Horticulture Innovation Australia

Final Report

Fruit maturity assessment on farm using NIR

Greg Owens
Northern Territory Farmers Association

Project Number: MG16002

MG16002

This project has been funded by Horticulture Innovation Australia Limited with co-investment from GHD and fund from the Australian Government.

ISBN 978 0 7341 3949 8

Published and distributed by:
Horticulture Innovation Australia Limited
Level 8, 1 Chifley Square
Sydney NSW 2000
Tel: (02) 8295 2300
Fax: (02) 8295 2399

Content

Summary

The percentage of dry matter (%DM) in mango fruit has long been used as a measure of harvest maturity, along with other maturity indicators such as fruit size and shape, skin texture, internal flesh color, flowering times and heat sum calculations and background skin color in some minor varieties. Near Infra-red (NIR) scanning of fruit is now an accepted technology for assessing the percentage of dry matter contained in the flesh of the fruit without damaging the appearance of the fruit as previously occurred for dry matter analysis (Walsh *et al.* 2007). This allows many fruits to be sampled quickly and non-destructively and can be done in the field before harvest, in the packing shed or in the market.

The use of the NIR produce quality meter commonly called the NIR gun made it possible to assess the %DM of many fruit quickly and record that data in blocks or orchards for maturity assessment. The technology allows for repeat sampling of individually tagged fruit or designated blocks over the fruit development period to analyse trends over time to effect timely and planned harvest. MG16002 was a project designed to encourage mango growers across Australia to utilize NIR technology to develop harvest plans based on dry matter analysis as a Best Practice behavior for the industry. Some growers had already invested in the technology notably in the Darwin region of the NT and were well practiced in assessing %DM and developing harvest plans.

The project successfully demonstrated the use of the NIR gun across 9 regions, visiting 61 farms in NT, QLD and NSW. The project recorded data from over 6,000 scans, on 5 varieties and reported the average %DM and range of readings to the grower. By utilizing industry development officers and local farming associations the project took advantage of existing networks to reach the interested growers who could self-nominate for assessment when the NIR guns were in the area. A few of these farms were visited multiple times over the developmental period and by using the trend of the data produced began the process of developing an evidenced based harvest plan. This planning process will be developed further in subsequent seasons and now that these growers are familiar with the technology they can make an informed choice on investing in the technology individually or working with the local and national mango associations to improve their harvest planning.

The project identified issues with the use of the technology on the wider scale that will need consideration by the industry and ongoing technical and extension support to deliver the full benefits that this technology promises for the industry. Access to technical support for ongoing calibration of the meters for each region, variety and season is a must for accurate dry matter assessments. Newer models of the NIR guns with different software packages will complicate the calibration and confidence in the technology. Training and extension support will be needed in the correct use of the meter in the field and in displaying and interpreting the data to develop the evidence based harvest plans. There were also issues of the effects of orchard irrigation practices and rain events on the accuracy of the %DM readings that need to be investigated and incorporated into the use of this technology.

Overall the project found that the NIR produce quality meter technology was a useful tool for the industry to adopt as a measure of fruit maturity and to support the decision to harvest as well as produce evidence based harvest plans. However, it needs further follow up work to account for the variability across the industry regions, people and practices and should be used in conjunction with the traditional methods of fruit maturity assessment until systems are designed to cater for those variations. It is not a silver bullet that can be used off the shelf as a stand-alone definitive measure of in-field fruit maturity.

Keywords

Mango quality
NIR
Near Infra-red
Maturity
Quality Meter
Dry Matter
Extension
Technology uptake

Introduction

The maturity of the first ripe eating mangoes of the season in September/October each year sets the tone of the market for much of the season. If that fruit is mature and ripens well to good eating quality and appearance, then the market price and volume flows will remain higher and with better returns for growers. It is critical for the mango industry that the early fruit, especially the main variety Kensington Pride (KP), is harvested at the required maturity and the consumer has confidence in the flavor of the mango they have purchased. This will lead to repeat purchases, consistent throughput and maintain higher returns for the season. The decision-to-pick process is the gathering of information by the grower of all available maturity indicators of the mangoes that will support their decision to start the harvest.

Mangoes are a climacteric fruit which will ripen when picked green mature to a soft ripe sweet fruit. Numerical standards for dry matter of 14%, then later 15% were determined for Kensington Pride mangoes as the minimum dry matter required at harvest to ensure good eating quality when consumed. Eating quality comes through the conversion of the starches laid down in the fruit during the fruit development period that will change to sugars when the fruit ripens after harvest. If mangoes are harvested before they have reached the correct maturity they will not reach their flavor potential

Traditional dry matter assessment of orchards for predicating and managing harvest timing was based on a small number of fruit that were picked at various stages of maturity and destructively analysed which could take up to 48hrs. The difficulty was in determining the range of %DM within a block, let alone a whole orchard, that often have different microclimates that affected flowering timing and fruit development periods.

The testing of dry matter in mango fruit in the field while still attached to the tree is complex as this is a dynamic system. The tree is pumping mango sap that is a solution of starches, water and other nutrients into the fruit under pressure into the mango. The consistency of the sap and the sap pressure applied can vary greatly between orchards and due to maturity stages, different irrigation and fertilizer practices and rain events. This means the %DM of the fruit will be influenced by these environmental factors or the irrigation management. In Fact, mango fruit often split on the tree in the NT after large rain events as increased water flow is pumped into the fruit. This contrasts with after the fruit is picked when there is a relatively stable relationship between the solids and water content of the fruit even as the starches convert to sugars during the ripening process which make for consistent NIR assessment in the market.

This project was designed to enable growers to have mango maturity checked prior to commencement of harvest. The project funded staff from NT Farmers and AMIA to assist growers with the decision-to-pick process, using NIR technology with the Felix 750 Produce Quality Meters. On-farm testing through the Northern Territory, Queensland, NSW and WA provided growers with information to assist the decision-to-pick process and minimise the volume of immature mangoes reaching the market.

Analysis of the project outcomes showed the extent of uptake of the technology, the impact on the "decision to harvest" and the adoption of evidence based harvest plans and the improved outturn and performance of mangoes in the markets. The project also identified a number of issues that will need to be addressed if the mango industry is to adopt in-field %DM testing as the definitive harvest maturity indicator and the basis for developing the evidence based decisions to harvest and harvest plans for future harvests

Methodology

This project demonstrated to growers the application of NIR technology in the decision to pick process for mango farmers throughout Australia. The project utilised 2 Felix Produce Quality meters, staff from NT Farmers and AMIA will visit growers interested in learning to use the technology and to assist in the analysis of the data in the lead up to harvest and provide advice on dry matter levels of fruit in blocks/orchards prior to harvest. The project was advertised through the NTMIA and AMIA e-news and newsletters and discussed at previous conferences so growers were aware the NIR technology was going to be available for the 2016/17 season.

In the early part of the season, both meters were used in the Northern Territory (September, October, November). Prior to the start of the Queensland season, one meter was used in Queensland, Bowen/ Burdekin (late October/November) and then following on to Mareeba/Dimbulah (November/December and January for late season varieties). The last regions in central and south east Queensland (December/January) and northern NSW only required one meter due to the smaller number of growers in that region. Upon the finish of the Northern Territory and North Queensland season, the other meter was sent to the Carnarvon and Gingin regions of Western Australia (January/February/March)

In preparation for the season, the Felix Produce Quality meters needed to be calibrated for each of the key varieties. The initial calibration process was undertaken with 100 pieces of fruit and the calibration process measures dry matter on the sample of fruit and then calibrates the meter against dry matter measured in the traditional method (measuring and weighing a sample of mango flesh from each mango and then drying and weighing to measure dry matter content). Each meter was regularly checked with a 'mini' calibration during the season to ensure accuracy of measurements. The calibration was undertaken by staff from Central Queensland University in association with NT DPI&F and QDAF staff in the relevant region.

Growers self-nominated to either NT Farmers or AMIA who coordinated the farm visits to maximize the number of visits in a region and reduce the travel component. One staff member from NT Farmers worked in the Darwin and Katherine regions during the NT season with assistance from one staff member from AMIA. AMIA staff were responsible for delivery of the project in Queensland. The project used some other regional Industry Development Officers (IDO's) from local farmer associations and a private consultant to achieve maximum coverage of regions during the major overlap period of November to December.

In Western Australia, the project used a local consultant who visited nine growers in the Gingin to Dandaragan region to assess dry matter of the fruit on February 27. The machine with the growers and they conducted the additional testing. Following the completion of harvest, the consultant drove returned to Gingin to pick up the machine and to discuss the usefulness of the machine with the growers.

%DM data was recorded in accordance with the individual grower's requirements, such as by block or variety. This was usually done on a variety and block basis with a summary of the data returned to the grower showing the average %DM, maximum and minimum values and a standard deviation for that block. Individual fruit data was available to the growers if requested.

This summary data was recorded in a spreadsheet of results (Appendix 1) and then summarized across the regions.

Outputs

The Felix Produce Quality meters were correctly and regularly calibrated for Kensington Pride, R2E2, Calypso and Honey Gold mangoes by utliising mango fruit at different maturities at the start and throughout the season. The calibration information was uploaded to the meters used in the project and to other NIR produce meters in the NT and Qld. These calibrations were recorded and became part of a larger data set that form the basis for the algorithms that produce the maturity models for the NIR guns. This calibration was mostly provided by a Central Queensland University post graduate research student that was onsite for related projects at Acacia Hills Farm (Photo 1, Appendix 2). An example of the calibration summary is attached (Appendix 1).

The project collected over 6,300-point data sets (Photo 2 & 3) and reported these back to each grower/manager as an average %DM for the block or orchard and for each variety tested. The maximum and minimum reading and standard deviation was also provided with each block assessed. This provided the participating grower with an indication of the fruit maturity against a minimum 15%DM standard and the range of maturities in the block. The data was collected and summarized in the attached results spreadsheet in Appendix. Growers and orchard names have been removed from this spreadsheet but results for the farms for each region are listed to show the variation in orchard results over the periods that the NIR meters were in that area.

Total	Farms Visited	No of visits	Varieties	Period
9 regions	70	110	5	30/9/16 – 13/3/17

Some trend data was collected from farms visited and tested several times across the start of the season in the NT. One Katherine major farm was visited 5 times to develop a block by block harvest program, similarly a farm in Mareeba was visited 4 times and a Burdekin farm 3 times to collect trend data for evidence based planned harvests. Some farms where there were multiple visits but on different blocks, which made it hard to get trend data especially when the first blocks tested were harvested before the return visit. Other growers, who only asked for a single visit to assess the fruit %DM then applied 0.1%DM per day accumulation to plan harvest start date for their orchard.

The project visited 70 farms but was also aware of more farms that were using either privately owned meters or that owned by the NTDPIR. The project has set a base line of engagement with the NIR technology in the field across the industry. The adoption of the NIR analysis in the field technology was limited to a few growers. This project was successful in showcasing the technology to many interested growers in just one season. A summary of the data by region collected is given below in Table 1.

Region	**Farms Visited**	**Varieties**	**Period**	**Visits**	**Readings**	**KP Ave ranges**	**R2E2 Ave ranges**
Darwin	12	KP, R2E2	30/9/16 - 9/11/16	18	822	10.3- 16.0	12.0 - 14.5
Katherine	6	KP R2E2, Calypso	6/10/16 - 16/11/16	12	574	13.5- 16.4	14.3 - 14.8
Bowen Burdekin	14	KP, R2E2, HG	2/11/16 - 2/12/16	20	797	14.8 - 19.1	12.3 - 17.1
Mareeba	19	KP, R2E2, Cal, HG	21/11/16 - 2/1/17	31	2547	14.2 - 18.3	13.9 - 19.2
Bundaberg Rockhampton	8	KP, R2E2,Cal, HG, Keitt	20/12/16 - 12/1/17	19	1495	13.0- 16.8	13.2 - 17.8
Northern NSW	2	KP, HG	29/12/16 - 20/2/17	3	150	14.3 - 14.3	NA
Gingin WA	9	KP	27/2/17 - 13/3/17	9	NA	NA	NA
8 regions	**70**	**KP, R2E2, Cal, HG, Keitt**	**30/9/16 - 20/2/17**	**112**	**6385**	**Ave 10.3 - 19.1**	**Ave 12.0 19.2**

Table 1. Summary of %DM data collected by project staff for MG16002

The final output of the project is the final report with the de-identified spreadsheet showing individual farm visit summary results by block and variety, available in the appendix.

Outcomes

The range of average %DM data from farms reflects the position of each region in the harvest window. Darwin being the first area to harvest had the early low values as the developing crops were sampled to get both the initial calibration of the instrument and the timing of the early harvest determined. These values progressively increased as the fruit approached the predicted harvest period calculated from flowering time and heat sum calculations. As the meters became available in the other regions the fruit was approaching maturity so the averages were all closer to the threshold levels required of 15%DM.

The ranges of %DM from the other regions which mostly started at around the 13% mark would indicate these farms were about a fortnight to 3 weeks prior to first harvest. This was because the fruit in the regions following the NT had been developing to the near harvest conditions while the NIR meter was in the NT. Some farms were revisited on a regular basis and assessed the fruit in the same blocks over time to develop an evidence based harvest plan. Most farms though only had one or 2 visits which was enough to demonstrate the use of the NIR meters, introduce the technology and do a simple assessment of the blocks tested. The conversations were then about the possible scaling up for next season and how the farmers could factor the NIR meters into their next harvest planning cycle.

Growers will need to have better access to NIR meters to move to evidence-based, block by block harvest plan. The accumulation of trend data of the blocks and the variation of fruit maturity in a block needs at least weekly access to the NIR gun and for 2-3hrs minimum at a time to generate enough data to be statistically valid. Acacia Hills farm in the NT, where a NIR meter was purchased when they were first available and used exclusively on that one farm for multiple seasons to develop detailed maturity trends shows how successful the technology can be when used and analysed to its fullest extent. This farm is now working to integrate the NIR, heat sums and farm records with precision agricultural practices using remote imaging to further fine tune the process.

When any new technology rolls out across an industry there are often incidents and issues that are highlighted at different farms or regions that need to be addressed by those advocating the adoption of that technology. This is especially true when the issue of harvest maturity of early fruit from the NT is a contentious and well-argued issue in the first place. Add this to the fact that the minimum maturity levels were adjusted up from 14%DM to 15%DM on limited research on Qld fruit.

Issues impacting grower's confidence in the NIR technology.

Calibration: The was much discussion around the calibration of the NIR guns and the consistency of readings between the units used in the project and those owned privately or by the NTDPIR. These discrepancies challenged the concept that the technology was the definitive measure of fruit maturity. The time required for the guns to be out of circulation during peak demand, the competence and training of the person doing the calibration, the availability of a range of fruit at different maturity stages in each variety and region, and the constant requirement to upload the calibrations must be factored into the long-term use of this technology. This was complicated when the newer version of the meter was obtained for the project with different software.

Consistency of reading with an individual quality meter: Mango fruit have an irregular shape and the NIR technology is dependent on the assessment taking place on the similar part of the fruit each time. The beam needs to be directed at the mid-line and at a slight angle so that the NIR doesn't interact with the seed. Very immature or "skinny" fruit can give a false high reading and is not appropriate to be assessed by this meter. It is difficult to repeat an exactly equal reading on the fruit unless the spot is

marked and done by a trained operator. This creates some uncertainty and is a good reason why multiple readings on multiple fruit is necessary to create an average value for a block or orchard.

Consistency of reading between quality meters: Growers in the NT with their own NIR produce quality meters compared their results with the meter used in the project on some harvested fruit. The results varied by up to 1.5% and then with the results from other fruit tested. When the fruit was cut to assess internal flesh color the maturity of the fruit was questioned. The exercise exposed a degree of mistrust with the meters but also highlighted the need for the machines to be calibrated together. The grower's meter was not calibrated as often as the project NIR machine as this was peak demand time and with the grower managing orchards in the Darwin and Katherine areas, their meter was in constant use or travel.

Consistency of reading between farms with different irrigation practices: When a local area has a major mango flowering event and shares very similar microclimates, then the maturity of the fruit from that flowering event in neighboring farms should all reach maturity at 1600 heat units from flowering stage 6 in Kensington Pride (KP). This has been demonstrated with the crop forecasting research and harvest planning systems development in the NT during the early 2000's.

This year in Katherine, 3 neighboring farms were assessed with the NIR meter. The majority of the KP fruit was from one major flowering event. The flesh color of the fruit was very similar and moving towards pale yellow that would indicate the fruit would be mature within 7 days and would ripen to give the required Katherine quality characteristics at eating ripe stage. This with the heat sums values would be sufficient in the past for the fruit to be harvested from all 3 farms depending on the market strategy employed by each farm.

The NIR on the same day recorded large differences across the three farms. The only variable that was significant and may have caused these differences was the amount of irrigation applied to the trees each week on the different farms. The farm with the lowest irrigation applied had high NIR %DM values, the middle irrigation farm had NIR %DM values as would be expected from the flesh color and the farm that was applying almost excess water each week had the lowest %DM. This indicates a direct relationship with the amount of irrigation water applied to the crop.

This is consistent with the research published in Mango Matters Research by Clare De Luca in her paper *Factors that influence dry matter* on March 23, 2017. One of the findings was

- *Denial of irrigation water from two to ten weeks before harvest resulted in increased fruit DM. The longer duration treatments also resulted in decreased fruit size.*

This implies that irrigation practices need to be considered when issuing advice on harvest decisions or developing harvest plans when using %DM as a maturity indicator. More work needs to be done to quantify these effects and recommendations developed to incorporate irrigation practices.

Effect of rain events on %DM: It was noted after more than one large rainfall event average fruit %DM in a block could fall between 1-2% if there was a large rain event. The Darwin region had a very wet start to the 2016 mango season and regular afternoon thunderstorm falls of 25-50mm were recorded in parts of the Darwin region. Fruit that was at the threshold of 15% DM one day was at 13% the next after rain. This would indicate that there needs to be more research to determine how this may be incorporated into the use of the NIR technology. It may be that the relationship between the amount of rain and time before sampling with NIR needs to be determined so that a table of recommendations can be developed as guidelines for growers and IDO's to use in these circumstances. This will be further

complicated by soil type and irrigation practices on each farm. Given that the mango harvest is predominantly in the tropics and sub-tropics in the wet season this is likely to be a common occurrence in many regions.

Fear of exposure: A negative outcome was recorded by some NT growers who were reluctant to harvest until the average was comfortably above the 15%DM minimum resulted in earlier fruit being over mature and starting to ripen before harvest was initiated. The comment that they didn't want to send immature fruit to market and get published in the market %DM information in mango e-news was a common theme. The fruit was probably mostly mature and would have been picked if the grower was relying on the traditional mango maturity indicators of flesh color, skin texture and fruit shape. By waiting until they were sure that there would be no immature fruit being sent there was a considerable amount of fruit that was starting to ripen that could not be packed and sent to market. This clearly demonstrated that there is a very heightened awareness that the NIR %DM is being used as the industry measure of fruit maturity but there is not necessarily a confidence in the process by the grower.

Evaluation and discussion

The use of the NIR quality produce meters in the field will be a continuing practice in the Australian mango industry as a tool to assess the %DM of the fruit. The meters can measure numerous fruits non-destructively and quickly. The meter records data which can be analysed to support the decision-to-harvest and used to create an evidence based harvest plan. This higher level of application of the data requires the capacity to analyse and display data as graphs or trends and develop thresholds for each area unit being tested. The larger mango farms have this capacity but often smaller farms lack the skills or the hardware to make the most use of this data. It may be that a support process will need to be developed to display this data directly from the meter or through a live web connect to a custom-built app.

The project identified several issues with the use and adoption of the NIR %DM technology in the field to determine harvest maturity. The accuracy of the NIR to produce quality meters on measuring %DM in the field depends on the technical support available for the calibration requirements. The meter must be used correctly, at the correct site on the fruit and at the correct angle and growers require training in these areas. The relationship between %DM and the maturity of the fruit while still attached to the tree can vary due to tree moisture status. These issues resulted in growers comparing results and pointing out inconsistencies during the project activities. This resulted in growers losing confidence in the technology to provide definite accurate data. It will not an off-the-shelf silver bullet but another improved tool to add to the suite of harvest maturity indicators for mangoes.

Evaluation (Modified Bennett's evaluation)

Broader Impact
Social- economic-environmental outcomes
The project can claim that it contributed to achieving some of the improvement in the harvest maturity for the 2016/2017 mango harvest season but it is difficult to quantify the impact of the project due to many other farm, supply chain and seasonal factors. The longer-term impact of NIR technology as a preharvest maturity determinate will need to be assessed as more meters start to operate in the industry.

Direct effects
Practice change
Evidence of practice change is difficult to collect over an 8-month project. One farm did produce a harvest plan of the KP blocks in Katherine region based on 5 return visits by project staff to that farm. Other farmers took the NIR %DM readings as confirmation of their decision-to-harvest from 1 or 2 visits. The fact that 61 farms, that don't own a NIR produce quality meter, participated in this project clearly demonstrated an interest to consider changing to a data based decision-to-harvest and/or develop evidence based harvest plans. A direct measure of practice change would be to record the number of NIR meters sold to mango farmers for the 2017/2018 season.

Knowledge, attitudes, skills, and aspirations. (KASA)
There is direct evidence of the increase in knowledge of the growers following the project activities. The clearest examples are from the discussions on farm with growers trying the technology and how the NIR %DM reading related to other methods of assessing mango fruit maturity on their farm or within their regions. Growers quickly learnt the method of using the meters but did not get much chance to set the machine up for each block of data or to analyse the data on their own computer. A few growers in the

Darwin and Katherine areas were sent a redacted data set of the raw data as well as summarized information on each block but did not contact project officers to further analyse or display that data.

The attitudes displayed by the project participants ranged from very embracing to highly skeptical. As the group was self-selecting there was no one totally antagonistic to the project aims. The attitude that it will help control all those "other blokes" who pick and send immature fruit was common. Fear of being exposed with immature fruit on the market was evident in several conversations and led to negative consequences in one instance where the grower held off too long and lost fruit that was harvested too ripe to transport to market.

The skill development was minor as the use of the NIR gun is simple, just hold at the correct site and angle to the fruit and push the button. Developing higher level skills of data analysis and display were not the aim of project. The skills that were desired were using the summary data to assist with the decision to harvest and develop evidence based harvest plans. While most growers in the project did not have the skill to formally document a harvest plan, an understood harvest plan was a non-written outcome on most farms. Farmers regularly internalized the information and could talk about which blocks would be harvested when and in what sequence per the %DM readings.

There was a clear aspiration that growers would like access to the NIR technology to assist with harvest decisions and planning. Growers could see that the project had limited capacity to support all growers in a region as the meter was required at the same time by all growers in an area. Most aspired to a meter of their own or within a cooperating group but the support for buying their own meter waned as soon as the price was mentioned. A narrative of the interacts with a manger from a major Katherine mango farm is attached in the Appendix 4.

Reactions

There were several strong reactions to the project by the growers. The first was that it was good to see the associations back in the field and actively engaging with the growers in an area of concern to them, which was harvesting mature mangoes, or to be more honest, making sure the "other bloke" was harvesting mature fruit.

The next reaction was the amount of interest in the technology and what it could do to or for their businesses. Growers had been informed at the pre-season meetings in 2016 that %DM would be used in the 2016/17 harvest to determine maturity in the market and the results published weekly. After that growers were very interested in seeing the meters and checking out how they were used.

Finally, there was a degree of skepticism when the absolute values of the %DM were seen to vary depending on rain or irrigation as well as fruit maturity. The variation of %DM on the same fruit using different meters at the same time also brought into question the repeatability and reliability of the technology.

Growers in WA found the machine very useful and are keen for the service to continue. One grower commented that he thought a minimum dry matter content of about 17 % for KP would probably give better eating qualities while ensuring that the fruit made it through the supply chain.

Participation

The project officers visited 61 recorded different farms in 9 regions across 4 States and Territories in a 4 month period. This was achieved with growers self-nominating from the information distributed by the AMIA and NTFA communication channels. This level of participation by growers during their busiest time of the year is outstanding and clearly demonstrates growers were interested in the technology and wanted to "have a look" at what the meters could be used for on their farms. Approximately 40% of those farms were visited on more than one occasion, some multiple times. It also provides evidence that the communication channels of the associations do get to the growers where they can select activities that they think will add value to their businesses. Often the lack of response leads Associations and funding bodies to question the effectiveness of these communication tools.

Total	Farms Visited	No of visits	Varieties	Period
9 regions	70	112	5	30/9/16 – 13/3/17

Internal Project Factors

Activities

The major activities of the project were the NIR %DM assessments the project staff collected on their farm visits and the reporting of the analysed average and variances communicated back to the growers. During the farm visits the project officers took the opportunity to explain or instruct most growers in the operation of the meters and how to take the required measurements in the field. The project staff also discussed with the growers how the information could be used to support the "decision to harvest". The conversations then went to how they may use the NIR guns to develop an evidence based harvest plans.

Inputs

The project inputs included the staff and travel costs for NTFA and AMIA expenses for coordinating and delivering the project to growers in these 9 mango regions across Australia and the use of short term contracts with local IDO's where needed to cover competing regional areas or staffing gaps. This was provided by Hort Innovation funding from the mango industry levy and Australian government. The inputs of NT Farmers association vehicles, IT, office space, communications, professional indemnity and other insurances were provided in kind from these associations.

Outputs

The significant outputs of the project were the spreadsheet showing the region and number of visits to farms and the summary data of the %DM recorded by the NIR produce quality meters, and the milestone and final reports. The recommendations in this report indicate follow-up activities or projects that would facilitate improvement in the confidence in the NIR %DM and its dynamic relationship with mango fruit maturity in the field where factors can impact quickly or over time on this relationship.

Factors outside the project control

The project worked with the mango harvest season and responded as quickly as possible to mango fruit approaching maturity in the different regions across Australia. When fruit in different regions was ready for assessment at the same time, meters were crisscrossing NT and Qld in hand luggage of mango

industry members and unrelated departmental and association staff volunteers. We thank them for their assistance.

Recommendations

This project would support the continued roll out of the NIR Produce Quality meters in field. This needs to be matched with continued research on orchard moisture status effects on %DM. These can come from irrigation practices, effects of soil types on water uptake by the trees and the impact of rain events in the different regions. This would result in a set of recommendations or considerations that can be included in the field NIR %DM assessment.

The project would seek to ensure that the wider industry including market and value chain members understand the difference between the in-field dynamic %DM relationship between the fruit, its maturity and the moisture conditions in its environment while still attached to the tree, as opposed to harvested fruit that becomes a static or predictable relationship.

There needs to be continued high level technical support or training for local industry development officers to ensure accurate calibration of NIR meters for each variety, multiple regions and differing seasons. Trained operators are also recommended in major growing regions which could be provided through IDO networks such as state government departments or farmers associations for introducing new growers to the technology.

The aim of the project is to ultimately contribute to the best quality of mangoes being presented to the consumers of Australia. Any further in-field projects across the industry needs better coordination between maturity testing in the field and in the market, so that fruit performance can be accurately tracked.

Scientific refereed publications

None to report

Intellectual property/commercialization

No commercial IP generated

References

Walsh K, Subedi P, Owens G, 2007, 'Prediction of mango eating quality at harvest using short wave infra-red spectrometry', *Post-harvest Biology and Technology Journal,* Vol. 43, No. 3

Clare De Luca, 2017, 'Factors that influence Dry Matter' March 23, 2017 Mango Matters, Research

Acknowledgements

Mango farmers of Australia

Acacia Hills Farm manager and staff

AMIA staff

NT Farmers Staff

NTMIA

NTDPIR Horticulture staff

UCQ staff and related project staff

Gumlu Growers Association

Black Earth Cotton Company

Appendices

1. NIR Calibration examples
2. Summary spreadsheet of NIR visits and results without identifiers
3. Photo 1, 2 &3
4. Narrative of manager from the Katherine mango farm

Appendix 1.

Example of calibration and bias measurements of 4 NIR meters in NT

Here are the validation stats for the previous models predicting this last calibration.

Low SD for both populations, HG not much variability; and the KP population was just making use of what was premature picked for the NDVI project.

The HG model looks good after a bias adjustment (built originally on QLD fruit) except for CQU unit. Will have to have a look into that.

KP looks alright after a bias adjustment as well, most of the larger errors occur >14 %DM.

HG

Gun	R2	Bias	RMSE	SEP
AMIA	0.79	-0.97	1.16	0.63
CQU	0.78	-2.95	3.06	0.84
NTG	0.76	-1.11	1.31	0.69
Pinata	0.79	-1.53	1.65	0.63
	Average	17.04	**SD**	1.38

KP

Gun	R2	Bias	RMSE	SEP
AMIA	0.74	-1.47	1.62	0.67
CQU	0.58	-0.35	0.89	0.82
NTG	0.73	-1.35	1.51	0.68
Pinata	0.8	-1.66	1.75	0.57
	Average	15.5	**SD**	1.27

MG16002 NIR Mango Quality Project Farm Visits								
Darwin Region								
Date	Block	Variety	Visited by	crop stage	Visit number	Number of readings	Results	Comment
30/09/2016	Gusher Old Bynoe	KP	GO	Pre-harvest-select	1	87	average13.7 max 16.6	
17/10/2016	Lambells Lagoon	KP	GO, JM	Select	2	97	3 blocks>15.3 Max 18.8 3 blocks <15	
4/10/2016	Humpty Doo	R2E2, KP	JM, GO, ST	Pre harvest	1	40	1. Average 12.9; 2. Average 10.3; 3. Average 11.8	Calypso model on R2E2 as no R2E2 model available at beginning of season
4/10/2016	Noonamah	KP	JM, GO, ST	Pre harvest	1	32	Average 14.15	
6/10/2016	Berry Springs	KP	JM, ST	Select pick	1	48	Average 16.00	
23/10/2016	Berry Springs	KP		Select pick	2			
23/10/2016	Berry Springs	R2E2		Pre harvest	2			
9/11/2016	Berry Springs	KP	GO	Select pick	3			
6/10/2016	Acacia Hills	KP	JM, ST	Pre harvest	1	44	Average 16.00	
18/10/2016	Acacia Hills	KP	JM	Pre harvest	2	250	1. Average 14.27; 2. Average 14.17; 3. Average 14.59; 4. Average 14.31; 5. Average 15.00	
9/11/2016	Acacia Hills	KP	GO	Pre harvest	3			
18/10/2016	Lambells Lagoon	Various	JM	Pre harvest	1	27	Average not applicable	Various varities taken on Calypso model
19/10/2016	Berry Springs	KP	JM	Select pick / pre harvest	1	100	1. Average 15.27; 2. 15.70	
20/10/2016	Humpty Doo	KP, R2E2	JM / GO	Pre harvest	1	51	1. Average 14.11; 2. Average 14.06; 3. Average 14.45	
20/10/2016	Lambells Lagoon	KP	JM / GO	Pre harvest	1	26	Average 15.42	
20/10/2016	Buckley Rd	R2E2	JM / GO	Pre harvest	1	20	Average 14.48	
9/11/2016	Berry Springs	KP	GO	Select pick	1	25	Average 15.7	

MG16002 NIR Mango Quality Project Farm										
Katherine Region										
Date	Block	Variety	Visited by	crop stage	Visit number	Number of readings	Results	Comment		
5/10/2016	Fox Rd	KP	JH	Pre harvest	1	69	ave 12.9 max 16.9	early fruit		
5/11/2016	Fox Rd	KP	GO, JH	Preharvest	2	39	4 blocks Ave >15.3	very varied across farm		
		R2E2	GO,JH	Select pick	2	20	Ave 14.6 Max 15.	Harvest plan uncertain		
7/11/2016	Fox Rd	KP	GO	Select pick	3			Farm harvest plan developed		
16/11/2016	Fox Rd	KP	GO	Harvest	4	71	Ave 17.2 max 19.8	harvest polan confirmed		
5/10/2016	West	KP	GO, JH	Select pick	1	59	Ave 14.9 max 16.7	check field maturity after select pick		
7/11/2016	Shed	KP	GO,	Harvest	2	15	Ave 14.8 max 18.7	check shed maturty at harvest		
5/10/2016	K2	Calypso	GO, JH	Select pick	1	7	Ave 15.9 max 17.0	check shed maturity selected harvest		
5/11/2016	Fox Hole	KP	GO	Pre harvest	1	41	Ave 16.2 max 18.2	Certified organic		
	Fox Hole	R2E2	GO	preharvest	1	20	Ave 14.4 max 15.8	Farm harvest date determined		
5/11/2016	Fox Rd	R2E2	GO	Pre harvest	1	36	Ave 14.2 max 16.1	preliminary harvets plan		
		KP	GO	Select Pick	1	25	Ave 15.0 max 16.4	Check harvest date		
		KP	GO	Harvest	1	22	Ave 17.1max 19.2	Confirm harvest plan		
5/11/2016	Florina Rd	KP	GO	Select pick	1	61	Ave 15.9 max 19.0	Farm harvest plan developed		
		R2E2	GO	pre-harvest	1	17	Ave 14.7 max 15.9	pre harvest check		
		KP	GO	post harvest	1	15	Ave 15.6 max 17.0	Maturity check of harvested fruit in shed		
5/11/2016			GO					Returned pinata NIR machine after calibration in Darwin		

MG16002 NIR Mango Quality Project Farm								
Bowen Burdekin Region								
Date	Block	Variety	visited by	crop stage	Visit number	Number of readings	Results	Comment
2-Nov	home	KP	Andrew	pre spot pick	1	20	13.5	most advanced rows
		R2E2	Andrew	pre spot pick	1	20	12.5	random sample
7-Nov	home	KP	Andrew & Anna	pre spot pick	1	10	13.8	most advanced trees
		R2E2	Andrew & Anna	pre spot pick	1	30	13.4	random sample
7-Nov	shed	R2E2	Andrew & Anna	started picking	2	20	13.8	bin sample
1-Dec	shed and paddock	R2E2	Jessica	Picked and to pick	3	43	1. Average - 14.36; 2. Average 15.27	1. Paddock 2. Picked fruit
7-Nov	shed	R2E2	Andrew & Anna	Spot pick	1	20	13.9	bin sample
7-Nov	block 1	KP	Andrew & Anna	Pre spot pick	1	20	13	random sample, gun played up
8-Nov	front block	KP	Andrew	spot pick	1	20	14.94	random sample
	first shed	R2E2	Andrew	pre spot pick	1	20	12.32	random sample
8-Nov	home block	KP	Andrew	pre spot pick	2	20	14.6	most advanced trees
		R2E2	Andrew	pre spot pick	2	20	13.6	random sample
8-Nov	early block	KP	Andrew	pre spot pick	1	20	14.2	most advanced trees in orchard
8-Nov	early block	KP	Andrew	pre spot pick	1	20	14.6	most advanced trees

15-Nov	shed	KP	Andrew	spot pick	2	20	15.275	spot picked friut
	first shed	R2E2	Andrew	pre spot pick	2	20	14.37	pre spot pick
15-Nov	Home	KP	Andrew	just before picking	3	20	15.2	starting spot pick in few days
		R2E2	Andrew	pre spot pick	3	20	14.3	random sample
15-Nov	shed	KP	Andrew	spot picked	2	20	14.8	spot pick
15-Nov	Early block/shed	KP	Andrew	after spot pick/harvested fruit	2	20	13.8/14.9	spot pick
16-Nov	Mt Kelly	Kp	Andrew	shed/behind pickers/up coming	1	40	15.6/14.6/14.7	right behind pickers
16-Nov	Mt Kelly	R2E2	Andrew	pre picking	1	20	14.8	random
	Mt Kelly	Kp	Andrew	pre spot picking	1	20	15.2	most advanced trees
16-Nov	Home Block	R2E2	Andrew	first pick	1	30	16.8	beautiful large fruit, deep blush highest reading was 20.4
		KP	Andrew	pre picking	1	10	14.3	small fruit
17-Nov	Shed	KP	Andrew	spot picking	1	20	14.7	spot pick
1-Dec	Hermit Park	KP and R2E2	Jessica	Pre-harvest	1	102	1. Average 18.07; 2. Average 16.66; 3. Average 16.15; 4. Average 17.10; 5. Average 16.31	1. KP block one; 2. R2E2 block three; 3. R2E2 block two; 4. R2E2 flooded area; 5. R2E2 block one
1-Dec	Bowen	R2E2	Jessica	Spot pick and pre-harvest	1	34	1. Average 15.22; 2. Average 14.52	1. Fruit on tree; 2. Picked fruit
2-Dec	Various (Bowen)	HG and R2E2	Jessica	Spot pick and pre-harvest	1	98	1. Average 14.60; 2. Average 16.31; 3. Average 16.12; 4. Average 19.10; 5. Average N/A	1. Honey Gold orchard two; 2. R2E2 orchard; 3. Honey Gold orchard one; 4. Honey Gold picked; 5. R2E2 picked

MG16002 NIR Mango Quality Project Farm Visits								
Mareeba Region								
Date	Block	Variety	Visited by	crop stage	Visit number	Number of readings	Results	Comment
21/11/2016	Dimbulah	Calypso	JM	Pre-harvest	1	151	1. Average N/A; 2. Average 15.29; 3. Average 15.19; 4. Average 14.06	1. Small sample Calypso; 2. Calypso block three; 3. Calypso block four; 4. Calypso block five
30/11/2016	Dimbulah	Calypso	JM	Pre-harvest	2	86	1. Average 14.29; 2. Average 16.47; 3. Average 16.01	1. Calypso block five; 2. Calypso block three; 3. Calypso block four
22/11/2016	Mutchilba	KP / R2E2	JM	Pre-harvest	1	69	1. Average N/A; 2. Average 15.07; 3. Average 15.14; 4. Average 16.11; 5. Average N/A; 6. Average N/A; 7. Average 14.64; 8. Average 16.59; 9. Average N/A ; 10. Average 15.22; 11. Average N/A	1. KP bock one (small sample); 2. KP block two; 3. KP block three; 4. KP block four; 5. R2E2 block four (small sample); 6. R2E2 block five (small sample); 7. R2E2 block six; 8. KP block seven; 9. KP block eight (small sample); 10. KP block nine; 11. KP block ten
9/12/2016	Mutchilba	KP / R2E2	JM	Pre-harvest	2	189	1. Average 17.03; 2. Average 16.29; 3. Average 16.21; 4. Average 15.81; 5. Average N/A; 6. Average 16.20; 7. Average 17.17	1. R2E2 block one; 2. R2E2 block two; 3. R2E2 block three; 4. KP block four; 5. KP block five (small sample); 6. KP block six; 7. KP block seven
22/11/2016	Mutchilba	R2E2 / HG / KP	JM	Pre-harvest	1	78	1. Average 14.19; 2. Average N/A; 3. Average N/A	1. R2E2 block; 2. Honey Gold (small sample); 3. KP small sample
22/11/2016	Mareeba	R2E2 / KP	JM	Pre-harvest	1	58	1. Average 14.81; 2. Average N/A; 3. Average 16.18; 4. Average 13.71	1. R2E2 block one; 2. KP block one (small sample); 3. R2E2 block two; 4. KP block 76
7/12/2016	Mareeba	R2E2 / KP	JM	Pre-harvest	2	80	1. Average 14.74; 2. Average 13.89; 3. Average N/A; 4. Average 14.02; 5. Average 14.51	1. R2E2 block five; 2. R2E2 block four; 3. R2E2 block three; 4. KP block two; 5. R2E2 block one
23/11/2016	Dimbulah	Calypso	JM	Pre-harvest	1	52	1. Average 15.14; 2. Average 16.99	1. Calypso block one; 2. Calypso block five
23/11/2016	Dimbulah	KP	JM	Pre-harvest	1	97	1. Average 15.92; 2. Average 15.43; 3. Average 15.51	1. KP fruit block one; 2. KP fruit block two; 3. KP fruit block three

8/12/2016	Mutchilba	KP / R2E2 / Calypso	JM	Picked and pre-harvest	2	56	1. Average 15.30; 2. Average 14.42; 3. Average 14.80; 4. Average N/A; 5. Average N/A	1. KP fruit picked (in shed; defect fruit); 2. KP fruit picked (in shed; other fruit); 3. KP fruit on tree; 4. Small sample Calypso on tree; 5. Small sample R2E2 on tree
24/11/2016	Mareeba	KP / Other	JM	Pre-harvest	1	29	Averages not provided as other varities tested on KP model and small sample sizes	N/A
8/12/2016	Mareeba	KP / Other	JM	Pre-harvest	2	56	Averages not provided as other varities tested on KP model and small sample sizes	N/A
14/12/2016	Mareeba	KP	JM	Pre-harvest	3	104	1. Average 14.24; 2. Average 14.44; 3. Average 13.65	1. KP fruit first block blush; 2. KP fruit second block blush; 3. KP fruit mixed fruit (blush and green) third block
5/01/2017	Mareeba	KP	JM	Pre-harvest	4	34*	Average 14.42	KP fruit block one *Note readings taken during rain event (paused for almost two hours and further readings taken of picked fruit in house)
29/11/2016	Dimbulah	KP	JM	Pre-harvest	1	75	1. Average 14.35; 2. Average 15.88; 3. Average N/A; 4. Average 16.75; 5. Average 15.87	1. Block five; 2. Block four; 3. Block three; 4. Block two; 1. Block one
14/12/2017	Dimbulah	KP	JM	Harvesting and pre-harvest	2	90	1. Average 15.90; 2. Average 15.98; 3. Average 16.36	1. KP fruit currently picking; 2. KP fruit taller / older trees (pre-harvest); 3. KP fruit back block near neighbours (pre-harvest)
7/12/2016	Mareeba	KP / R2E2	JM	Pre-harvest	1	115	1. Average 14.34; 2. Average 14.30; 3. Average 14.04; 4. Average 14.28	1. R2E2 block; 2. KP fruit second block; 3. KP fruit first block green fruit; 4. KP fruit first block blush fruit
14/12/2016	Mareeba	KP	JM	Pre-harvest	2	92	1. Average 15.21; 2. Average 15.27	1. KP block one; 2. KP block two

8/12/2016	Dimbulah	KP	JM	Pre-harvest / spot pick	1	168	1. Average 15.99; 2. Average 16.67; 3. Average N/A; 4. Average 16.20; 5. Average 16.36; 6. Average 15.02	1. KP block one; 2. KP block two; 3. KP block three (small sample); 4. KP block four; 5. KP block five; 6. KP in shed already picked
14/12/2016	Dimbulah	R2E2	JM	Pre-harvest	2	50	Average 15.74	R2E2 block one
13/12/2016	Mareeba	Honey Gold / R2E2	JM	Pre-harvest	1	124	1. Average 15.14; 2. Average 16.09; 3. Average 15.53; 4. Average 17.12	1. Honey Gold block near front gate (block five); 2. R2E2 block near front gate; 3. Honey Gold block nearer to lychees (block four); 4. R2E2 block nearer to lychees
5/01/2017	Mareeba	Honey Gold	JM	Pre-harvest	2	68	1. Average 16.20; 2. Average 15.35	1. Honey Gold block nearer to lychees (block four); 2. Honey Gold block near front gate (block five)
14/12/2016	Mareeba	R2E2	JM	Pre-harvest	1	122	1. Average 15.18; 2. Average 14.65; 3. Average 14.67; 4. Average 15.63	1. Block one; 2. Block two; 3. Block three; 4. Block four
15/12/2016	Mareeba	KP	JM	Picking / pre-harvest	1	106	1. Average 16.30; 2. Average 15.79; 3. Average 15.13	1. KP picked in shed (defect mangoes); 2. KP block to be picked; 3. KP block currently picking
15/12/2016	Mareeba	KP / R2E2	JM	Pre-harvest	1	60	1. Average 14.40; 2. Average 14.26	1. KP block; 2. R2E2 block
15/12/2016	Mareeba (Spring Mount orchard)	KP	JM	Pre-harvest	1	126	1. Average 15.15; 2. Average 15.04; 3. Average 15.61; 4. Average 14.76	1. Block three; 2. Block four old trees; 3. Block four young trees; 4. Block four a watered trees

16/12/2016	Mareeba	KP / R2E2	JM	Pre-harvest	1	60	1. Average 15.92; 2. Average 16.58	1. KP fruit; 2. R2E2 fruit
6/01/2017	Mareeba	KP / R2E2	JM	Pre-harvest	2	60	1. Average 19.23; 2. Average 18.48	1. R2E2 fruit; 2. KP fruit
5/01/2017	Tolga	KP	JM	Pre-harvest	1	38	Average 15.33	BMCH BLOCK

MG16002 NIR Mango Quality Project Farm Visits								
Bundaberg_Rockhampton								
Date	Block	Variety	Visited by	crop stage	Visit number	Number of readings	Results	Comment
20/12/2016	Various (Bundaberg)	R2E2, KP	JM	Pre harvest	1	126	1. Average 15.19; 2. Average N/A; 3. Average N/A; 4. Average 15.52; 5. Average 14.40; 6. Average N/A; 7. Average N/A; 8. Average N/A	1. R2E2 fruit; 2. KP fruit; 3. KP fruit; 4. KP fruit; 5. R2E2 fruit; 6. KP fruit; 7. KP fruit; 8. R2E2 fruit.
9/01/2017	Various (Bundaberg)	R2E2, KP, Honey Gold	JM	Harvesting / pre harvest	2	180	1. Average 16.92; 2. Average 16.34; 3. Average N/A; 4. Average N/A; 5. Average 15.62; 6. Average 16.83; 7. Average 15.17	1. R2E2 fruit already picked; 2. Honey Gold fruit; 3. Random R2E2 tree in block; 4. Random KP trees in block; 5. Honey Gold separate block; 6. KP block currently picking (third
20/12/2016	Gin Gin	KP, R2E2, Other	JM	Pre harvest	1	100	1. Average 15.47; 2. Average 14.66; 3. Average 13.27; 4. Average N/A	1. KP fruit block six; 2. R2E2 fruit block 11; 3.R2E2 fruit block 10; 4. Bundy special on KP
9/01/2017	Gin Gin	R2E2	JM	Pre harvest	2	60	1. Average 15.30; 2. Average 15.84	1. R2E2 fruit block 10; 2.R2E2 fruit block 11
6/02/2017	Gin Gin	Keitt and Other	JM	Picking and pre harvest	3	72	1. Average 17.01; 2. Average 17.73; 3. Average 18.18	1. Keitt (picked); 2. Palmer (block four) on Keitt; 3. Keitt block five
21/12/2016	Childers	KP, R2E2	JM	Pre harvest	1	62	1. Average 12.96; 2. Average 13.21	1. KP block; 2. R2E2 block
10/01/2017	Childers	R2E2	JM	Pre harvest	2	32	Average 15.28	R2E2 block
7/02/2017	Childers	Keitt	JM	Pre harvest	3	60	1. Average 15.67; 2. Average 14.73	1. Keitt block one (under shade cloth); 2. Keitt block three (in paddock)

11/01/2017	Bundaberg	Honey Gold and Calypso	JM	Picked and pre harvest	1	154	1.Average 16.00; 2. Average 15.17; 3. Average 14.87; 4. Average 15.00; 5. Average 15.27	1. Honey Gold picked (class two in shed); 2. Calypso block one; 3. Calypso block four; 4. Calypso block six; 5. Honey Gold Block Ten.
11/01/2017	Bundaberg	R2E2	JM	Picked	1	30	Average 16.92	R2E2 picked
7/02/2017	Bundaberg	Keitt	JM	Picked and pre harvest	2	64	1. Average 17.70; 2. Average 17.89	1. Keitt already picked; 2. Keitt on tree
11/01/2017	Benaraby	Honey Gold	JM	Picked and pre harvest	1	122	1. Average 18.02; 2. Average 15.93; 3. Average 16.94; 4. Average 16.23	1. Honey Gold picked; 2. Honey Gold block three; 3. Honey Gold block four; 4. Honey Gold block one
8/02/2017	Benaraby	Keitt	JM	Pre harvest	2	44	Average 15.35	Keitt block
11/01/2017	Benaraby	R2E2, Honey Gold	JM	Picked and pre harvest	1	54	1. Average 17.83; 2. Average 16.92	1. R2E2 already picked; 2. Honey Gold block 450
8/02/2017	Benaraby	Keitt	JM	Picked and pre harvest	2	66	1. Average 17.34; 2. Average 17.11	1. Block 1 KT 1000; 2. Keitt in shed - picked
11/01/2017	Yarwun	KP, Honey Gold	JM	Picked and to pick	1	107	1. Average N/A; 2. Average N/A; 3. Average 17.43; 4. Average 17.75; 5. Average 17.35	1. Honey Gold picked; 2. KP picked; 3. Honey Gold block two; 4. Honey Gold block three; 5. Honey Gold block four
12/01/2017	Yeppoon (Bungundarra)	Honey Gold	JM, KW	Picked	1	30	Average 17.63	Honey Gold picked

MG16002 NIR Mango Quality Project Farm Visits								
Northern NSW								
Date	Block	Variety	Visited by	crop stage	Visit number	Number of readings	Results	Comment
29/12/2016	Yelgun	Honey Gold	JM	Pre harvest	1	68	1. Average 14.27; 2. Average 15.20	1. HG block one; 2. HG block two
10/02/2017	Yelgun	Honey Gold	JM	Pre harvest	2	50	Average 16.96	Honey gold front home block
29/12/2016	Koonorigan	KP	JM	Pre harvest	1	32	Average 14.73	KP block

Appendix 3. MG16002 Photos

Photo 1. NIR produce quality meters being calibrated s at the same time using a selection of KP fruit with a range of maturities in the Darwin region. Oct 2016

Photo 2. NIR produce quality meters being used by project staff to measure %DM of fruit still developing on the trees during October 2016 in the Darwin region.

Photo 3. NIR produce quality meters being used by project staff to measure %DM of harvested fruit during November 2016 in the Katherine region.

Appendix 4. Narrative

Date: 7 December 2016

Submitted by: Samantha Tocknell

Industry: Mango Industry

Issue: Mango Maturity

Stakeholder: A manager of a large mango farm in Katherine.

Engagement: Greg Owens met with the manager on his farm to conduct NIR testing of his mangoes before the season kicked off. I attended the farm and met with the manager to follow up on his progress one week later, after he had received his results from the NIR testing.

Reaction: The manager was very interested in the use of NIR dry matter testing for his mangoes and assisted on farm guiding the testing process. He saw the value in in this tool to assist with decision making around picking. Particularly early in the season, because he needed to get the fruit off the trees as soon as he could, before they reached a ripening point where they then become a target for bats. But he also needed to maintain a high standard of fruit quality and therefore mango maturity, at market, within the optimum dry matter range. The manager recognised that the implications of this tool in assisting to maximise his businesses productivity and profitability are substantial.

Actions: After receiving the results of the NIR testing the manager told us that he then felt confident to start picking. He said that dry-matter was not yet a complete dictator of when to pick, because there are other factors he must consider. But, it is a useful and accurate decision making tool, to assist with advising farmers and guiding their practices. He also said that it helped remove doubt and provided him with more confidence and assurance about his own on farm knowledge and assessments. The manager noted that NIR testing is also a useful tool to assist with labour planning and logistics, because it provided a more defined plan on when to pick and how much.

Impacts: As a result of picking based on the NIR test results, He was able to get the fruit of the trees at the precise time is was ready and therefore his fruit appeared beautifully at market. It was at optimum maturity and excellent standard. The manager reports that he is pleased with how much fruit he was able to get off in time and that he is receiving excellent reports of how his fruit is showing up and holding up at market. he says that he finds the NIR testing to be incredibly useful and would be keen to assist in developing and improving the model and would like to continue NIR testing on his farm next season.