FINAL REPORT

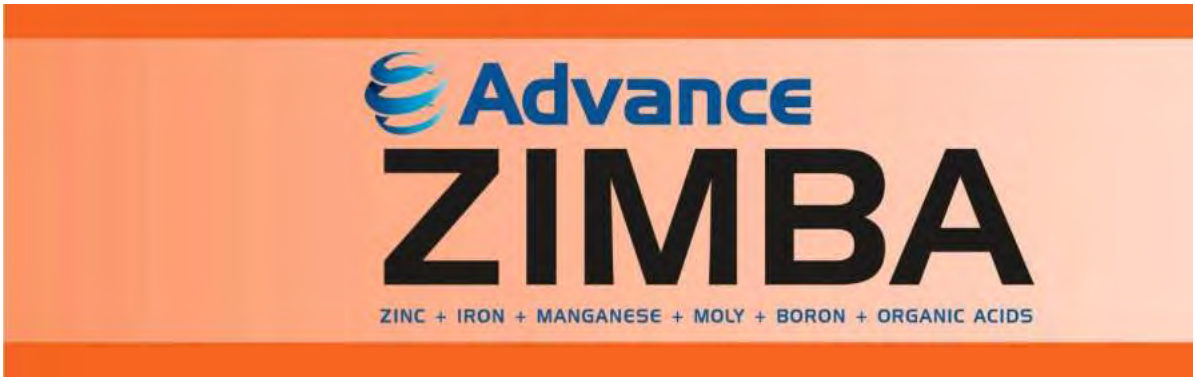
Evaluation of Zimba crop safety when applied with or without a tank mix to tropical fruit –

Macadamia Orchard

by

Chris Themsen and Dale Parker

September 2022



Title of Project:	Evaluation of Zimba crop safety when applied with or without a tank mix to tropical fruit
Project Protocol No.	Zimba – Tropical fruit - 2022
Project No.	AA-V0035
Report No.	AA-V0035-2

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ABSTRACT

A replicated field trial was conducted at a commercial macadamia orchard at Wallaville, Queensland in 2022. Treatments were applied two times, with a motorise backpack, commencing when MCDIN was at the BBCH 79 growth stage.

Under the condition of this trial, no phytotoxic effects were observed for Zimba (4.2% + 1.6% + 1% + 0.15% + 4.5% Zn + Fe +Mn + Mo + B + organic acids, complex carbohydrates) on MCDIN.

Under the condition of this trial, Zimba applied alone increased all key elements when compared to the untreated control.

Key Words

Macadamia, Zimba

ABBREVIATIONS

Short Abbreviation	Expanded Text
MCDIN	*Macadamia integrifolia* cv. A203
# DA-A	Number of days after application A
g ai/ha	Grams active ingredient / hectare
g ai/100 L	Grams active ingredient / 100 L
RCB	Randomised complete block
PORO	Point of run off
ACCRST	According to crop stage
°C	Degrees Celsius
KPH	kilometre per hour
BROADC	Broadcast application
kPa	kilopascal
KNAMOT	Knapsack sprayer – motorised
kPa	kilopascal
AIASF	Air-aspirating flat fan
PUMDIA	Pump – diaphragm

STATISTICAL ABBREVIATIONS

Short Abbreviation	Expanded Text
PHYGEN	Phytotoxicity - general / injury
%UTC	% Increase / decrease relative to the untreated control
NSD	Not Applicable due to a p-value > 0.05 (or >0.1)

INTRODUCTION

Background

Tropical tree crops such as macadamia, custard apple, avocados and citrus can suffer from several micronutrient deficiencies due to improper nutrient uptake through root system. In comparison to macronutrients (N, P, K, Ca, Mg & S), the amount of individual micronutrients necessary to promote optimal performance are very small. However, they play a significant role in the physiology of trees during active growth periods, making them a major component of an orchard nutrition program[1]. Micronutrients such as zinc, boron and iron are not readily absorbed through plant roots due to different factors. Foliar applications of micronutrients are usually recommended to compensate the micronutrient deficiencies and show positive response in quality attributes in tropical tree crops.

In fruit crops, zinc deficiency is one of the most prevalent deficiencies with low soil zinc levels in most production areas. Zinc is relatively immobile in soil which is required for photosynthesis and phytohormone metabolism[3]. There is a widespread problem with zinc deficiency in fruit tree crops, and soil application is usually ineffective at resolving it[2]. In a recent study, for avocado, foliar zinc applications are inefficiently absorbed, with less than 1% foliar uptake, there was sufficient absorption of zinc to increase leaf zinc concentrations[2]. In another study, for custard apples, foliar zinc applications have influenced yield attributes which resulted in increased number of flowers per tree and high fruit set[6].

In avocados, foliar applications of boron at flowering can be benefited, as timing is crucial for convincing fruit set and increased yield[4]. It is evident that, high boron levels in pistils can increase pollen germination rate and pollen tube growth[5]. For macadamias, foliar fertilization with macro and micronutrients is recommended even though boron is the only nutrient proven to respond[2]. Deficiencies of boron can be found at growing points, at root tips, in young leaves, and in developing fruit[1]. The incomplete development of the raceme suggests a possible boron deficiency; therefore, boron deficiencies are suspected when flowering is poor[1]. Foliar sprays of boron have shown increase in yield and kernel quality of macadamias[1].

Iron is sometimes not readily available for root uptake due to alkaline soil conditions and high manganese or phosphorous in soil[7]. A study reported that, foliar applications of iron have increased fruit weight, length and diameter[8].

Objectives

To evaluate and compare the phytotoxic effects of Zimba (4.2% Zn + 1.6% Fe + 1% Mn + 0.15% Mo + 4.5% B + organic acids) applied alone and applied with Kocide (350 g/kg cupric hydroxide), Merivon (250 g/L pyraclostrobin + 250 g/L fluxapyroxad), Trivor (186 g/L Acetamiprid + 124 g/L pyriproxyfen), Transform (240 g/L Sulfoxaflor), Bulldock (25 g/L Beta-cyfluthrin) and Prodigy (240 g/L methoxyfenozide) in MCDIN cv. A203.

Methods

A replicated field trial was conducted at a commercial macadamia orchard at Wallaville, Queensland in 2022. Treatments were applied two times, with a motorise backpack, commencing when MCDIN was at the BBCH 79 growth stage.

The crop safety of Zimba was assessed by checking for phytotoxic symptoms including, but not limited to, chlorosis, necrosis and plant growth effects at 7 DA-A, 14 DA-A, 7 DA-B and 14 days after application B (DA-B).

The efficacy of treatments was assessed at 7 DA-A, 14 DA-A, 7 DA-B and 14 DA-B.

Leaf samples were taken at 0 DA-A and 14 DA-B and processed by Phosyn Analytical.

Data was analysed using analysis of variance (ANOVA) test with ARM2022.

Conclusion

The collected efficacy data reflect the test products efficacy and no external biotic factors have influenced the trial.

Weather conditions during the trial were considered typical for this time of year.

Under the condition of this trial, no phytotoxic effects were observed for Zimba on MCDIN, when applied alone or when applied in a tank mix.

Under the condition of this trial, Zimba applied alone increased all key elements when compared to the untreated control.

PROTOCOL DEVIATIONS

There were no significant deviations from the protocol.

All work undertaken followed the test site SOPs. In case of any conflict between the SOPs and the protocol, the protocol took priority.

RESULTS

Table 1. Phytotoxic effects to MCDIN

Treatment		Rate (g ai/100L)	Phytotoxicity (0 – 100%)			
			7 DA-A	14 DA-A	7 DA-B	14 DA-B
1	Untreated control		0.0	0.0	0.0	0.0
2	Zimba	46	0.0	0.0	0.0	0.0
3	Zimba Kocide	46 52.5	0.0	0.0	0.0	0.0
4	Zimba Merivon	46 20	0.0	0.0	0.0	0.0
5	Zimba Trivor	46 12.4	0.0	0.0	0.0	0.0
6	Zimba Transform	46 9.6	0.0	0.0	0.0	0.0
7	Zimba Bulldock	46 0.625	0.0	0.0	0.0	0.0
8	Zimba Prodigy	46 9.6	0.0	0.0	0.0	0.0
Treatment Prob(F)			1.0000	1.0000	1.0000	1.0000
LSD P=0.05			NSD	NSD	NSD	NSD

Means followed by same letter or symbol do not significantly differ (P=.05, LSD, #P=.1, LSD)
Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.

Foliage of MCDIN plants were inspected for any symptoms of phytotoxicity including, but not limited to necrosis and/or chlorosis and/or plant growth effects.

Under the condition of this trial, no phytotoxic effects were observed for Zimba when applied alone or in a tank mix.

Table 2. Elemental increase

Treatment		Rate (g ai/100L)	Zn (mg/kg)		Fe (mg/kg)		Mo (mg/kg)		Mn (mg/kg)		B (mg/kg)	
			0 DA-A	14 DA-B	0 DA-A	14 DA-B	0 DA-A	14 DA-B	0 DA-A	14 DA-B	0 DA-A	14 DA-B
1	Untreated control		12.0	13.5	43.0	35.0	-0.1	0.0	91.5	62.0	92.5	63.5
2	Zimba	46	11.0	46.0	44.0	84.5	-0.1	0.9	174.5	156.5	99.5	84.5
% Increase to UTC				2445.5		595.7		809.5		69.0		52.9

Under the condition of this trial, Zimba applied alone increased all key elements when compared to the untreated control.

CONCLUSIONS

- Under the condition of this trial, no phytotoxic effects were observed for Zimba on MCDIN, when applied alone or when applied in a tank mix.
- Under the condition of this trial, Zimba applied alone increased all key elements when compared to the untreated control.

PHOTOGRAPHS

Photograph 1: Trial site at application A, 0 DA-A

Photograph 2: Crop stage at application A, 0 DA-A

Photograph 3: Zimba (400 ml/100L) + Kocide (150 g/100L) at 14 DA-A

Photograph 4: Zimba (400 ml/100L) + Prodigy (40 ml/100L) at 14 DA-A

Photograph 5: Zimba (400 ml/100L) + Trivor (40 ml/100L) at 14 DA-A

Photograph 6: Zimba (400 ml/100L) at 14 DA-A

Photograph 7: Untreated control at 14 DA-A

Photograph 8: Zimba (400 ml/100L) + Transform (40 ml/100L) at 14 DA-A

APPENDICES

Appendix I. Treatment details

Products

Product name	Active ingredient	Concentration	Formulation	Batch number
Zimba	Zn + Fe + Mn + Mo + B + organic acids	4.2% + 1.6% + 1% + 0.15% + 4.5%	Liquid	Not provided
Kocide WG	Copper (Cu) present as cupric hydroxide	350 g/kg	Water Dispersible Granule	Not provided
Merivon 500 SC	pyraclostrobin + fluxapyroxad	250 g/L + 250 g/L	Suspension Concentrate	0020290448
Trivor 310 DC	Acetamiprid + pyriproxyfen	186 g/L + 124 g/L	Dispersible Concentrate	98190377
Transform 240 SC	Sulfoxaflor	240 g/L	Suspension Concentrate	C781J6R00
Bulldock 25 EC	Beta-cyfluthrin	25 g/L	Emulsifiable concentrate	Not provided
Prodigy 240 SC	methoxyfenozide	240 g/L	Suspension Concentrate	1625971100

Treatments

No.	Product	Rate		Application schedule
		Active ingredient (g ai/100 L)	Product (g or mL/100 L)	
1	Untreated control	- -	- -	- -
2	Zimba	46	400	Two broadcast foliar applications, in a spray volume of 1050 L/ha, on a 15-day interval
3	Zimba + Kocide	46 + 52.5	400 + 150	
4	Zimba + Merivon	46 + 20	400 + 40	
5	Zimba + Trivor	46 + 12.4	400 + 40	
6	Zimba + Transform	46 + 9.6	400 + 40	
7	Zimba + Bulldock	46 + 0.625	400 + 25	
8	Zimba + Prodigy	46 + 9.6	400 + 40	

Chronology of events

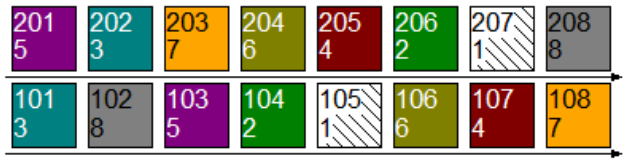
Date	DA-A	Crop stage	Event
14/06/2022	0 DA-A	BBCH 79	Treatment application (A) Leaf analysis
21/06/2022	7 DA-A	BBCH 79	Crop safety assessment
28/06/2022	14 DA-A	BBCH 79	Crop safety assessment
29/06/2022	15 DA-A	BBCH 79	Treatment application (B)
05/07/2022	7 DA-B	BBCH 79 / 51	Crop safety assessment
12/07/2022	14 DA-B	BBCH 79 / 51	Crop safety assessment Leaf analysis

Appendix II. Site details

Site details

Location	Wallaville, Bundaberg
GPS co-ordinates	-25.078218° 151.994351°
Soil type	Sandy loam
Crop	*Macadamia integrifolia*
Variety	A203
Trial design	Randomised complete block
Replications	4
Plot size	1 tree
Row spacing	8 m
Plant spacing	4 m
Plant density	312.5 plants/ha
Irrigation type	Trickle

Trial plan



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Trial location map

Application details – spray

Application Description		
	A	B
Application Date	14/06/2022	29/06/2022
Appl. Start Time	10:00 AM	10:00 AM
Appl. Stop Time	01:00 PM	11:00 AM
Application Method	BROADC	BROADC
Application Timing	ACCRST	ACCRST
Application Placement	FOLIAR	FOLIAR
Applied By	LS	LS
Air Temperature	22 ºC	19 ºC
% Relative Humidity	73	74
Wind Velocity+Dir	3 KPH E	2 KPH SE
Wet Leaves (Y/N)	N	N
Soil Moisture	Moist	Moist
% Cloud Cover	40	70
Application Equipment		
Equipment Type	KNAMOT	KNAMOT
Operation Pressure	800 kPa	800 kPa
Nozzle Type	COHOAD	COHOAD
Nozzle Size	1.5	1.5
% Coverage	100	100
Carrier	WATER	WATER
Application Amount	PORO	PORO
Propellant	PUMDIA	PUMDIA
Volume	1050 L/ha	1050 L/ha

Assessments

Phytotoxicity to MCDIN				
Dates	21/06/2022	28/06/2022	05/07/2022	12/07/2022
Days after application	7 DA-A	14 DA-A	7 DA-B	14 DA-B
Method and sample size	Phytotoxicity was monitored within the plot area and rated as percent leaf area affected (0-100%). Symptoms monitored included chlorosis (yellowing and discolouration of leaf tissue), necrosis (death of leaf tissue) and plant growth affects.			
Leaf elements				
Dates	21/06/2022		12/07/2022	
Days after application	7 DA-A		14 DA-B	
Method and sample size	Leaf samples were collected and processed by Phosyn Analytical.			

Statistical analysis	Where applicable, analysis of variance (ANOVA) test and Duncan's New MRT test were conducted using ARM2022. Where data violated the assumptions of ANOVA, data correction transformations were conducted. Non-transformed means are presented with ANOVA and letters of separation from transformed data

Appendix III. Statistical analysis

1. Phytotoxic effects to MCDIN

Crop Type, Code				C, MCDIN		C, MCDIN		C, MCDIN		C, MCDIN	
Rating Date				21/06/2022		28/06/2022		05/07/2022		12/07/2022	
Part Rated				NNNNN, -		NNNNN, -		NNNNN, -		NNNNN, -	
Rating Type				PHYGEN		PHYGEN		PHYGEN		PHYGEN	
Rating Unit/Min/Max				CROP INJ, -, -		CROP INJ, -, -		CROP INJ, -, -		CROP INJ, -, -	
Trt-Eval Interval				7 DA-A		14 DA-A		7 DA-B		14 DA-B	
ARM Action Codes											
No.	Name	Rate	Unit	1		2		3		4	
1	Untreated control			0.0	a	0.0	a	0.0	a	0.0	a
2	Zimba	46	g ai/100L	0.0	a	0.0	a	0.0	a	0.0	a
3	Zimba Kocide	46 52.5	g ai/100L g ai/100L	0.0	a	0.0	a	0.0	a	0.0	a
4	Zimba Merivon	46 20	g ai/100L g ai/100L	0.0	a	0.0	a	0.0	a	0.0	a
5	Zimba Trivor	46 12.4	g ai/100L g ai/100L	0.0	a	0.0	a	0.0	a	0.0	a
6	Zimba Transform	46 9.6	g ai/100L g ai/100L	0.0	a	0.0	a	0.0	a	0.0	a
7	Zimba Bulldock	46 0.625	g ai/100L g ai/100L	0.0	a	0.0	a	0.0	a	0.0	a
8	Zimba Prodigy	46 9.6	g ai/100L g ai/100L	0.0	a	0.0	a	0.0	a	0.0	a
LSD P=.05				.		.		.		.	
Standard Deviation				0		0		0		0	
CV				0		0		0		0	
Bartlett's X2				0		0		0		0	
P(Bartlett's X2)				.		.		.		.	
Skewness				.		.		.		.	
Kurtosis				.		.		.		.	
Replicate F				0		0		0		0	
Replicate Prob(F)				1		1		1		1	
Treatment F				0		0		0		0	
Treatment Prob(F)				1		1		1		1	

Means followed by same letter or symbol do not significantly differ (P=.05, LSD, #P=.1, LSD)
Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.

2. Elemental increase

Crop Type, Code				C, MCDIN	C, MCDIN	C, MCDIN	C, MCDIN	C, MCDIN	C, MCDIN	C, MCDIN	C, MCDIN	C, MCDIN	C, MCDIN
Rating Date				21/06/2022	28/06/2022	21/06/2022	28/06/2022	21/06/2022	28/06/2022	21/06/2022	28/06/2022	21/06/2022	28/06/2022
Part Rated				LEAF, -	LEAF, -	LEAF, -	LEAF, -	LEAF, -	LEAF, -	LEAF, -	LEAF, -	LEAF, -	LEAF, -
Rating Type				%UTC	%UTC	%UTC	%UTC	%UTC	%UTC	%UTC	%UTC	%UTC	%UTC
Rating Unit/Min/Max				Zn, mg/kg	Zn, mg/kg	Fe, mg/kg	Fe, mg/kg	Mo, mg/kg	Mo, mg/kg	Mn, mg/kg	Mn, mg/kg	B, mg/kg	B, mg/kg
Trt-Eval Interval				7 DA-A	14 DA-A	7 DA-A	14 DA-A	7 DA-A	14 DA-A	7 DA-A	14 DA-A	7 DA-A	14 DA-A
ARM Action Codes													
No	Name	Rate	Unit										
1	Untreated control			12.0	13.5	43.0	35.0	-0.1	0.0	91.5	62.0	92.5	63.5
2	Zimba	46	g ai/100L	11.0	46.0	44.0	84.5	-0.1	0.9	174.5	156.5	99.5	84.5
	Elemental % Increase to UTC				2445.5		595.7		809.5		69.0		52.9

Appendix IV. Plot data

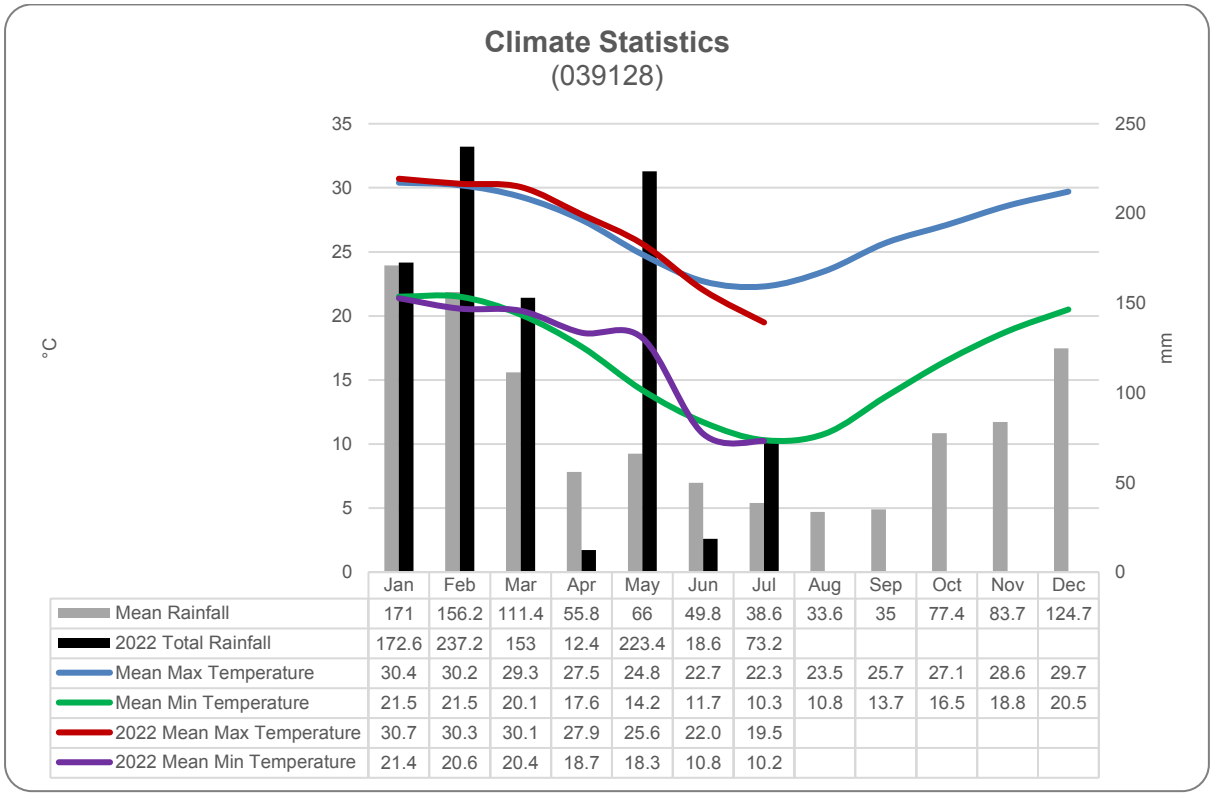
1. Phytotoxic effects to MCDIN

Crop Type, Code					C, MCDIN	C, MCDIN	C, MCDIN	C, MCDIN
Rating Date					21/06/2022	28/06/2022	05/07/2022	12/07/2022
Part Rated					NNNNN, -	NNNNN, -	NNNNN, -	NNNNN, -
Rating Type					PHYGEN	PHYGEN	PHYGEN	PHYGEN
Rating Unit/Min/Max					CROP INJ, -, -	CROP INJ, -, -	CROP INJ, -, -	CROP INJ, -, -
Trt-Eval Interval					7 DA-A	14 DA-A	7 DA-B	14 DA-B
No.	Name	Rate	Unit	Plot	1	2	3	4
1	Untreated control			105	0.0	0.0	0.0	0.0
				207	0.0	0.0	0.0	0.0
Mean =					0.0	0.0	0.0	0.0
2	Zimba	46	g ai/100L	104	0.0	0.0	0.0	0.0
				206	0.0	0.0	0.0	0.0
Mean =					0.0	0.0	0.0	0.0
3	Zimba	46	g ai/100L	101	0.0	0.0	0.0	0.0
	Kocide	52.5	g ai/100L	202	0.0	0.0	0.0	0.0
Mean =					0.0	0.0	0.0	0.0
4	Zimba	46	g ai/100L	107	0.0	0.0	0.0	0.0
	Merivon	20	g ai/100L	205	0.0	0.0	0.0	0.0
Mean =					0.0	0.0	0.0	0.0
5	Zimba	46	g ai/100L	103	0.0	0.0	0.0	0.0
	Trivor	12.4	g ai/100L	201	0.0	0.0	0.0	0.0
Mean =					0.0	0.0	0.0	0.0
6	Zimba	46	g ai/100L	106	0.0	0.0	0.0	0.0
	Transform	9.6	g ai/100L	204	0.0	0.0	0.0	0.0
Mean =					0.0	0.0	0.0	0.0
7	Zimba	46	g ai/100L	108	0.0	0.0	0.0	0.0
	Bulldock	0.625	g ai/100L	203	0.0	0.0	0.0	0.0
Mean =					0.0	0.0	0.0	0.0
8	Zimba	46	g ai/100L	102	0.0	0.0	0.0	0.0
	Prodigy	9.6	g ai/100L	208	0.0	0.0	0.0	0.0
Mean =					0.0	0.0	0.0	0.0

2. Elemental increase

Crop Type, Code					C, MCDIN	C, MCDIN	C, MCDIN	C, MCDIN	C, MCDIN	C, MCDIN	C, MCDIN	C, MCDIN	C, MCDIN	C, MCDIN
Rating Date					21/06/2022	28/06/2022	21/06/2022	28/06/2022	21/06/2022	28/06/2022	21/06/2022	28/06/2022	21/06/2022	28/06/2022
Part Rated					LEAF, -	LEAF, -	LEAF, -	LEAF, -	LEAF, -	LEAF, -	LEAF, -	LEAF, -	LEAF, -	LEAF, -
Rating Type					%UTC	%UTC	%UTC	%UTC	%UTC	%UTC	%UTC	%UTC	%UTC	%UTC
Rating Unit/Min/Max					Zn, mg/kg,	Zn, mg/kg,	Fe, mg/kg,	Fe, mg/kg,	Mo, mg/kg,	Mo, mg/kg,	Mn, mg/kg,	Mn, mg/kg,	B, mg/kg,	B, mg/kg,
Trt-Eval Interval					7 DA-A	14 DA-A	7 DA-A	14 DA-A	7 DA-A	14 DA-A	7 DA-A	14 DA-A	7 DA-A	14 DA-A
No.	Name	Rate	Unit	Plot										
1	Untreated control			105	13.0	15.0	45.0	37.0	-0.1	0.1	91.0	61.0	89.0	70.0
				207	11.0	12.0	41.0	33.0	-0.1	-0.1	92.0	63.0	96.0	57.0
Mean =					12.0	13.5	43.0	35.0	-0.1	0.0	91.5	62.0	92.5	63.5
2	Zimba	46	g ai/100L	104	12.0	54.0	58.0	94.0	-0.1	1.0	198.0	190.0	94.0	79.0
				206	10.0	38.0	30.0	75.0	-0.1	0.7	151.0	123.0	105.0	90.0
Mean =					11.0	46.0	44.0	84.5	-0.1	0.9	174.5	156.5	99.5	84.5

Appendix V. Meteorological details



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Rainfall	171	156.2	111.4	55.8	66	49.8	38.6	33.6	35	77.4	83.7	124.7
2022 Total Rainfall	172.6	237.2	153	12.4	223.4	18.6	73.2					
Mean Max Temperature	30.4	30.2	29.3	27.5	24.8	22.7	22.3	23.5	25.7	27.1	28.6	29.7
Mean Min Temperature	21.5	21.5	20.1	17.6	14.2	11.7	10.3	10.8	13.7	16.5	18.8	20.5
2022 Mean Max Temperature	30.7	30.3	30.1	27.9	25.6	22.0	19.5					
2022 Mean Min Temperature	21.4	20.6	20.4	18.7	18.3	10.8	10.2					

Graph 1: Climate Statistic / Actual Jan 2022 – July 2022

Year: 2022 **Location: Bundaberg Aero (station 039128), Queensland, Australia**

	June				July			
		Min °C	Max °C	mm		Min °C	Max °C	mm
1		12.6	22.4	0.0		16.5	21.4	0.0
2		13.4	20.5	0.0		16.1	17.4	8.0
3		11.4	24.2	0.0		13.0	16.1	6.8
4		17.2	23.0	0.8		11.0	12.0	7.6
5		8.3	22.7	0.0	**A**	10.3	13.7	10.8
6		13.6	21.6	16.2		10.9	20.1	3.4
7		13.1	N/A	1.0		7.8	21.7	0.2
8		8.5	18.3	N/A		8.9	19.9	0.0
9		6.2	17.6	0.0		4.6	18.3	0.0
10		7.1	17.9	0.0		6.5	20.2	0.0
11		7.1	19.2	0.0		7.6	20.9	0.0
12		8.6	17.7	0.0	**A**	10.5	17.8	0.4
13		8.6	21.1	0.0		9.6	19.2	1.0
14	**T**	11.0	23.9	0.0		8.7	18.9	0.0
15		13.3	23.6	0.0		8.6	21.8	0.0
16		13.8	25.0	0.0		10.3	21.5	0.0
17		11.5	22.8	0.2		10.5	22.9	0.0
18		7.9	22.2	0.0		10.4	25.1	0.0
19		11.4	23.6	0.0		8.7	22.8	0.2
20		13.1	23.1	0.0		11.3	21.8	0.6
21	**A**	12.0	23.0	0.0		14.3	17.7	0.2
22		9.3	23.8	0.2		15.3	N/A	34.0
23		10.2	23.7	0.0				
24		8.5	23.5	0.0				
25		8.0	23.2	0.0				
26		9.7	23.4	0.0				
27		13.7	23.1	0.0				
28	**A**	10.3	21.3	0.0				
29	**T**	11.9	21.2	0.2				
30		12.4	N/A	0.0				
31								
Total		**10.8**	**22.0**	**18.6**		**10.2**	**19.5**	**73.2**

N/A = Not Available
T = Treatment application
A = Assessment

The trial site was situated at Bundaberg, 10 km NNE of BOM 039128.

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