorbed was low in the previous treatments – making comparing results to the control group difficult. In addition, the selection of Cat Chu and Dai Loan mango varieties on the same garden for flowering intervention was controversial, in terms of having precise impact interpretation as well as for subsequent scaling up – given most Cat Chu mango gardens in Dong Thap were mono cultivated.
- As previously stated, the number of mangoes that entered the sap burn experiment was very small, so when selling to local traders, they mixed it with other batches of mangoes – making it difficult to track the product within the supply chain for assessment.

4 Insights

Based on the impact evaluation results of the three technical interventions, we offer the following insights.

- The fertiliser experiment on Cat Chu mango is the most promising intervention for increasing farmer income, as evidenced by two outstanding criteria: (i) Cat Chu mango fruit is on average 50 g larger and more uniform in size than those of the traditional fertilised mangoes and (ii) the average selling price is VND1,000 to 3,000/kg higher than that of traditionally cultivated mangoes. This means a total annual income gain of VND19.0 to 27.3 million/ha from the main harvest season resulting from selling mango and reducing cost of fertiliser.

- For Hoa Loc mangoes, although there was no difference in selling price, the proportion of grade 1 (>500 grams) and grade 2 (400 to 500 grams) increased to 15% and 5%, respectively. This change in output would produce a total income gain of VND66.6 million/ha/year, as a result from reducing cost of fertiliser and increasing return from selling mango of grade 1 and 2.
- To date, the results from the flowering trial cannot by analysed yet to assess any impacts. More work is required to complete a full impact assessment in the future.
- The experimental results show that by extending the ripening time under normal (traditional market) and cooler temperatures, this technique has the potential to reduce post-harvest loss (supermarkets, high-end fruit shops). It also helps to improve mango appearance, which leads to faster consumption at the supermarket. The dilemma is that consumers prefer the pedicels to be intact, which is no longer present in the mango under sap burn treatment. Furthermore, because the experiment was conducted on a small scale and in a controlled supply-chain environment, it was not possible to accurately quantify the post-harvest loss rate caused by this treatment.
- Mango farmers are facing increasing disadvantages due to scarce and expensive hired labour, unpredictability of weather, and fluctuating mango prices.