April 2021

Hort Innovation Papaya R&D Levy
Project – PP20002

Nutrient Requirements for Papaya Production

Project Background

Current information on the nitrogen (N) and phosphorus (P) requirements of papaya in Australia is based upon RD&E information more than a decade old. The opportunity exists to review the current scientific literature on the nutrient requirements of papaya in commercial production to either validate current practices or identify knowledge gaps in the Australian production system that indicate the need for RD&E to bring Australian papaya crop nutrition management closer to world's best practice.

The results and outputs of this project will:

- provide the papaya industry with a better understanding of the current global scientific evidence base for the nutrient requirements of papaya in commercial production through a systematic literature review
- prioritise any knowledge gaps for the nutrient requirements of papaya in commercial production for potential R&D investment.

Industry

The Australian papaya industry is a small tropical fruit industry. Papaya is produced in tropical Australia, particularly Queensland (85%) dominated by Mareeba and Tully, with remaining commercial production occurring in Western Australia (8%) and the Northern Territory (7%). There are over 130 growers in Australia, but production is dominated by several large producers. In 2018/19, 14,921 tonnes of papaya were produced with a production value of $27.5 million.

The volume of papaya production has remained steady over the last 6 years, while value has increased by $7.5 million (38%) since 2012/13. 99% of the volume of papaya production is supplied to the domestic market, with negligible volumes of processing and exported product. Insignificant volumes of product are imported to the fresh market.

The footprint of the Australian papaya industry is such that 85% of its production area flows into the Great Barrier Reef Marine Park. Community expectations of rural industries are that they show high levels of environmental stewardship to the use and protection of Australia's natural resources. This project will contribute to the science-based management of farm nutrient use and any potential off-farm impact.

Literature Review Summary

Papaya (*Carica papaya* L.) is a soft-wooded, perennial, herb-like, pachycaul tree in the family Caricaceae. It also has common names of Paw Paw and Papaw.

Papaya has a tremendous yield potential due to its precocious bearing and indeterminate growth habit with simultaneous vegetative growth, flowering, and fruiting. After a brief juvenile phase, vegetative growth coincides with flower development - an inflorescence emerges continuously in the axil of each leaf, provided climatic and cultural factors are adequate. Based upon published trial data from plant densities of approximately 1,600 plants per hectare, total fruit yields of 128 tonnes/ha from a 2-year crop cycle are not uncommon.

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One trial reported up to 224 tonnes/ha in a year of papaya production. In Australia, marketable yield reduces this total yield figure by between 15-30%.

Papaya is therefore considered a nutritionally heavy feeder by all authors. It is an exhaustive crop requiring heavy and continuous supply of nutrients to sustain its high yield potential and its indeterminate growth habit with simultaneous leaf and fruit production.

The Queensland Department of Agriculture and Fisheries (QDAF) have published several research reports and commercial guides on their research and development (R&D) activities. These form the underlying basis of many papaya crop management practices currently used commercially in Australia.

Of note is the "Papaya Agrilink Kit". This publication describes in detail the current interpretation by QDAF scientists of Australian and international research as it applies to managing commercial papaya crop nutrition. Nitrogen and phosphorus uptake into the crop and removal through fruit harvest is presented in the "Papaya Agrilink Kit" and shown below in Table 1.

Nitrogen

The bulk of the literature suggests that split applications of nitrogen fertilizer be applied to account for its soil mobility (and potential loss from the root zone) and increasing crop requirement.

Little, if any research findings specifically on the placement of nitrogen fertilisers was uncovered. However, most authors reported fertigation as their application technique for split nitrogen applications which given the papaya root system plasticity, would indicate that soluble nitrogen fertiliser was being applied into the wetted root zone of the crop.

Many authors have reported an almost linear response of papaya yield to increasing nitrogen input. In one North Queensland trial report the author reported increasing fruit weight per plant with increasing nitrogen rate per hectare continuously up to their maximum nitrogen rate trialled being 620kg N/ha/24 months.

Another North Queensland researcher reported amounts of nitrogen uptake and harvested removal over 21 months for five rates of N studied and found a fruit removal peak at approximately 600kg/ha/21 months for nitrogen.

Tree age	3.5 months	5 months	6 months	7 months	8 months	15 months	21 months
Nitrogen							
Uptake	0.86	4.21	6.65	23.5	43.3	124.8	248
Removal	0	0	0	0	10.8	82.2	187
Total	0.86	4.21	6.65	23.5	54.1	207	435
Phosphorus							
Uptake	0.1	0.91	2.42	7.52	7	10.4	44.6
Removal	0	0	0	0	2.5	8	30.4
Total	0.1	0.91	2.42	7.52	9.5	18.4	75

Table 1. Nutrient requirements (kg/ha) to satisfy harvest removal and plant uptake in papaw at various ages for papaws grown in north Queensland. Yield is based on 115t/ha

For mature plants, the harvested N proportion of total N uptake and removal is on average about half and illustrates the effects of intensive and sustained high production levels. See Figure 1.

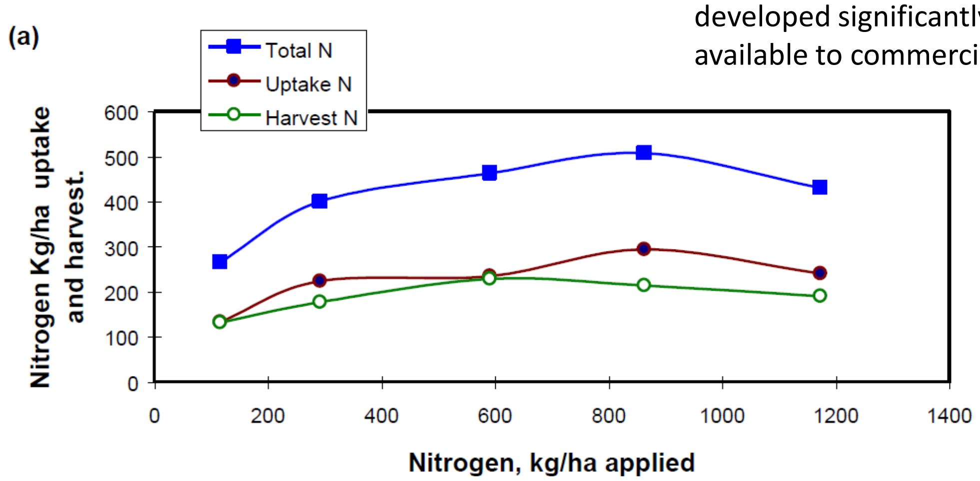

Figure 1. Uptake and fruit removal (kg/ha) in response to applied nitrogen

The use of plant and soil analysis as a diagnostic tool has a history dating back to studies of plant ash content in the early 1800s. It's use to commercially manage crop nutrition has developed significantly with many services now available to commercial Papaya growers.

The "Papaya Agrilink Kit" presents soil and leaf analysis test levels and their interpretation in making soil management and fertilizer decisions.

There now exists additional technologies with which to gain a rapid assessment of the nitrogen status of papaya.

There is no doubt that the nutrient requirements of papaya under tropical, irrigated management are high. Grower survey results from North Queensland have shown that mean application rates are 692 kg/ha N and 414 kg/ha P per two-year cycle. However, the sustainability of such high average industry application rates does need to be considered in the light of results from these previous studies which indicated that rates of applied N above 300 kg/ha only marginally increase yields.

Due to the higher efficiency of nitrogen fertigation when compared to traditional broadcast application, productivity can increase. With a productivity increase of 25% when fertigation is used, papaya trees appear to respond the same as many other crops to this application method.

Technologies such as Merck's Reflectoquant meter and test strips, the SPAD 502 chlorophyll meter, and Near Infrared Spectroscopy (NIR S) are three commonly reported instruments used to rapidly gauge the nitrate status of plant tissue.

A knowledge gap exists in defining an industry standard measure and methodology/protocol to manage the optimisation of nitrogen use efficiency of papaya production systems within Australia.

A knowledge gap exists in defining a broadly applicable technique for the application of non-destructive and rapid assessment technology to determine the nitrogen status of papaya crops in a way that allows a nitrogen fertiliser decision process to be undertaken in near real time.

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Phosphorus

Phosphorus is important for the development of an active root system, and in flower initiation and fruit set. When applied as superphosphate, it is relatively insoluble and moves very slowly through the soil profile. Low pH and high soil iron levels, particularly in leached red soils can reduce phosphorus availability.

Consensus from the literature is that 30 – 50 kg/ha per crop cycle of phosphorus is removed.

As a general guide for phosphorus, the "Papaya Agrilink Kit" recommends spreading superphosphate along plant rows before mounding as a pre-plant operation and an NPK mixed fertiliser application incorporated into the mound just prior to planting.

The "Papaya Agrilink Kit" recommends 100kg/ha of phosphorus be applied in the pre-harvest stage followed by an additional 180 kg/ha of phosphorus during the harvest stage of the crop cycle. With crop removal accounting for between 30-50kg/ha of phosphorus, the nutrient use efficiency of this recommendation seems poor. However, given that some papaya in Australia are grown on red soils that tie up a significant proportion of applied phosphorus, such a recommendation could be justified to overcome such soil chemistry constraints. It becomes critical however to ensure that this fertilised soil is not eroded from the production area releasing into the environment substantial quantities of phosphorus.

Papaya plants are dependent on mycorrhizas for their nutrition and benefit greatly from soil mulching and appropriate drainage that facilitate biotic interactions in the rhizosphere and phosphorus uptake.

Soil testing before planting is recommended in all reports. The literature notes that greater than 30g/kg of phosphorus extracted from the soil sample using the Colwell method is the optimum range for papaya for soil phosphorus.

The need for a rapid test to measure the phosphorus status of a papaya crop is not deemed as important as a nitrogen rapid test given the significantly lower amounts of phosphorus used by the crop and the large, less mobile, soil reserves generally developed in cropping land. This may imply that a pre-plant soil test for phosphorus is generally sufficient to generate a phosphorus management plan for the crop.

A knowledge gap exists for the role and quantification of biological soil health practices (including mycorrhiza, phosphate solubilising microbes and organic mulches) and their management for increasing the phosphorus use efficiency of papaya.

The timing and placement of fertiliser to increase papaya phosphorus use efficiency has not been fully explored in the Australian context. Review of the Australian grains R&D on phosphorus use efficiency management via timing and placement management of phosphorus fertiliser may well yield insights into phosphorus management in papaya.

Hort Innovation Strategic levy investment | PAPAYA FUND

This project has been funded by Hort Innovation using the papaya research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au