BANANAS ON NORTHLAND DAIRY FARMS

– A POSSIBLE OPTION FOR FORAGE SUPPLY AND EFFLUENT CYCLING?

Background

Funding from the Our Land and Water Science Challenge has enabled us to explore the use of banana plant leaves and stems as feed for livestock and how they can be incorporated into an effluent system

Banana plants can grow quickly in the peak of summer and are relatively deep-rooted and drought tolerant. Much of their water is stored vertically in the stems. This could be an advantage in Northland where summer droughts are predicted to become increasingly frequent and severe. There are multiple potential benefits:

1. High summer growth rates could increase resilience of forage supply during dry periods.
2. High nutrient demand (esp. potassium) could fundamentally change whole-farm nutrient cycling.
3. Potential for 'cut and carry" or for on/off strip grazing of plants.

New information is needed for Northland dairy farmers to make an informed decision about incorporating bananas into their farm system with an opportunity to support the establishment of a new industry in Northland if fruit production supply chains are established in the future.

What we did

This project investigated if growing bananas on Northland dairy farms has potential to increase the economic and environmental sustainability of the dairy enterprise, by:

- Measuring the timing, quantity and quality of growth of an existing banana plot
- Test whether banana leaves and stems are nutritionally appropriate as cattle feed
- Investigate if bananas can effectively take up nutrients in effluent
- Present data to the community through a field day and a Rural Delivery story

Potential impact

At a farm scale, the use of bananas in a farm effluent system could:

- reduce the requirement for bought-in feed during summer
- reduce the area and budget needed for effluent management
- reduce the gradual overload of soil nutrients from effluent application, particularly potassium
- reduce the area needed for cropping each year

Banana surveys:

Plant measurement surveys were conducted at multiple times over the project. Samples were collected and frozen with liquid nitrogen before transporting and storing samples frozen and freeze dried for food quality

Date	Work undertaken
2nd September	Full plant height survey, feed quality samples, foliar mineral analysis
16th September	Cutting main stems in cutting trial (see below), DM samples
10th December	Plant height survey, feed quality samples, DM samples
20th January	Plant height survey, feed quality samples, DM samples
29th June	Full plant height survey, DM samples, soil samples

Northland S.M.A.S.H. field day on 10th December

Dry matter percentage:

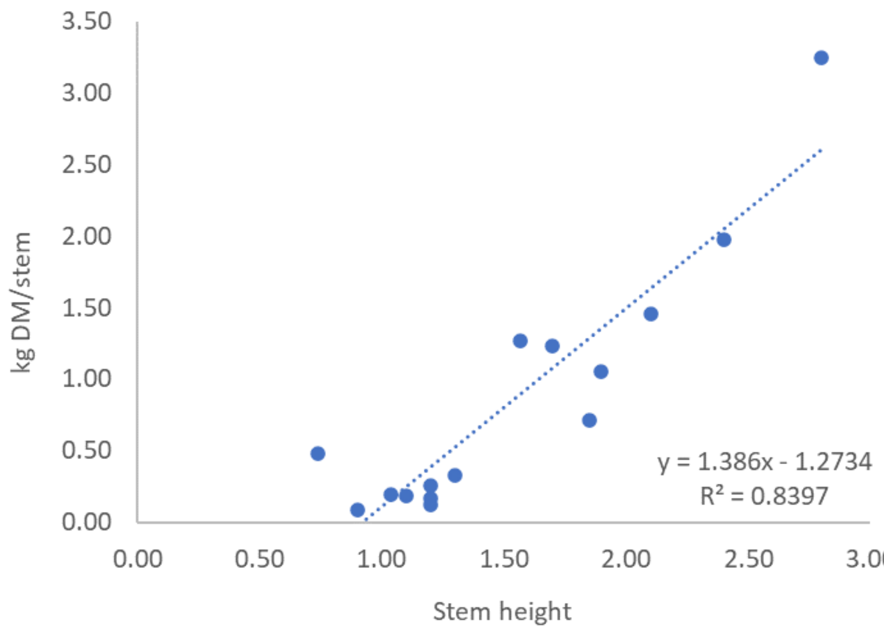
To determine the DM% of the plants, the stems and leaves were separated where the petiole joined the stem and the two parts calculated individually. The dry matter percentage of stems and leaves shows large variation. Some of the variation in the leaf material may be contributed to the difference between petiole (much like stem) and the leaf lamina. A more accurate result may have been achieved had the leaf lamina been separated from the petiole. Not enough samples were collected to have confidence in seasonal or size relationships. An additional potential variation was identified by incorporating some fast regrowth stems from previously cut stumps although these were not universally of lower DM%. The average DM% for leaf and stem, 16.3 and 8.3, were used to calculate standing DM and growth.

Dry matter percentage estimates of leaf and stem

Date	Stem size	DM% Leaf/petiole	DM% Stem
Sept	Small	17.5	9.3
	Medium	13.9	10.4
	Large	20.2	8.6
Dec	Small	9.3	6.7
	Medium	21.6	8.5
	Large	23.0	8.5
June	Small	12.4	7.0
	Medium	12.1	6.9
	Large	14.1	6.0
Average		16.3	8.3
Std. deviation		5.0	1.3

Height to DM relationship:

To estimate the quantity of feed a relationship needs to be determined to estimate DM present in standing plants. Height and 'diameter at breast height' (DBH) were assessed for their relationship with DM. DBH was discounted for two reasons – not all stems cut were tall enough to have a DBH and because of large variation in DBH above and below a leaf (up to 3 cm). Height of stem was measured to the highest intersection of two petioles or between petiole and emerging leaf. This approximates the highest point of the 'stem' before turning into petiole and leaf. Height of each stem on every plant was measured at each plant height survey to track growth.



The relationship between height and DM was suitable for calculating an approximate DM for standing plants although variation between samples was observed. This could be due to differences between season, plant variation and stem type (new stem or fast regrowth). No reliable relationships between these variables can be developed at this point.

Cutting Trial:

Two groups of 15 plants were monitored in a split plot trial to investigate if cutting large stems would result in increased growth the remaining stems. One group of plants were left as they were with many stems and the second group had a number of large stems removed. It was proposed that removing large stems would make the small stems grow faster, increase the number of new emerging stems and increase total growth rates. The following cutting rules were developed to guide the removal of stems:

- Cut all main stems – the stems originally planted and nearest to flowering
- Leave at least 4 stems over 0.5 m
- Leave no more than 4 stems over 1 m
- Leave no more than 2 stems over 2 m

The number of stems remaining on the plants ranged in from 3 to 8 stems and the largest stems being 2.2 m. A total of 26 stems were removed. All stems on the 30 plants were then left to grow during the measurement period. The cutting treatment was considered as an approximation of what may have occurred had the plants been defoliated (harvested or grazed) in the previous season.

Cutting observations:

Our initial expectation with the cutting trial was that cutting out stems would result in the production of additional new suckers from the corm of the cut stem. This was only partly observed with no major difference between the two treatments at the start (119:118 stems) or at the end of the trial (146:150 stems). New stems formed in both treatments but more new stems were produced in the cut treatment to replace the stems cut out.

Not all of the cut stems required replacing. Stems that had not begun their reproductive cycle, i.e. without a reproductive spike present in the centre of the stem, rapidly regrew from the same growing point. These regrowing stems grew in height at a significantly greater rate than other stems on the plant. Most cut stems regrew to their original height within 3 to 5 months. Notably, a number of stems that were over 2m tall when cut in September had reached that height again by January. This rapid regrowth can potentially be exploited for multiple harvest in a season but consideration of impacts on energy reserves in the corm will need to be investigated. A small number of stems outside of the cutting trial were cut multiple times and they continued to regrow. Growth rates of these additional stems were not measured.

Standing DM estimates and growth:

Banana plants showed strong growth over the measurement season. Stem extension (change in stem height) was compared using the average change in height of stems between measurement periods including the growth of new stems. To compare like results the main stems of the non-cut group were ignored from this analysis as most of them were mature and were no longer growing. The stems of the cut plants, which had the largest stems removed, grew faster than the non-cut treatments.

Average growth of individual stems (change in height in meters)

Treatment	Sep-Dec	Dec-Jan	Jan -Jun
Not Cut	0.45	0.43	0.34
Cut	0.58	0.47	0.34

The cut treatment also grew additional stems leading to a much greater total stem elongation per plant.

Growth of stems per plant (cumulative change in height in meters)

Treatment	Sep-Dec	Dec-Jan	Jan -Jun
Not Cut	3.6	3.8	3.2
Cut	5.2	4.7	3.4

The standing DM was estimated for each visit for both treatments (all stems included).

DM estimate of all stems following each survey

Treatment	Sep	Sep Post-cut	Dec	Jan	Jun
Not Cut					
DM/plant (kg)	6.8	6.8	9.9	14	15.9
DM/ha @ 1600 plants per ha (T/ha)	10.8	10.8	15.9	22.4	25.5
Cut					
DM/plant (kg)	6.6	3.2	6.3	10.9	14.6
DM/ha @ 1600 plants per ha (T/ha)	10.6	5.0	10.1	17.5	23.3

An estimate of growth was calculated from the difference in DM estimates between surveys.

DM production at 1600 plants per ha (T DM/ha)

Treatment	Sep-Dec	Dec-Jan	Jan -Jun	Growing season
Not Cut @1600	4.9	6.6	3.1	14.6 T DM/ha
Cut @1600	5.2	7.4	5.8	18.4 T DM/ha

Cutting the largest stems out of the plant in September promoted substantial additional growth for the cutting treatment. There could be potential to increase this quantity as plants become better established. Average Queensland (tropical) Cavendish plantations produce over 30 t/ha of fruit so there must be potential for substantial amounts of foliage in tropical conditions. 1600 stems per ha is a common planting rate for fruit however some varieties are increased to 2000.

Rainfall was not collected during the whole growth period but from Jan onwards a weather station had been set up on farm by the farmer. While rainfall was low during summer and the plants continued to be irrigated with effluent wastewater. No measurement of the volume of effluent water applied was made.

Rainfall and temperature measured on farm from January to June

Month	Rainfall (mm)	Average temperature (°C)
Jan	71	18.8
Feb	62	18.8
Mar	32	17.6
Apr	131	15.7
May	69	13.5
Jun	210	12.6

Feed Quality:

Samples were collected for feed quality throughout the summer period. Plant material was separated into stem and leaf at the base of the petiole and reduced to a representative sample. Samples were frozen with liquid N and in the field and freeze dried for analysis. NIR spectroscopy was used to estimate identify any extremes or variation in season or size but few trends were evident. Wet chemistry was used on 3 leaf and 3 stem sample to confirm the feed quality. A weighted average was estimated based on an average leaf to stem ratio of 35:65, although this ratio showed a large variation between stems.

Feed quality estimate by NIR spectroscopy (average of 8 per column)

	Leaf	Stem	Weighted average (35:65)
ADF % w/w DM	24.0	19.9	21.3
Ash % w/w DM	9.9	8.4	8.9
CP % w/w DM **	12.1	5.5	7.8
Lipid % w/w DM	3.2	1.3	2.0
ME (est) MJ/kg DM	12.0	13.6	13.0
NDF % w/w DM	39.2	27.4	31.5
OMD (in vivo) % w/w DM	82.0	93.1	89.2
SSS % w/w DM	13.5	32.0	25.5

Feed quality estimate by Wet Chemistry (average of 3 per column)

	Leaf	Stem	Weighted average (35:65)
ADF % w/w DM	23.7	29.4	27.4
Ash % w/w DM	9.9	8.8	9.2
CP % w/w DM	11.2	10.6	10.8
Crude fat % w/w DM	3.0	4.2	3.8
ME (est) MJ/kg DM	11.8	9.6	10.4
NDF % w/w DM	40.0	43.9	42.5
DOMD % w/w DM	81.2	54.5	63.8
WSC % w/w DM	13.4	20.3	17.9

Under these conditions, the banana plant has potential as a suitable feed crop for cattle. Typical feed value analysis shows that banana is low in protein much like maize or fodder beet, low in fibre and high in water soluble carbohydrate. The weighted average digestibility of around 64% is similar to various silages. There has been no consideration of secondary compound that may impact on animal production.

Effluent application:

Dairy effluent was applied to the banana plot weekly over the summer and was reduced from March onwards. Volumes applied were not measured during the season. To get an indication of mineral loading in the soil at the end of summer soil samples were collected in June. Soil samples were taken at four depths to see how minerals were moving through the soil profile following a season of effluent application.

Depth	Total nitrogen (%)	Potassium (MAF)
0 – 7.5 cm	0.49	20
7.5 – 15 cm	0.29	8
15 – 30 cm	0.23	4
30 – 45 cm	0.20	2

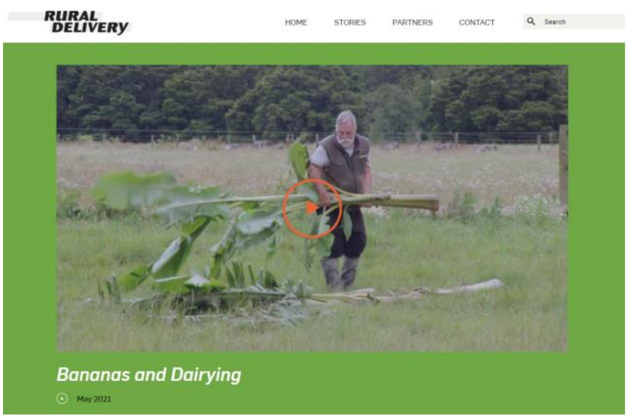
Without being able to estimate a mineral mass balance (amount applied less amount taken up in plants) these results give some confidence that there is nothing unusual occurring. There doesn't seem to be any unexpected accumulation of nitrogen or potassium. This warrants further investigation, particularly under a harvesting or grazing situation where significant amounts of nutrient will be removed from the site.

Harvesting potential

Following the first two surveys the farmer prompted the research team to consider harvesting/grazing strategies. On the 6th of January all of the stems from two plants were harvested. The main reproductive stem did not regrow, but all other stems recovered from the growing point. Between Jan 6th and Jun 30th the cut stems had grown to between 1.3 and 1.5 m (stem height) and a number of smaller stems (0.6 to 1.2m) had emerged. This regrowth was estimated to be 3.5 kg DM/plant which if planted at 1600 plants/ha would be 5.7 t DM/ha.

Same plant following full cut with 2 weeks regrowth (left) and 25 weeks regrowth (1.4m to top of stems)

Regrowth potential is high and it we suspect that mobilisation of energy reserves out of the corm drives the growth. Future questions around longevity of plants with this kind of defoliation would need consideration. If banana plants were to be harvested/grazed in summer then we could expect a similar growth to what we have seen in the trial so far with a potential for 10+ t DM/ha at 1600 stems/ha. Due to the small size of plants as they regrow, there is a potential for significantly closer spacings.



Rural Delivery filmed a segment for their show featuring bananas on the Edwards' farm

www.ruraldelivery.net.nz/stories/Bananas-and-Dairying

Negative observations

The use of bananas on farm has shown strong potential as a new forage system and importantly no major red flags were identified in this short investigation.

Two potential issues have been identified to date**:**

- Potential for grazing damage –

  On one occasion, pulling a stem over instead of cutting it off at ground level broke the corm out of the ground preventing regrowth from the stem. If cattle are pushing plants over then there may be potential impacts on the number of stems per ha surviving. There is unknown potential for treading damage to the base of the stems when cattle are in the crop/plantation.
- Pest damage –

  Some animal damage was seen this summer at the base of the plants. It is suspected that this was the result of pūkeko damage shredding the base to get the flesh or water within the stem. The damage weakened the base of large stems and several plants fell.

Stem damage due to pest attack (round white tape measure 5cm diameter for reference)

Future work

The next priorities for further investigation should be:

- Environmental – a better understanding of nutrient cycling including a nitrogen mass balance to estimate N loss
- Grazing or harvesting strategies – how does the plant respond to cattle grazing? How does grazing impact regrowth compared to cutting.
- Will cows eat it?