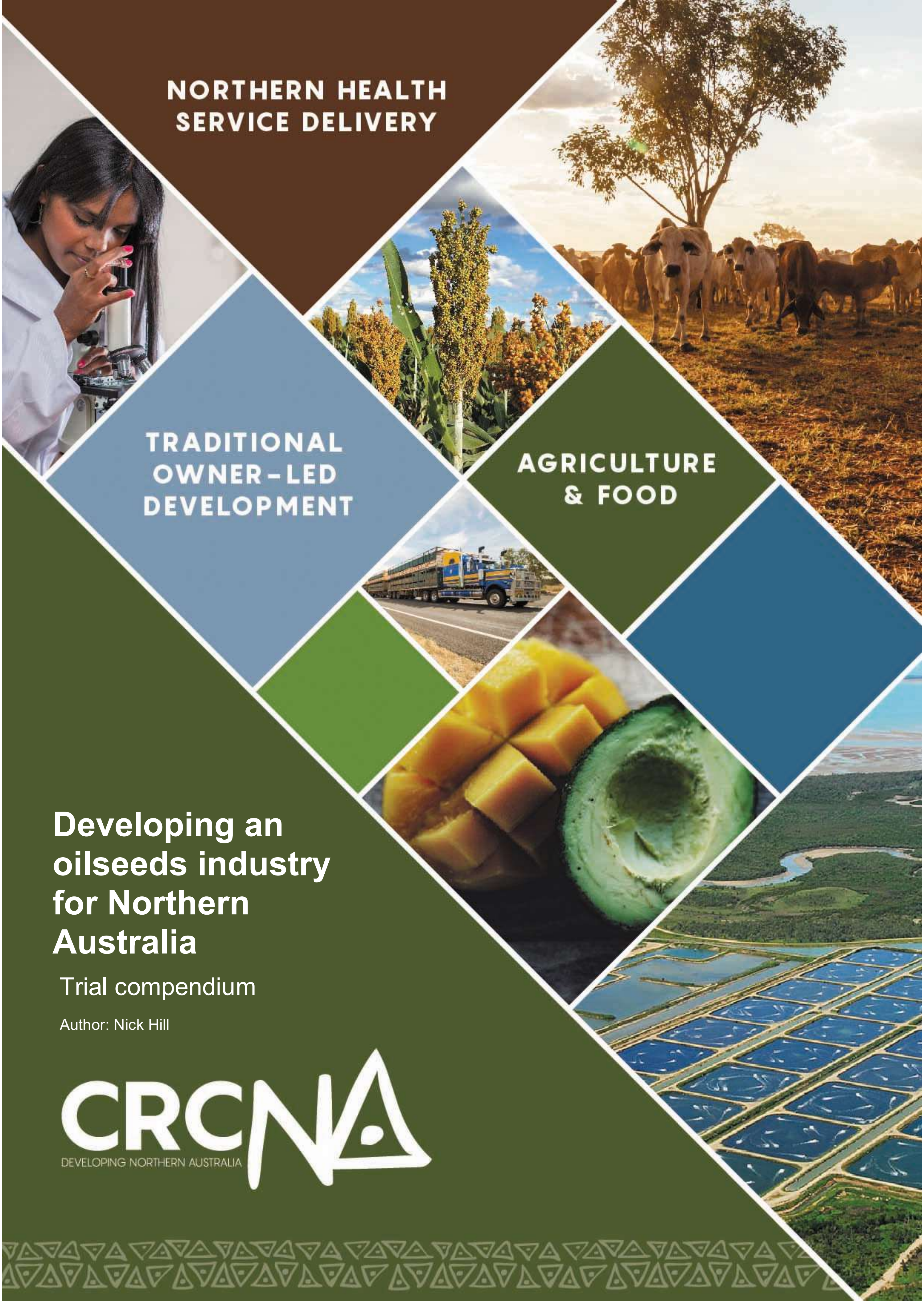

Developing an oilseeds industry for Northern Australia

Trial compendium

Author: Nick Hill

CRCNA
DEVELOPING NORTHERN AUSTRALIA

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Disclaimer

Peer Review Statement

The CRCNA recognises the value of knowledge exchange and the importance of objective peer review. It is committed to encouraging and supporting its research teams in this regard.

The author(s) confirm(s) that this document has been provided to CRCNA and Broadacre cropping project(s) representatives for review.

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Disclaimer

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Developing an oilseed industry for northern Australia, project overview.

Furthering agricultural industry within northern Australia has been identified as a national priority under the Australian Government White paper: *Developing Northern Australia,* due to the proximity of Asia, and other global trading markets, and the potential for increased production due to soil type(s) and water availability. Amongst the 10 highest producing agricultural sectors by gross value of production cattle and sugarcane rank the highest and the broadacre crops: wheat and sorghum amongst the lowest, with the Commonwealth government aspiring to increase the area under such forms of broadacre agricultural cropping (Commonwealth of Australian, 2015). As a response to the White paper the Cooperative Research Centre for Northern Australia (CRCNA) was established with the overarching goal to: "*develop new technologies, products and services which address industry issues in Northern Australia within three initial focus areas: Agriculture and food (including aquaculture, horticulture, and forestry), Northern Australia health service delivery Traditional Owner-led business development*" (CRCNA no1, 2021). As a component of Agriculture and Food focus area the CRCNA established four Broadacre cropping projects with the view to investigate the potential for establishment of alternative forms of broadacre cropping within northern regions so as to provide proven options for existing agricultural enterprises (CRCNA no2, 2021). The CRCNA project: *developing an oilseed industry in northern Australia*, was established to primarily investigate options for oilseed production in northern Australia and the associated agronomic factors impacting upon crop outcomes. The project life extended from July 2019 until July 2022 and over this period a range of both traditional and alternative oilseed crops were trialled over winter, spring, and summer cropping periods. From 2019 to 2021 project governance was provided by Savannah Ag Pty Ltd and from 2021 to 2022 by Farmacist Pty Ltd. A list of trials conducted by year crop and organisation is provided in Table 1.

Initial trials conducted by Savannah Ag were primarily located at the at the Queensland Government Department of Agriculture and Fisheries (QDAF) Walkamin Research Station in the Atherton Tablelands region of Nth Qld. The climate of Walkamin is classified as sub-tropical with cool dry winters and the potential for frost. Average rainfall for the site is listed as 760mm, with majority of rainfall experienced between October and March (QDAF, 2017.). Soils of the QDAF site are deep ferrosols identified as being non-crusting and well-drained. Trials conducted by Farmacist were primarily located in the Burdekin and Mackay regions and had a primary focus of integration of oilseeds within Nth Qld sugarcane farming system(s). Mackay trials were located at the Farmacist: Professional Grower Network trial site. The site is fully irrigated via an overhead sprinkler system and the soil type is classified as a "silty Sandiford": silty loam A horizon and a clay B horizon. The climate of Mackay is classified as tropical with daytime temperatures ranging from 29-30^{o}C in summer to 21-25^{o}C in winter. Average annual rainfall is 1585mm primarily received over the December March period, with August to September being the driest months (Bureau of Meterology no1, n.d.). Burdekin trials varied in location over the winter, spring, and summer trial periods. As per standard Burdekin farming practices all sites were furrow irrigated. The Burdekin region is within the dry tropic region of north Qld with a long-term annual rainfall of approx. 650mm which is primarily received over November to April, with long term average temperatures ranging from a maximum of 32^{o}C in summer to a minimum of 25^{o}C in winter (Bureau of Meteorology no2, n.d.).

Table 1. CRCNA Developing an oilseed industry for Nth Australia. Trial year by cropping period by organisation crop, and trial.

Trial year by cropping period	Organisation	Crop	Trial
2019 winter 2020 winter	Savannah Ag	Canola	Herbicide tolerant canola regional varietal suitably assessment by row spacing.
2019 winter		Safflower	E40R safflower: herbicide screening assessment; row spacing.
2019 winter 2020 winter		Carinata	Varietal assessment.
2019 winter		Nigella	Varietal assessment by row spacing ; herbicide screening assessment.
2019 winter		Indian mustard	Varietal assessment and cultivar comparison.
2019 winter		Linseed	Varietal assessment by plant population density.

2019 spring		Camelina	Crop assessment by row spacing by plant population density.
2020 summer		Sunflower	Varietal assessment by region (1).
2019-2020 summer		Soybean	Varietal assessment by region (4).
2020-2021 summer 2021-2022 summer	Farmacist	Soybean	Plant population by variety; preventative fungicide application by variety. Varietal assessment by region (1).
2021 spring 2022 summer		Sesame	Nitrogen rate by region (2).
2021 winter		Safflower, Carinata, Indian Mustard	Crop assessment by region (3).

Determination of the regional suitability, and the impact of row spacing upon Triazine Tolerant, Roundup Ready and Clearfield varieties of canola (*Brassica juncea*) within the Atherton Tableland region of Far Nth Qld. Introduction

Introduction

Traditionally grown in southern regions of Australia, canola (*Brassica napus* L.) is one of the most important global oilseed crops (Kirkegaard *et al*., 2016) and between 2013 and 2017, calculated upon the 5-year average, was the third highest Australian grain export commodity by volume and second highest by value (GRDC, 2018). To further the Australian canola industry extensive research has been conducted to address significant issues such as invertebrate pests (Gu, et al., 2007), disease (Li, et al., 2007; Khangura et al., 2011), weed control (Asaduzzaman et al., 2020), row spacing (Kutcher et al., 2013) , tolerance to soil constraints (Sabagh, et al., 2019) and regional fit, with yield and oil content shown to be strongly influenced by factors pertaining to geographic location, i.e., water availability, soil type and temperature (Robertson and Holland, 2004). As with all forms of cropping, maintaining weed control in canola is a major component of achieving yield outcomes with herbicide tolerant canola varieties developed to enable the use of pre-emergent and post-emergent herbicides, i.e., triazine, glyphosate, imidazolinone, and glufosinate ammonium (Asaduzzaman et al., 2020).

To investigate the regional fit for herbicide tolerant canola in northern Australia, and to further assess the effect of row spacing, a trial was established during the 2019 winter cropping season at the QDAF Walkamin research site. Two row spacings: 25cm and 50cm, and three forms of herbicide tolerant canola were evaluated: Triazine tolerant, Roundup Ready and, Clearfield (Imazamox & Imazapyr). Varietal selection was based upon suitability for direct harvesting and to provide growers from the northern regions with options for in-crop weed control. Trial outcomes were determined via yield (tonnes per hectare) and oil (%), at time of harvest. A full listing of varieties by post emergent herbicide and row spacing is listed in Table 2.

Table 1. CRCNA developing an oilseeds industry for northern Australia. 2019 Canola herbicide tolerant variety evaluation by row spacing trial. Herbicide tolerant cultivar by row spacing by maturity.

Herbicide	Variety by seed company 50cm row spacing	Variety by 25cm row spacing	Maturity rating
Triazine tolerant (Atrazine)	ATR Stingray (Nuseed)	ATR Stingray	Early *
	ATR Bonito (Nuseed)	ATR Bonito	Early to mid *
	45TO3 TT (Pioneer)	45TO3TT	Mid **
	44TO2 TT (Pioneer)	44TO2TT	Early to mid **
	Hyola 350 TT (Pacific)	Hyola 350TT	Early ***
	Hyola 530 XT (Pacific)	NA	Mid ***
	ADV–Intuitive (Pacific)	NA	nd
	ADV-Astute (Pacific)	NA	nd
	Hyola 550TT (Pacific)	NA	Mid to early ***
	Hyola 559TT (Pacific)	NA	Mid to early ***
	Hyola 580CT (Pacific)	NA	Mid to early ***
Roundup Ready (Glyphosate)	GT-53 (Nuseed)	GT53	Mid *
	Hyola 410XX (Pacific)	Hyola 410XX	Early to mid ***

	Hyola 530XT (Pacific)	Hyola 530XT	Mid ***
	Hyola 540XC (Pacific)	NA	Mid to early ***
	ADV-Genius (Pacific)	NA	nd
Clearfield canola (Intervix)	Hyola 580CT (Pacific)	Hyola 580CT	Mid to Early ***
	45Y91CL (Pioneer)	45Y91CL	nd
	45Y93CL (Pioneer)	45Y93CL	Mid **
	Hyola 970CL (Pacific)	NA	Late ***

*Sourced from: https://www.nuseed.com/au/
** Sourced from: https://www.pioneerseeds.com.au/
*** Sourced from: https://www.pacificseeds.com.au/
nd: no data available.

Methodology

Trial site establishment occurred on the 16th of May 2019. Prior to sowing a basal fertiliser application was applied across the site(s) and worked in to a depth of 10cm to provide the following nutrition: 120kg/ha Nitrogen, 30kg/ha Phosphorus, 100kg/ha Potassium and 2.5kg/ha Sulphur. Trial sites were comprised of plots 1.6m wide by 20m long, replicated 4 times. Seed was sown at an approximate depth of 15-20mm via a multi row Jang seeder tool bar. Emergence across all varieties was noted to commence 6 days post sowing (22nd of May). In-crop irrigation was applied fortnightly via an overhead sprinkler system at 15m intervals. In-crop observations were conducted on a weekly basis, where insect or disease pressure were identified on-label chemical applications were applied via a commercial spray boom, with subsequent outcomes monitored. Harvest was conducted via a Hege small plot harvester with timing of harvest based upon maturity / natural dry down for individual variety(s). Roundup Ready and Triazine varieties were harvested between the 18th of September and the 8th of October 2019 (125 – 145 days post sowing) and Clearfield varieties were harvested between the 27th of September and the 17th of October 2019 (134 – 154 days post sowing). Seed obtained from the individual plots was screened for extraneous matter then weighed to achieve yield (kg) per plot. The individual samples were subsampled and tested for oil % via a CROPSCAN 1000H NIR On farm crop analyser.   Yield and oil data was collated in Microsoft Excel. Statistical models were created for the individual forms of herbicide tolerant canola using ASREML statistical analysis software. Resulting models were subjected to L.S.D post hoc pairwise analysis to determine significant difference at the 95% confidence limits (P=0.05) between: varieties, row spacing and interaction between variety and row spacing.

Results

Trial outcomes have shown that within the individual forms of herbicide tolerant canola significant differences in yield (t/ha) (Table 2.), and oil percentage (%) (Table 3.) at time of harvest was primarily driven by variety, with no significant effect of row spacing or interaction between row spacing and variety observed. Comparison of yield (t/ha) and oil% by form of herbicide tolerant canola shows that Clearfield canola achieved significantly less yield than both Triazine Tolerant and Roundup Ready canola’s which were which were not significantly different from each other; and Roundup Ready canola achieved significantly greater oil% than both Triazine Tolerant and Clearfield canola’s which were not significantly different from each other.

Over the course of the trial in-crop observations identified variation in emergence across the different forms of herbicide tolerant canola, and high levels of pest pressure via green peach aphid (*Myzus persicae*) and *Heliothis punctigera* larvae. These issues, either individually or combined are considered to have potentially influenced minimum and maximum yields (t/ha) noted for individual varieties. Significant variation in crop development was further noted with early maturing varieties observed to be flowering 6 weeks post sowing, mid maturity varieties at stem elongation and later maturity varieties at commencing stem elongation.

Triazine tolerant canola mean yield results (Table 2.), show significant variation in yield across varieties, where primarily, 44T02TT recorded significantly greater yield (t/ha) than: Hyola 559TT, ADV-Astute, 45T03TT and Hyola 530XT and 45T03TT. Mean oil% results (Table 3.), identify significant differences between varieties, where primarily ADV-Astute achieved greater oil% than 45703TT. Nominally comparing individual varieties by yield (t/ha) and oil% demonstrates that ATR Stingray, ATR Bonito, and Hyola 350TT achieved both greater yield and oil; and 45T03TT achieved both reduced yield and oil.

Roundup Ready canola mean yield (t/ha) results (Table 2.), identify significant differences between varieties with GT-53 recording significantly greater yield (t/ha) than all varieties excluding Hyola 410XX. Mean oil% results (Table 3.), identify no significant differences between varieties however it can be observed that ADV-Genius and Hyola 410XX achieved highest oil% and Hoyla 540XC the lowest. Nominally comparing yield (t/ha) and oil% results show that GT-53 and Hyola 410XX achieved both greater yield and oil; and Hyola 530XT and Hyola 540XC recorded reduced yield, with limited difference noted between varieties for oil%.

Clearfield canola mean yield (t/ha) outcomes (Table 2), identify that Hyola 580CT achieved significantly greater yield than both 45Y91CL and 45Y93CL. Mean oil% results (Table 3.), identify that 45Y91CL and Hyola 580CT achieved significantly greater oil% than 45Y93CL. Comparison of yield (t/ha) and oil% outcomes show that Hyola 580CT nominally achieved both increased yield and oil; and 45Y93CL recorded lower yield and oil.

Comparison of mean trial yield (t/ha) and oil% results with Grains Research and Development Corporation (GRDC) canola National Variety Trial (NVT), results from medium to high rainfall zone(s) provides the following comparisons. Triazine Tolerant varieties included in the Nth Qld trial had combined maximum and minimum yields ranging from 0.23 to 2.84 t/ha and a total combined average yield of 1.28 t/ha; and combined maximum and minimum oil% ranged from 22.7 to 41.1% with a combined average of 34.5%. In comparison NVT Nth Eastern NSW long term results show that Triazine Tolerant varieties had a combined average yield ranging from 0.81 to 3.03 t/ha with a combined average yield of 1.86 t/ha (GRDC, n.d. no1.), and oil% over a 5-year trial period ranged from a combined minimum of 37.4% to a combined maximum of 45.3%, with a combined average oil% of 42.05% (GRDC n.d. no2). Roundup Ready canola varieties from the Nth Qld trial combined display minimum and maximum yields ranging from 0.63 to 2.85t/ha with a combined average of 1.4t/ha and oil% ranged from a combined minimum of 29.3% to a combined maximum of 42% with a total combined average oil % of 38%. Roundup Ready NVT Nth Western NSW long term yields range from a minimum of 1.34 t/ha to a maximum of 2.54 t/ha (GRDC n.d. no3); and oil results recorded a combined minimum oil% of 41% and a combined maximum oil % of 48.4% with a combined average of 44.7% oil (GRDC, n.d. no4). Nth Qld Clearfield canola trial results provided combined minimum and maximum yields of 0.64t/ha and 1.78t/ha and a combined total average of 0.73 t/ha. Minimum and maximum oil% ranged from 30.2 to 38.2% with a combined average of 34.48%. In comparison Clearfield canola NVT Nth Eastern NSW long term yields ranged from a minimum of 0.87t/ha to a maximum of 3.07t/ha and a combined average of 1.96t/ha (GRDC, n.d. no5); and oil% ranged from 38.1% to 47% with a combined average of 42.32%.

Across the different forms of herbicide tolerant canola varieties trialled it can be observed that the early to mid-season cultivars achieved both greater yield(t/ha) and oil(%).

Table 2. CRCNA developing an oilseeds industry for northern Australia. 2019 Canola herbicide tolerant variety evaluation by row spacing. Mean yield, tonnes per ha (t/ha) at time of harvest.

Herbicide	Variety	Row spacing (cm)	Mean yield (t/ha)
Triazine tolerant	44T02TT	25	1.73 a
	Hyola 350TT	25	1.55 ab
	ATR Bonito	25	1.52 ab
	ATR Bonito	50	1.6 ab
	Hyola 550TT	50	1.4 abc
	ATR Stingray	25	1.38 abc
	ATR Stingray	50	1.36 abc
	ADV-Intuitive	50	1.34 abc
	Hyola 580CT	50	1.31 abc
	44T02TT	50	1.31 abc
	Hyola 350TT	50	1.3 abc

	Hyola 559TT	50	1.24 bc
	ADV-Astute	50	0.95 cd
	45T03TT	25	0.95 cd
	Hyola 530XT	50	0.75 d
	45T03TT	50	0.57 d
Roundup Ready	GT-53	50	2.23 a
	Hyola 410XX	25	1.62 ab
	Hyola 410XX	50	1.52 b
	ADV-Genius	50	1.34 b
	GT-53	25	1.33 b
	Hyola 540XC	50	1.2 b
	Hyola 530XT	50	1.12 b
	Hyola 530XT	25	0.97 b
Clearfield	Hyola 580CT	25	1.27 a
	Hyola 580CT	50	1.3 a
	45Y91CL	50	0.56 b
	45Y91CL	25	0.45 b
	45Y93CL	50	0.37 b
	45Y93CL	25	0.29 b

Note: numbers followed by different letters are significantly different at the 95% confidence limits (P=0.05)

Table 3. CRCNA developing an oilseeds industry for northern Australia. 2019 Canola herbicide tolerant variety evaluation by row spacing. Mean canola oil percentage (%) at time of harvest.

	Treatments	Row spacing	Oil(%)
Triazine tolerant	ADV-Astute	50	39.38 a
	ATR Stingray	50	38.48 ab
	ATR Bonito	50	38.42 ab
	Hyola 350TT	50	37.65 ab
	Hyola 350TT	25	37.35 ab
	Hyola 530XT	50	36.52 abc

	ATR Stingray	25	35.55 abcd
	ATR Bonito	25	35.47 bcd
	ADV-Intuitive	50	35.27 bcd
	Hyola 580CT	50	35.07 bcd
	Hyola 559TT	50	33.15 cde
	Hyola 550TT	50	32.5 def
	44T02TT	25	31.82 def
	45T03TT	50	30.15 ef
	44T02TT	50	29.3 fg
	45T03TT	25	25.92 g
Roundup Ready	Hyola 530XT	25	37.5
	Hyola 530XT	50	37.35
	Hyola 540XC	50	36.2
	GT-53	25	38.48
	ADV-Genius	50	40.05
	Hyola 410XX	50	39.83
	Hyola 410XX	25	40.17
	GT-53	50	36.72
Clearfield	45Y91CL	25	36.43 a
	45Y91CL	50	35.67 a
	45Y93CL	25	32.70 b
	45Y93CL	50	31.80 b
	Hyola 580CT	25	35.88 a
	Hyola 580CT	50	33.97 a

Note: numbers followed by different letters are significantly different at the 95% confidence limits (P=0.05)

Discussion

Overall trial results have shown that over the 2019 winter cropping period canola was able to be successfully established and taken to harvest in the Atherton Tableland region of Nth Qld, and row spacing was not observed to be a significant factor affecting either yield (t/ha) or oil%. Comparison of averaged trial outcomes with averaged GRDC NVT trial work shows that the combined Roundup Ready varieties included in the Nth Qld trial exceeded nominated NSW mid to high rainfall NVT yield (t/ha) and oil% results and recorded significantly greater yield (t/ha) and oil% when compared to Triazine Tolerant and Clearfield canola varieties included in this trial. Within the individual forms of herbicide tolerant canola, variation in yield (t/ha) and oil% can be seen across individual varieties, showing that certain varieties may be better suited to the Nth Qld or Walkamin region which is displayed via the combination of both high yield and oil% (Table’s 2 and 3.), which in the majority of instances was displayed by the early to mid-season varieties. However, when viewing trial results, it should be considered that the observed variation in plant population establishment and levels of pest pressure experienced may have impacted upon outcomes, as could have the applied nutrition with rates of sulphur considered below crop requirements (i.e., NSW DPI, 2022).

Conclusion

It has been proven that over the 2019 winter cropping trial period canola was successfully grown in the Walkamin locality of Nth Qld. Results have indicated that the Roundup Ready varieties included the trial were able to achieve greater outcomes, and within all forms of herbicide tolerant canola trialled specific early-to-mid-season varieties were better suited to the conditions experienced. To fully determine a fit for canola in Nth Australia, further trial work is required to investigate varietal suitability by individual region with other agronomic factors such as time of sowing, needing to be addressed so as to maximise crop outcomes.

The impact of row spacing and plant population density, and the effect of pre and post emergent herbicides upon E40R Safflower (*Carthamus tinctorius*), as determined by yield at time of harvest.

Introduction

Over the 2019 winter cropping season, two trials were conducted upon E40R safflower (*Carthamus tinctorius*). The first was investigating the impact of row spacing by plant density, and the second was an herbicide safety screening trial assessing the effect of a suite of commercially available herbicides at two different rates. Trial outcomes for both trials were determined via yield (t/ha) at time of harvest.

Safflower is an annual oilseed crop that is suited in a dryland cropping rotation due to its reduced nutrient requirements, moderate tolerance to salinity and sodicity, options for breaking disease/weed cycles, and a deep tap root that aerates the soil and effectively sources water from within a soil profile enabling it to be grown in low rainfall environments (Gilbert et al., 2008). E40R safflower was released within Australia in 2019 and is a super high oleic oil variety that was developed by the Australian Commonwealth Scientific and Industry Research Organisation (CSIRO) and the Australian Grains Research Development Corporation (GRDC). The high levels of oleic acid (92% per litre) have a high thermal burning point and can be used in the manufacturing of multiple products such as: lubricants, resins, plastics, biofuels, cosmetics, and polymers (Richards, 2019). As E40R is a new variety the agronomic parameters required to achieve maximum production outcomes are uncertain. Determination of suitable row spacing and seeding density has been demonstrated to be an important component of maximising safflower yield and oil content (i.e., Sharifmoghaddasi and Omidi, 2009), with variation in trial outcomes noted in the literature due to location and associated climatic conditions (i.e., Caliskan and Caliskan, 2018; Özaşık et al., 2019). Weed control in safflower is considered to be a major issue affecting yield outcomes due to poor competition in the early stages of growth with weeds persisting over a crop cycle demonstrated to reduce yields by up to 93% (Jha et al., 2017) due to competition for water, nutrients, light, and space (Budak, 2020).

To address row spacing by plant density, and determination of herbicide safety by rate of application, with respect to the Nth Qld situation, two separate trials were located at the QDAF Walkamin Research Station in the Atherton Tablelands region of Nth Qld.

Methods

Across both trial sites granular fertiliser was applied prior to sowing and incorporated so as to achieve a soil nutrition status of: 120kg/ha Nitrogen, 30kg/ha Phosphorus, 100kg/ha Potassium and 2.5kg/ha Sulphur. Sowing was conducted via a multi row Jang seeder tool bar with seed sown at an approximate depth of 15-20mm. Overhead irrigation was applied on a fortnightly basis, and in-crop investigation was conducted weekly to monitor nominated trial outcomes and determine occurrence of pests, weeds, and diseases. Harvest was conducted by a Hege small plot harvester with timing of harvest based upon natural dry down. Post-harvest, seed achieved from each individual trial / trial plot was cleaned, extraneous matter removed, and individual weights recorded and entered into Microsoft Excel. Data was analysed by QDAF biometric statisticians. Statistical models were created for the individual forms of herbicide tolerant canola using ASREML statistical analysis software. Resulting models were subjected to L.S.D post hoc pairwise analysis to determine significant difference at the 95% confidence limits (P=0.05).

Row spacing by plant density trial. Individual treatment bed dimensions were 1.6m wide by 30m long. 50cm row spacing: 3 rows per bed, 25cm row spacing: 6 rows per bed. Plant population treatments were 5, 10 and 20 plants per 1m of row. Treatments were replicated 4 times. Sowing took place on the 9th of May with seed sown at 25cm spacing to ensure required establishment. Emergence commenced on the 14th of May, 5 days after sowing, with plant densities applied to individual plots via manual removal of plants on the 19th of May.

Herbicide screening trial. Individual treatment dimensions were 1.6m wide by 8m long, with 6 rows at 25cm row spacing applied per bed. 10 herbicides at two different rates were applied as per label instructions A full listing of herbicides, rates and timing of application is provided in Table 1. Pre- plant herbicides were applied on the 21st of May, and as required, were mechanically incorporated within 1hour of application. Sowing took place on the 22nd of May. Pre-emergent post sowing herbicides were applied on the 23rd of May which was followed by approximately 25mm of irrigation. Emergence was noted on the 27th of May, 5 days after sowing.

Table 1. CRCNA developing an oilseeds industry for northern Australia. 2019 E40R safflower herbicide screening trial. Product by active, by rate and timing of application.

Product name	Active constituent	Rate 1	Rate 2	Timing
Dual Gold	S-metolachlor	1L/ha	2L/ha	Pre-Plant
Treflan	Trifluralin	3L/ha	6L/ha	Pre-Plant (incorporated)
Rustler	Propyzamide	1L/ha	2L/ha	Pre-Plant
Boxer Gold	Prosulfocarb+S-Metolachlor	2.17L/ha	4.35L/ha	Pre-Plant
Valor	Flumioxazin	180g/ha	360g/ha	Pre-Plant
Balance	Isoxaflutole	25g/ha	50g/ha	Post-Sowing, Pre-Emergent
Brodal	Diflufenican	150ml/ha	300ml/ha	Post Emergent
Associate	Metsulfuron methyl	5g/ha	10g/ha	Post Emergent
Verdict	Haloxyfop+Kwicken	150ml/ha	300ml/ha	Post Emergent
Select	Clethodim+Oil adjuvant	120g/ha	240g/ha	Post Emergent

Results and discussion.

Row spacing by plant density trial results identified a significant effect of row spacing and plant density upon yield at time of harvest, but not a significant interaction between row spacing by plant density. As observed in Table 2., the 25cm row spacing and 5 and 10 plants per 1m of row achieved significantly greater yield (t/ha) when compared to the 50cm row spacing and 20 plants per 1m of row treatments. Trial work conducted by Sharifmoghaddasi, and Omidi (2009) showed a similar result in safflower via combined analysis over two trial years with decreasing row spacing and plant density resulting in increased yield and oil content. In this trial it was observed that the reduction in both row spacing, and plant density caused a reduction in the number of plants per unit area but an increased number of seed heads per unit area which was translated into yield. However, as shown by Caliskan and Caliskan, (2018), in an unirrigated Mediterranean type of environment, optimum row spacing varied between 45 and 30cm due to season and 20cm plant spacing was considered optimum in conditions were yield is limited due to environment. As the Walkamin trial was irrigated on a regular basis, row spacing by plant population density may be considered specific to region, water availability and other limiting factors.

Table 2. CRCNA developing an oilseeds industry for northern Australia. 2019 E40R safflower row spacing by plant density trial. Row spacing by plant density per 1m of row by averaged yield, tonnes per ha (t/ha) at time of harvest. Significance of treatment effect.

Row spacing	Yield (t/ha)	Plant density per 1m of row	Yield (t/ha)
25	3.05a	5	2.98a
50	2.69b	10	3.15a
		20	2.49b

Note: numbers followed by different letters are significantly different at the 95% confidence limits (P<0.05).

Herbicide screening trial results identify a significant effect of form of herbicide upon yield (t/ha) but not a significant effect of either rate, or interaction between rate and form of herbicide. As seen in Table 3., Prosulfocarb+S-Metolachlor achieved significantly more t/ha than all products excluding S-metolachlor and Diflufenican. Amongst products Prosulfocarb+S-Metolachlor recorded the highest t/ha and Flumioxazin the lowest. As a registered herbicide Flumioxazin is noted to control a range of broadleaf weeds and is used in safflower for the purpose of desiccation prior to harvest. It also has a a 3-month plant back interval when planting safflower (Nufarm, n.d.) . Consequently, the viewed decline in yield when Flumioxazin was applied is as expected. The nominally increased yields achieved via Prosulfocarb+S-Metolachlor when compared to S-metolachlor and Diflufenican may be considered to be due to the broader spectrum of weeds controlled (i.e., Syngenta, n.d.) which combined with the absence of a negative effect upon safflower yield (t/ha) at time of harvest resulted in the increased results. The lack of significant difference noted for both rate and rate by form of herbicide identifies that application of the herbicides at the lower rate, across all herbicides trialled, resulted in comparable results with the higher rate. For a grower this would save input costs and result in increased gross margins. Making safflower a more attractive crop to grow.

Table 3. CRCNA developing an oilseeds industry for northern Australia. 2019 E40R safflower herbicide screening trial. Herbicide by averaged yield at time of harvest. Significance of treatment effect (P<0.05).

Product name	Chemical	mean
Boxer Gold	Prosulfocarb+S-Metolachlor	2.90 a
Dual Gold	S-metolachlor	2.72 ab
Brodal	Diflufenican	2.66 abc
Select	Clethodim + Oil Adjuvant	2.6 bc
Balance	Isoxaflutole	2.58 bc
Verdict	Haloxyfop + Kwicken	2.56 bcd
Associate	Metsulfuron Methyl	2.48 bcd
Treflan	Trifluralin	2.42 cd
Rustler	Propyzamide	2.42 cd
Valor	Flumioxazin	2.28 d

Note: numbers followed by different letters are significantly different at the 95% confidence limits (P<0.05).

Conclusion

Trial results have identified that for the 2019 trials located at the QDAF Walkamin research station 25cm row spacing and 5 and 10 plants per 1m of row achieved significantly greater yield (t/ha). It should be noted that this was under irrigated conditions, consequently further work is required to determine optimum plant population density specific to region, water availability and associated limiting factors. The herbicide screening trial clearly showed that the lower rate of Prosulfocarb+S-Metolachlor was the safest form of herbicide to apply with a resultant increase of yield (t/ha) when compared to the other herbicides included in the trial. As number and identification of weeds was not a component of the trial it is uncertain if this result would be translated across regions.

The effect of row spacing upon 3 varieties of Nigella (*Nigella sativa*), and the effect of pre and post emergent herbicide(s) as determined by yield at time of harvest, within the Atherton Tablelands region of Nth Qld.

Introduction

Over the 2019 winter cropping season investigation was conducted into the potential of Nigella (*Nigella sativa*), or black cumin, as a commercial crop and different agronomic factors impacting upon its production within northern Australia.

Native to Southwest Asia, North Africa, and Southern Europe, Nigella is currently primarily cultivated in Southern Europe, Middle Eastern Mediterranean, Saudi Arabia, Pakistan, Turkey, Iran, Northern India, and Syria for both seed and oil which are used as either a spice or for traditional medicine (Srinivasan, 2018.). Modern medical research has investigated Nigellas therapeutic benefits with evidence suggesting beneficial outcomes upon a multitude of ailments including diabetes, bronchial, and inflammatory disorders primarily due to the compound thymoquinone (Ahmad, *et al*., 2013). Due to its medical benefits Nigella is considered a high value crop (Dubey et al., 2016) and its financial value is expected to increase, with Nth Australia well placed to meet both domestic and international demands due to proximity to Asia and seasonal supply opposite with that of traditional sources (Rahman et al., 2021).

Nigella is a new crop to northern Australia. To provide base line agronomic information, two trials were conducted over the 2019 winter cropping season: 1) varietal assessment and row spacing by variety; and 2) herbicide screening trial. Row spacing is an important aspect of crop growth, development, and harvest outcomes due to various factors including, crop water uptake (Zhou et al., 2007), weed control (Wax et al., 1968), pests (Akinkunmi et al., 2012) diseases (Jaccoud-Filho et al., 2016), plant structure and yield (Abdolrahimi et al., 2012). As a commercial crop Nigella is considered to be a poor weed competitor due to relatively slow growth and an open canopy structure (Seyyedi , 2016). It is understood that weed control within cropping systems is a major factor impacting upon yield, and that herbicide application is a cost-effective method of control (Singh et al., 2013). Consequently, to facilitate the establishment of Nigella as a commercial cropping option for northern Australia herbicide options need to be fully defined.

Methods

Across both trial sites granular fertiliser was applied prior to sowing and incorporated so as to achieve a soil nutrition status of: 120kg/ha Nitrogen, 30kg/ha Phosphorus, 100kg/ha Potassium and 2.5kg/ha Sulphur. Sowing was conducted via a multi row Jang seeder tool bar with seed sown at an approximate depth of 15-20mm. Overhead irrigation was applied on a fortnightly basis, and in-crop investigation was conducted weekly to monitor nominated trial outcomes and determine occurrence of pests, weeds, and diseases. Harvest was conducted by a Hege small plot harvester with timing of harvest based upon natural dry down. Post-harvest, seed achieved from each individual trial / trial plot was cleaned, extraneous matter removed, and individual weights recorded and entered into Microsoft Excel. Data was analysed by QDAF biometric statisticians. Statistical models were created for the individual forms of herbicide tolerant canola using ASREML statistical analysis software. Resulting models were subjected to L.S.D post hoc pairwise analysis to determine significant difference at the 95% confidence limits (P=0.05).

Variety assessment by row spacing**.** Trial design was comprised of 2 row spacings: 25cm and 50cm which were applied to 3 varieties of Nigella: Deli, Elite and a standard variety - 6 treatments replicated 4 times. Individual trial plots were 1.6m wide by 30mtrs long. The site was established on the 9th of May and emergence noted to commence on the 23rd of May or 14 days after sowing. In-crop monitoring conducted on the 7th of June or 29 days after sowing and encompassed: the number of plants within a 1m quadrat, visual assessment of vigor, stem height and number of leaves. Harvest occurred on the 7th of October or 151 days after sowing.

Herbicide assessment. 10 forms of herbicide were included in the trial at two different rates, full listing of product and rate is provided in Table 1. Trial plots were 5 rows at 25cm row spacing 8m long, replicated 4 times. Pre-plant herbicides were applied May 21st with a calibrated backpack, and where required (Treflan), the chemical was mechanically incorporated within one hour of application to ensure product efficacy. The site was sown on the 22nd May using the standard variety of Nigella. Post-sowing pre-emergent herbicides were applied May 23rd followed by approximately 25mm of irrigation. Commencement of crop emergence was noted on June 4th, 13 days after sowing. In crop monitoring occurred on the 14th of September to determine efficacy of weed control, to which a score was applied: 0 being full control and 9 being no control. Plant height was further recorded. Harvest occurred on the 4th of October or 135 days after sowing.

Table 1. CRCNA developing an oilseeds industry for northern Australia. 2019 Nigella herbicide screening trial. Product by active, by rate and timing of application.

Product name	Active constituent	Rate 1	Rate 2	Timing
Dual Gold	S-metolachlor	1L/ha	2L/ha	Pre-Plant
Treflan	Trifluralin	3L/ha	6L/ha	Pre-Plant (incorporated)
Rustler	Propyzamide	1L/ha	2L/ha	Pre-Plant
Boxer Gold	Prosulfocarb + S-metolachlor	2.17L/ha	4.35L/ha	Pre-Plant
Valor	Flumioxazin	180g/ha	360g/ha	Pre-Plant
Balance	Isoxaflutole	25g/ha	50g/ha	Post-Sowing, Pre-Emergent
Brodal	Diflufenican	150ml/ha	300ml/ha	Post Emergent
Associate	Metsulfuron methyl	5g/ha	10g/ha	Post Emergent
Verdict	Haloxyfop	150ml/ha	300ml/ha	Post Emergent
Select	Clethodim	120g/ha	240g/ha	Post Emergent

Results and discussion.

2019 Nigella row spacing by variety trial outcomes show that variety significantly influenced yield but there was no significant effect of either row spacing or interaction between row spacing and variety. Variety by yield results (Table 1.) identifies that Elite and the standard variety recorded significantly more kg/ha than Deli and were not significantly different from each other. Viewing non-significant averaged data by variety and row spacing (Table 1.) shows that Elite recorded greatest yield (kg/ha) and the 25cm row spacing recorded increased yield across all varieties, with greatest response viewed for both Elite and the standard variety. Previous trial work has shown a response of Nigella to narrow row spacings. Kizil and Toncer, (2005) investigated the impact of row spacing upon factors including yield with the following row spacings investigated: 20cm, 30cm, 40cm and 50cm. Results identifying that the 30 and 40cm row spacing achieved greater yield. Abdolrahimi et al., (2012) compared seeding density by 20 and 40cm row spacings and identified that 20cm row spacing at 2cm plant density provided significantly increased outcomes. These results combined identify that for Nigella, reduced row spacings achieved greater crop outcomes. It can be theorised that this is due to the increased planting density resulting greater number of plants in a growing location. Although individual plant yield is decreased the total yield provided via a greater number of plants providing a compensatory mechanism (Moodi, 1999).

Table 2. CRCNA developing an oilseeds industry for northern Australia. 2019 Nigella variety by row spacing trial. Variety by row spacing and averaged yield, kg per ha (kg/ha) at time of harvest.

Variety	Row spacing (cm)	Yield (kg/ha)
Deli	25 b	233.07
	50 b	230.90
Deli total		**231.99 b**

Elite	25 a	654.52
	50 a	455.20
Elite total		**554.86 a**
Standard	25 a	589.34
	50 a	475.62
Standard total		**532.48 a**

Note: numbers followed by different letters are significantly different at the 95% confidence limits (P<0.05).

Herbicide assessment results (Table 3.) show that form of herbicide significantly impacted upon yield, and that there was no significant effect of either rate or interaction between rate and form of herbicide. Viewing significant differences between the individual treatments primarily shows that Isoxaflutole, S-metolachlor and Clethodim + Oil Adjuvant recorded significantly greater yield than Diflufenican, Trifluralin and Metsulfuron Methyl. Weed scoring identified limited difference between maximum and minimum values across the different forms of herbicides, which may have been a factor of timing of assessment. Determination of the effect of plant height further identified no significant impact of height upon yield outcomes. Comparison of yields between the two trials highlights the importance of effective weed control upon Nigella harvest results. In the variety by row spacing trial (Table 2.) weed control was applied manually which can be seen to have resulted in comparable or reduced outcomes when compared to the majority of herbicides trialed (Table 3.). Herbicide screening trial results have shown that Isoxaflutole, and S-metolachlor are current commercially available options that within this trial achieved effective weed control with a resulting yield benefit.

Table 3. CRCNA developing an oilseeds industry for northern Australia. 2019 Nigella herbicide screening trial. Herbicide by rate and yield at time of harvest. Significance of treatment effect (P<0.05).

Product name	Active constituent	Yield (t/ha)	Minimum weed score	Maximum weed score	Plant height (cm)
Balance	Isoxaflutole	1.26 a	3	9	54.5
Dual Gold	S-metolachlor	1.20 a	3	7	53.8
Select	Clethodim + Oil Adjuvant	1.09 a	3	9	56
Rustler	Propyzamide	0.97 ab	3	6	53.5
Verdict	Haloxyfop + Kwicken	0.95 ab	3	10	53.4
Boxer Gold	Prosulfocarb+S-Metolachlor	0.94 ab	3	7	55.5
Valor	Flumioxazin	0.90 abc	4	7	48.7
Brodal	Diflufenican	0.65 bc	4	8	56.7
Treflan	Trifluralin	0.64 bc	3	8	54.8
Associate	Metsulfuron Methyl	0.44 c	3	9	55.6

Note: numbers followed by different letters are significantly different at the 95% confidence limits (P<0.05).

Conclusion

Overall, trial outcomes have identified that for the 2019 winter cropping season the Nigella variety Elite was best suited to the growing conditions experienced at the QDAF Walkamin research station, 20cm row spacing provided increased yield at time of harvest and that the application of Isoxaflutole, and S-metolachlor resulted in increased yields greater than that observed in both the variety by row spacing and the herbicide screening trials. To confirm these results further trial work is required in other regions of Nth Australia to ensure that the variety Elite is suitable to other regions, and the appropriate permits are obtained to allow for commercial application of identified herbicides.

A comparison of 3 varieties of Indian mustard (*Brassica juncea*) and four varieties of Carinata (*Brassica carinata*) within the Atherton Tablelands region of north Queensland as determined via yield at time of harvest.

Introduction

Over the 2019 winter cropping period varieties of Indian mustard (*Brassica juncea*) and Carinata (*Brassica carinata*) were compared to assess regional suitability with outcomes determined at time of harvest via yield (t/ha) and oil% from harvested seed which were compared with key growth stages and in crop measurements.

Indian mustard is a winter oilseed crop (Sharma et al., 2013.) that is grown globally for oil, as a condiment and as a leafy vegetable (Edwards et al., 2007). Within Australia the domestic market for Indian mustard is limited due to importation of seed for condiments and Canola (*Brassica napus*) being primarily grown for oil. It is perceived that Indian mustard has the potential to replace canola in certain situations due to increased levels of disease resistance and reduced in-crop water requirement, with the potential for further industrial applications post processing (Rapp, 2018). Carinata is another winter oilseed crop, it is native to Ethiopia where it was traditionally grown as a food source (Cardone et al., 2003). Considered to be tolerant to drought and associated high temperatures it is well suited to marginal cropping conditions and has spread globally for the purposes of food and oil production. Over recent years there has been increasing interest globally in for its use as a biofuel due to new varieties being bred for lower levels of saturated fatty acids and high levels of linoleic and erucic acids (Hagos et al., 2020).

To determine a crop and an associated varietal fit for northern Queensland, a trial was established comparing 3 varieties of Indian mustard and 4 varieties of Carinata at the Queensland Government Department of Agriculture and Fisheries (QDAF) Walkamin Research Station in the Atherton Tablelands region of Nth Qld. The climate of Walkamin is classified as sub-tropical with cool dry winters with the potential for frost. Average rainfall for the site is listed as 760mm, with majority of rainfall experienced between October and March (QDAF, 2017.). Soils of the QDAF site are deep ferrosols identified as being non-crusting and well-drained.

Methods

Across both trial sites granular fertiliser was applied prior to sowing and incorporated so as to achieve a soil nutrition status of: 120kg/ha Nitrogen, 30kg/ha Phosphorus, 100kg/ha Potassium and 2.5kg/ha Sulphur. Varieties were sown on the 23rd of May into 1.6m wide by 20m long beds, 3 rows per bed at 50cm spacing with each variety replicated 4 times. Sowing was conducted via a multi row Jang seeder tool bar with seed sown at an approximate depth of 15-20mm. Emergence was noted on the 27th of May, four days after sowing. Overhead irrigation was applied on a fortnightly basis, and in-crop investigation was conducted weekly to monitor flowering dates and determine occurrence of pests, weeds, and diseases. Date of flowering commencement and conclusion was recorded based upon visual assessment when 50% of individual plots were at either full flowering or completion of flowering. Broadleaf weeds were manually removed, and grass weeds and pests were controlled via application of on-label herbicide and pesticide. Height of individual varieties was recorded prior to harvest. Harvest was conducted by a Hege small plot harvester with timing of harvest based upon maturity and natural dry down of individual varieties. Post-harvest, seed achieved from each individual trial / trial plot was cleaned, extraneous matter removed, and the sample(s) weighed. Samples were then subsampled and then tested for oil (%) via a CROPSMART NIR oils analysis. Weight and oil% data was recorded and entered into Microsoft Excel. Data was analysed by QDAF biometric statisticians. Statistical models were created for the individual forms of herbicide tolerant canola using ASREML statistical analysis software. Resulting models were subjected to L.S.D post hoc pairwise analysis to determine significant difference at the 95% confidence limits (P=0.05).

Results and discussion.

Results show variation in duration and timing of flowering between crops and individual variety's within crop type. As seen in Table 1.,the Indian mustard varieties commenced flowering before Carinata varieties with both PREMS-S and RAPP flowering before SBF-H. Within Carinata varieties DH-157.509 flowered first and DH-129.B036 flowered last. Comparing number of days until conclusion of flowering (Table 1.) within crop type shows that for Indian mustard PREMS-S had the shorter duration of flowering and SBF-H had the longest, and for Carinata DH-157.509 had the shorter duration of flowering and DH-168.321 the longest. Comparison across crop types identifies that the Carinata varieties DH-157.509, DH-129.B036 and DH-146.842 had the shorter duration of flowering and the Indian mustard varieties RAPP and SBF-H the longer duration. Comparison of days to maturity (sowing date to date of harvest) (Table 1.) by crop type identifies that the Indian mustard varieties

PREMS-S and RAPP had the same length of maturity which was less than SBF-H and for Carinata DH-157.509 had a shorter duration of maturity than DH-168.321. Comparison between crops shows that the Indian mustard varieties PREMS-S and RAPP had a shorter time until maturity and the Carinata varieties DH-146.842 and DH-168.321 had the longer rate of maturity. Comparing plant height(s) (Table 1.) within crop type shows that the Indian mustard variety PREMS-S was the shorter cultivar and SBF-H the taller, and for Carinata DH-157.509 was the shortest variety and DH-168.321 the tallest. Comparing crop height across varieties identifies that the Indian mustard varieties PREMS-S and RAPP were the shortest and the Carinata varieties DH-146.842 and DH-168.321 the tallest. Yield (t/ha) results (Table 1.) at time of harvest by crop type and variety shows significant variation between varieties with the Carinata varieties DH-157.509 and DH-129.B036 achieving greater yield than all Indian mustards and Carinata variety DH-168.321; Carinata DH-146.842 recorded significantly greater yield than the Indian mustards PREMS-S and SBF-H; there was no significant difference between Indian mustard cultivars and Carinata DH-168.321. Oil% results (Table 1.) at time of harvest by crop type demonstrates significant differences across crop types and varieties. PREMS-S recorded significantly greater oil% than DH-129.B036 and DH-146.842 which were not significantly different from each other, these varieties achieved significantly more oil% than DH-168.321, RAPP and DH-157.509, which were not significantly different from each other and recorded significantly more oil than SBF-H which recorded lowest oil% amongst varieties. Pearsons correlation and regression analysis applied to Indian mustard shows a significant effect of plant height, duration of flowering and days to maturity upon oil% with increased height, and increased period of flowering and days to maturity resulting in reduced oil%. This was not observed for Carinata where no significant effect of plant height, duration of flowering and days to maturity upon both yield and oil% was observed.

Conclusion

Trial results have identified that for the 2019 winter cropping period at the QDAF Walkamin research station the Carinata varieties DH-129.B036 DH-146.842 DH-157.509 produced greater yield outcomes (t/ha) and the Indian mustard variety PREMS-S produced greater oil%. When both yield and oil% outcomes are compared the Carinata varieties DH-129.B036 and DH-146.842 can be viewed to have produced both greater yield and increased oil%. Across the individual varieties of Carinata and Indian mustard trialled, Carinata varieties were not susceptible to duration of flowering, plant height and days till maturity unlike the Indian mustard where these factors significantly affected oil% which can be observed to be variety specific. When Carinata trial results are compared with Canola trial established over the same period and location, relatively comparable results were achieved. Further trial work confirming the suitability of Carinata across the different climatic regions and farming systems experienced in Nth Australia will provide greater insight as to its potential as an option for commercial cropping.

Table 1. CRCNA developing an oilseeds industry for northern Australia. 2019 Carinata and Indian mustard variety comparison trial. Crop by variety by date of flowering commencement and conclusion, flowering duration (days), date of harvest, days to maturity (date of sowing to date of harvest) and average crop height (cm), yield (tonnes per ha) and oil% at time of harvest.

Crop	Variety	Commence flowering	Conclude flowering	Flowering duration	Date of harvest	Days to maturity	Height (cm)	Yield (t/ha)	Oil%
Carinata	DH-129.B036	30/07/2019	1/09/2019	37	3/10/2019	118	152.50	1.54 a	38.67 b
	DH-146.842	28/07/2019	2/09/2019	46	17/10/2019	118	167.50	1.32 ab	36.63 b
	DH-157.509	26/07/2019	22/08/2019	53	30/09/2019	138	145.00	1.54 a	28.85 c
	DH-168.321	28/07/2019	4/09/2019	27	17/10/2019	130	157.50	0.58 bc	31.48 c
Indian mustard	PREMS-S	11/07/2019	17/08/2019	35	18/09/2019	147	105.00	0.74 c	43.7 a
	RAPP	11/07/2019	26/08/2019	38	18/09/2019	147	161.25	0.66 bc	30.15 c
	SBF-H	15/07/2019	6/09/2019	33	8/10/2019	133	172.50	0.47 c	8.97 d

Note: numbers followed by different letters are significantly different at the 95% confidence limits (P<0.05).

A comparison of 16 varieties of carinata and 4 varieties of canola within the Atherton Tablelands region of Nth Qld, as determined at time of harvest.

Introduction

For the 2020 winter cropping period a trial was established to compare the performance of new varieties of carinata and established canola cultivars.

Previous trial work conducted in 2019 comparing Carinata (*Brassica carinata*) and Indian mustard (*Brassica juncea*) demonstrated that Carinata was better suited to the Atherton tablelands region of Nth Qld with yields of up to 1.54 t/ha achieved at time of harvest compared to Indian mustard which achieved a maximum yield of 0.74 t/ha. There is considerable global interest in Carinata as a biofuel due to lower levels of saturated fatty acids and high levels of linoleic and erucic acids (Hagos et al., 2020) resulting in a high-quality fuel. Due to the potential economic value of Carinata, breeding programs have been established to develop new varieties with increased yield and oil content. As a biofuel Carinata can attract a premium price as long as it is grown under defined conditions; it must not replace an existing food crop, and fertiliser used to grow the crop must be environmentally friendly. It is seen that the Nth Qld sugarcane growing regions can fulfill this requirement as sugarcane is not classified as a food crop and mill mud, a by product of the sugar milling process, is considered an environmentally friendly fertiliser (B. Whittaker pers com, 2021). Due to the development of new varieties of Carinata and the demonstrated fit for Nth Qld sugarcane growing regions a trial was established over the 2020 winter cropping period in the locality of Biboorah to assess the performance of new varieties of Carinata, determined via yield (tonnes per ha) (t/ha) at time of harvest. Located within the Atherton Tablelands of Nth Qld Biboorah is dominated by summer rainfall and dry mild winters. The trial site was in a period of extended fallow following a 2019 sugarcane harvest.

Methods

Site preparation occurred on the 20th of May via cultivation and application of fertiliser at 123kg/ha of nitrogen, 26kg/ha of phosphorus, 63kg/ha of potassium, and 14kg/ha of sulphur. Fertiliser was worked in via a rotary hoe to 10cm depth and 1.3m wide beds were formed at 1.8m spacing - centre to centre. In preparation for sowing irrigation was applied via furrow irrigation. Sowing occurred over the 1st and 2nd of June 2020 using a Jang planter toolbar configuration. Trial design was 20 varieties replicated 4 times with each variety / treatment sown into individual beds at 7 rows per bed at 16.7cm row spacing. Included in the trial were 4 varieties of Canola to provide a benchmark. Visual in crop monitoring was used to determine: requirement for irrigation, crop condition and pest and disease pressure. Harvest occurred on approx. 30th of September via a Hege small plot harvester following natural crop dry down. Seed from each individual plot was cleaned and weighed with resulting data entered into Microsoft Excel in preparation for data analysis.

Results and discussion

Visual inspection of Carinata over the course of the season identified limited pest pressure and increased growth when compared to the bench mark Canola varieties. Analysis results (Table 1.) demonstrate that the Carinata variety HYB095 achieved significantly greater yield (t/ha) than the Carinata varieties HYB064, DH-174.557, AGR159-4A1A, AAC A120, AVANZA 641, DH-146.842, and the Canola variety Nuseed Diamond; Carinata AVANZA 641 recorded significantly less yield (t/ha) than Carinata HYB095, HYB036, HYB089, DH-157.055, and DH-140.356; and DH-146.842 recorded less yield (t/ha) than HYB095, HYB036, HYB089, DH-157.055, DH-140.356, HYB096, HYB072, DH-157.894, DH-129.B036, HYB100, HYB064, DH-174.557, and AGR159-4A1A. Amongst Carinata varieties greatest yield (t/ha) was achieved by HYB095 and lowest yield by DH-146.842. Canola results show that only Nuseed Diamond achieved yield which was significantly less than all Carinata varieties. Comparison of 2020 trial results (Table 1.) with 2019 outcomes (Table 2.) show that a proportion of the new Carinata varieties achieved greater yields than those included in the 2019 Carinata trials. Included in both trials were DH-129.B036 and DH-146.842 with results showing that DH-129.B036 maintained similar yield across events however DH-146.842 yield declined in 2020.

Table 1. CRCNA developing an oilseeds industry for northern Australia. 2020 Carinata and Canola variety comparison trial. Crop by variety by yield (tonnes per ha) at time of harvest.

Crop	Variety	Yield (t/ha)
Carinata	HYB095	2.31 a
	HYB036	2.01 ab
	HYB089	1.81 ab
	DH-157.055	1.75 ab
	DH-140.356	1.71 ab
	HYB096	1.67 abc
	HYB072	1.63 abc
	DH-157.894	1.63 abc
	DH-129.B036	1.60 abc
	HYB100	1.59 abc
	HYB064	1.54 bc
	DH-174.557	1.47 bc
	AGR159-4A1A	1.44 bc
	AAC A120	1.28 bcd
	AVANZA 641	0.94 cd
	DH-146.842	0.52 d
Canola	Nuseed Diamond	0.34 e
	Nuseed Quartz	0.00 NA
	Pioneer 44Y90 CL	0.00 NA
	Pioneer 45Y91 CL	0.00 NA

Note:

Numbers followed by different letters are significantly different at the 95% confidence limits ($P<0.05$).

NA = not applicable.

Table 2. CRCNA developing an oilseeds industry for northern Australia. 2019 Carinata yield (tonnes per ha) (t/ha). Variety by yield (t/ha) at time of harvest.

Crop	Variety	Yield (t/ha)
Carinata	DH-129.B036	1.54 a
	DH-146.842	1.32 ab
	DH-157.509	1.54 a
	DH-168.321	0.58 bc

Numbers followed by different letters are significantly different at the 95% confidence limits (P<0.05).

Conclusion.

Trial results have shown that selected new varieties included in the 2020 trial achieved greater yield than what was observed in the 2019 trial indicating a successful outcome of the breeding program. To fully determine the fit for Carinata within a sugarcane farming system further investigation into varietal performance across the different sugarcane growing regions of Nth Qld would provide greater insight as to crop outcomes under different climatic conditions and farming systems. So as to achieve the full price premium for harvested seed, an understanding as to the benefit or disadvantages of using mill mud as the sole source of crop nutrition should also be further investigated.

An investigation in to the effect of plant population density upon 4 varieties of Linseed (Linum usitatissimum) within the Atherton Tablelands region of Nth Qld, as determined via yield at time of harvest.

Introduction

Over the 2019 winter cropping period a linseed (*Linum usitatissimum*) variety by plant population density trial was established to assess regional suitability and impact of planting density upon yield (t/ha).

As a global crop, linseed is grown for oil, food, and fiber with oil primarily used for industrial purposes and fiber traditionally used for production of household cloth and clothing, with individual cultivars bred for the specific purpose of either oil or fiber. Linseed is traditionally grown in cooler regions due to the impact of water stress and temperatures exceeding 32^{O}C negatively affecting crop height and associated yield potential (Zuk et al., 2015). Development of new varieties has focused upon resistance to disease, lodging and earlier maturation due to the negative effect of these factors upon oil: content, protein, and fatty acid composition (Nykter and Kymäläinen, 2006). As per most crops, linseed crop density affects yield outcomes which has been identified as being specific to region and climate (Ganvit, et al., 2019). To specifically determine a regional fit for linseed three varieties: Glenelg, Streeton, and McCubbin, were subjected to two planting densities: 10 plants per meter of row and 20 plants per meter of row with results determined via yield (t/ha) at harvest, with trial activities located at the QDAF Walkamin research station.

Methods

Trial establishment occurred on the 9th of May 2019. Prior to sowing a basal fertiliser application was applied across the site(s) and worked in to a depth of 10cm to provide the following nutrition: 120kg/ha Nitrogen, 30kg/ha Phosphorus, 100kg/ha Potassium and 2.5kg/ha Sulphur. Post sowing, irrigation was applied fortnightly via overhead sprinkler system. The trial site was comprised of plots which were 1.6m wide by 30m long with 5 rows at 25cm spacing. Variety by plant population treatments were replicated four times. Commencement of emergence was noted on the 13th of May or 4 days after sowing with thinning conducted on the 20th of May. Weekly in-crop observations were conducted to monitor occurrence of weeds, pests, and diseases and crop growth stage. Crop maturity was noted on the 27th of September with a dessicant applied on the 28th of September to assist with crop dry down. Harvest occurred on the 4th of October or 148 days after sowing via a Hege small plot harvester. Post-harvest, individual samples from each plot were sieved to remove extraneous matter then weighed. Yield data was entered into Microsoft Excel. Data analysis was conducted by QDAF statisticians. Statistical models were created using ASREML statistical analysis software. Resulting models were subjected to L.S.D post hoc pairwise analysis to determine significant difference at the 95% confidence limits (P=0.05) between: varieties, plant population density and interaction between variety and plant population density.

Results and discussion

Trial results (Table 1.) identified no significant difference between varieties or interaction between variety and plant population density. A significant effect was noted for density with the 20 plants per meter of row achieving significantly greater yield (t/ha) at time of harvest. Nominal comparison of varietal yield outcomes identifies that Streeton achieved highest yield across both plant population densities. This outcome confirms the results of previous linseed plant population density trial work where increased plant population density resulted in greater yield at time of harvest, whick is considered to be due to the increased number of plants producing a greater quantity of seed (i.e., Ganvit et al., 2019; and Andruszczak et al., 2015).

Conclusion

This trial has shown that for the three varieties of linseed trialled in 2019 at the Walkamin research station 20 plants per meter of row achieved significantly greater yield, and although not significant it can be viewed that the variety Streeton out yielded Glenelg and McCubbin. Further work investigating the different agronomic factors impacting upon yield should be investigated as should crop fit for the different agro-ecological regions experienced across the Nth Qld region.

Table 1. CRCNA developing an oilseeds industry for northern Australia. 2019 linseed variety evaluation by plant population density per meter of row. Average yield, tonnes per ha (t/ha) at time of harvest.

Variety	Plant population density	Average yield (t/ha)
Glenelg	10 b	1.35
	20 a	1.69
Total yield		**1.52**
McCubbin	10 b	1.38
	20 a	1.57
Total yield		**1.47**
Streeton	10 b	1.58
	20 a	1.96
Total yield		**1.77**

Note: numbers followed by different letters are significantly different at the 95% confidence limits (P=0.05)

The effect of row spacing by plant population density upon Camelina (***Camelina sativa***) within the Atherton Tablelands region of Nth Qld, **as determined by yield** at time of harvest.

Introduction

A Camilina (*Camelina sativa*) row spacing by plant population density trial was established over the 2019 spring cropping season to assess regional suitability and impact of planting density upon yield (t/ha). A member of the Brassicaceae family, Camelina is an oilseed crop that was historically grown in Europe as a food crop with planting now occurring in other countries such as Canada and America due to its tolerance to a range of seasonal planting dates, climates, and soil types and lower requirement for water, nutrients, and chemical forms of pest control when compared to other types of Brassica spp. (Moser, 2010). Recent research has identified its potential as a source of biofuel and or seed meal due to the composition of fatty acids (Gugel and Falk 2006), with yield and oil content seen to be affected by agronomic factors time of sowing and region (Urbaniak, 2008). To determine the suitability for Carinata within Nth Qld and the effect of plant population density, one variety of camelina was subjected to two row spacings by 3 rates of plants per meter of row over the 2019 spring cropping period at the QDAF Walkamin Agricultural research station with trial outcomes determined via yield at time of harvest (t/ha).

Methods

One standard variety of camelina was planted at 25 and 50cm row spacings with either 20, 40 or 50 plants per meter of row. Individual treatments dimensions were 1.6m wide beds by 8m long replicated four times. Sowing occurred on the 23rd of July and emergence was observed on the 27th of July or 4 days after sowing. Treatments were thinned to the required number of plants per meter of row on the 4th of June. Harvest occurred on the 30th October or 99 days from sowing.

Results and discussion

Trial results (Table 1.), identified no significant effect of row spacing, plant population density or interaction between row spacing and plant population density upon yield (t/ha) at time of harvest. As reviewed by Urbaniak et al., (2008) previous trial work has identified no significant impact of plant population density upon carinata yield with sowing date considered to have a greater influence, with previous trial outcomes nominating 300 plants per m^2 as suitable for camelina - a much higher number of plants per m^2 than applied in this trial. Achieved yield results may be considered to be comparable with the literature. As identified by Moser (2010) carinata commonly records yields ranging from 0.35 to 2.24 tonnes per ha, indicating then that for the 2019 spring cropping period camelina was shown to be a suitable crop for the Atherton tableland region of Nth Qld with increased yields potentially able to be achieved via an increased plant population density.

Table 1. CRCNA developing an oilseeds industry for northern Australia. 2019 Carinata regional evaluation by row spacing and plant population density per square meter. Average yield, tonnes per ha (t/ha) at time of harvest.

Row spacing	Plant population per m^2	Yield (t/ha)
25cm	20	0.76 a
	40	0.53 a
	50	1.05 a
25cm total average		**0.78 a**
50cm	20	0.55 a
	40	0.69 a
	50	0.56 a
50cm total average		**0.60 a**

Note: numbers followed by different letters are significantly different at the 95% confidence limits (P=0.05)

Conclusion

Results have identified that for the 2019 Walkamin spring cropping season Camelina was able to be successfully grown and taken to harvest with yield outcomes comparable with that experienced globally. Increased yields may be achieved via further increasing plant population density however this would need to be confirmed via further trial work as would the suitability of Camelina for other regions of Nth Qld.

Comparison of 4 sunflower cultivars (*Helianthus annuus.*) within the Lakeland region of far Nth Qld, as determined by yield at time of harvest.

Introduction

To determine a varietal fit for sunflowers (*Helianthus annuus*.) in Nth Queensland a trial was established within the Lakeland rural irrigation scheme, approximately 250km Nth of Cairns. The Lakeland irrigation scheme was established in the early 1900's and has been identified as a priority region for increasing diversity of agricultural cropping and rates of production (RDA, 2017). Considered a versatile crop, sunflowers can be planted early spring or late summer, are resistant to soil pathogens that affect cereals, sorghum, and chickpeas, provide options for in crop grass weed control and act as a soil conditioner due to a fibrous root system and deep tap root (Australian Sunflower Association, 2022). To assess varietal fit a trial was established over the 2020 summer cropping period comparing 4 varieties of sunflowers, with varietal selection based upon medium length of maturity, disease resistance and oleic oil content.

Methods

4 varieties of sunflower: Ausigold62, Ausistripe14, NHT271, and NHT265 were planted on the 19th of February 2020 via a replicated randomised plot design. Seed was sown into existing soil moisture at an approximate depth of 15-20mm via a multi row Jang seeder tool bar. Individual plots were 3 rows wide at 50cm spacing by 8m long. Harvest occurred following natural dry down, approximately 120days post sowing.

Results and discussion.

Analysis of trial outcomes identifies that Ausigold 64 achieved significantly less yield at time of harvest than Ausistripe 14 and the yield from NHT15M265 and NHT15M271 was not significantly different to either Ausigold 64 or Ausistripe 14. Nominally it can be seen that that Ausistripe 14 achieved the greater yield. This observed variation in yield between varieties is not unexpected, as demonstrated by Vinogradov et al., (2021), different varieties of sunflower are better suited to individual climates which is reflected in yield output. Although sunflower yield can vary between seasons, comparison of 2020 Lakeland summer yield outcomes with that of averaged northern NSW 2008 data (NSW DPI, n.d.) demonstrates that comparable yields were achieved.

Conclusion

This trial has shown that for the 2020 summer cropping period within the Lakeland rural irrigation scheme region sunflower was successfully be grown and taken to harvest with comparable yields achieved when compared to established sunflower growing regions of northern NSW and amongst the varieties trialed Ausistripe 14 achieved the greater yield.

Table 1. CRCNA developing an oilseeds industry for northern Australia. 2020 Lakeland sunflower varietal comparison, averaged yield, tonnes per ha (t/ha) at time of harvest.

Variety	Averaged yield (t/ha)
Ausigold 64	1.05 b
NHT15M265	1.23 ab
NHT15M271	1.30 ab
Ausistripe 14	1.55 a

Note: numbers followed by different letters are significantly different at the 95% confidence limits (P=0.05)

The impact of 4 different rates of Nitrogen upon Black Sesame (*Sesamum radiatum*) upon crop physiology and yield at time of harvest within the Mackay and Burdekin sugarcane growing regions of Nth Qld.

Introduction

New varieties of non-shattering sesame (*Sesamum spp*.) have been identified as having potential within a sugarcane fallow for both soil conditioning and providing an alternative source of farm income over the summer fallow period. With the forecast introduction of the Queensland Government nutrition guidelines for cropping in the Great Barrier Reef Catchment, there is need to identify appropriate Nitrogen (N) application rates that will provide optimal crop outcomes, whilst ensuring environmental stewardship. Sesame is traditionally grown external to Australia with Nigeria, Ethiopia and India identified as the largest global exporters. Currently, Australia imports all domestic sesame requirements. Global demand for sesame is forecast to increase due to increased consumption in Asia and increasing use in pharmaceutical products. Previously sesame harvest has been restricted to manual operation due to the potential for pod shattering and associated loss of seed via commercial harvest equipment, making commercial production in Australia economically unviable. However, new varieties of non-shattering sesame have been developed allowing for commercial harvesting. Investigation into the suitability of sesame as a crop for Australian conditions has identified it as having potential due to drought/temperature tolerance, appropriate climate, soil type(s), and a fit with existing commercial agricultural production systems (Reynolds and Robinson, 2021). The combination of increasing global demand, proximity to Asian markets, opportunity for domestic market supply, new varieties suitable for commercial harvest, and suitability to Australian growing conditions identifies sesame a crop of interest with previous trial work demonstrating a fit for sesame within sugarcane farming systems (i.e., CRCNA, 2021). Nitrogen (N) fertiliser is an essential aspect of maintaining agricultural production (Robertson and Vitousek, 2009), however with threshold values for applied rates of N in the Great Barrier Reef Catchment areas being introduced for cropping in 2024 (Qld Gov, 2021) there is the need to quantify the appropriate rates of applied N for sesame grown in regions within the Great Barrier Reef catchment areas so as to maintain environmental outcomes whilst achieving commercial viability of sesame cropping. To investigate optimal N inputs for sesame grown in Nth Qld sugarcane growing regions, two trials were established over the 2021 spring and summer cropping periods to investigate the response of Black Sesame (*Sesamum radiatum*) to three different rates of N. One trial was located in the Burdekin locality of Clare, and the other in the Mackay region locality of Walkerston. Based upon previous trial work conducted by Babajide and Oyeleke (2014), Burdekin N treatments were applied at 0kgN/ha (Control), 50kgN/ha 75kgN/ha, 100kgN/ha, and Mackay N treatments were applied at 0kgN/ha (Control), 75kgN/ha, 100kgN/ha, and 125kgN/ha; with treatment effect monitored via key aspects of crop morphology.

Methods

Trial site(s) were as per standard sugarcane farming system with raised beds at 1.6m spacing, upon each bed two rows were established at 40cm spacing. Trial design was replicated and randomised; Burdekin site treatments were replicated 6 times, with beds 15m long by 3 beds wide, Mackay site treatments were replicated 8 times with beds 12m long by 3 beds wide. The Burdekin site was established on the 18th of August as an early Spring planting and the Mackay site was established on the 24th of December as a summer planting. For the Burdekin, irrigation was applied via furrow irrigation and at Mackay irrigation was applied via overhead sprinkler. Prior to site(s) implementation soils analysis was conducted to assess the N status of the 0-20cm section of the soil profile. Based upon analysis outcomes rates of fertiliser were applied to achieve the desired soil N value. N was supplied using liquid Urea Ammonium Nitrate which was subsurface applied via a double disk opener applicator at approx. 10cm depth. Sowing was conducted one day post N treatment application via a Jang JD precision planter at a rate of 400,000 seeds per ha to achieve 20 plants per $m^{2.}$ N treatment effect was assessed at 8 and 16 weeks after sowing (WAS) and at time of harvest via yield. At the 8 WAS assessment, two random 1m sections of bed were selected from within each treatment / replicate were marked out and the total number of plants counted to provide information upon plant establishment. At both 8 and 16 WAS, 6 plants from within each 1m section were selected and stem girth at ground level, primary stem height and number of branches recorded. At 16WAS each 1m section of treatment was cut to ground level and dried until a consistent weight was achieved with data used to calculate dry biomass per ha. For the Mackay site, due to the increased stage of crop maturity, biomass samples were threshed, seed removed, and individual dry matter and seed individually weighed. From these figures Harvest index was calculated for each individual treatment via seed weight divided by dry biomass weight. Post 16WAS the crop was monitored for maturity and when 80% of seed pods had achieved dry down desiccant was applied. At full crop dry down the middle bed from each treatment and replicate was harvested via a KEW small plot header. Burdekin was harvested on the 18th of January and Mackay on the 9th of June. Seed from each individual treatment was cleaned of extraneous matter and weighed to achieve yield. Data was entered into Microsoft Excel in preparation for analysis. Statistical analysis was conducted by DAF biometric statisticians using ASREML analysis software Wald Chi squared test with significant differences between treatments identified at the 95% confidence limits (P>0.05).

Results and discussion

Burdekin trial outcomes at both 8WAS, 16WAS monitoring events and at time of harvest identified no significant differences between N treatments. Viewing the data at the nominal level (Table 1.), identifies that at 8WAS monitoring event 75kgN/ha recorded greatest stem girth and 50kgN/ha recorded the greatest number of branches and stem height. For the 16WAS monitoring event 100kgN/ha recorded greater stem girth and number of branches and the 75kgN/ha recorded greater stem height. Dry biomass results identified minimal difference between the 50kgN/ha and 75kg/ha treatments which achieved greater dry biomass (t/ha) than the 0kgN/ha and 100kgN/ha treatments. At harvest 75kgN/ha recorded greatest yield (t/ha). Due to these outcomes, it can be perceived that the 75kgN/ha provided increased trial results.

Mackay trial results identify no significant effect of N treatment for 8WAS and 16WAS monitoring events, dry biomass (t/ha), harvest index or for yield(t/ha) at time of harvest. Nominal data outcomes (Table 2.) show that at the 8WAS event the 125kgN/ha treatment achieved greatest no of branches and primary stem height and the 0kgN/ha treatment recorded the greatest stem girth. At the 16WAS event 100kgN/ha recorded greatest stem girth, 75kgN/ha greatest number of branches, and the 0kgN/ha recorded greatest primary stem height. Dry biomass (t/ha) results identify that 100kgN/ha achieved greatest dry biomass. Harvest index and Yield (t/ha) at time of harvest show that the 125kgN/ha rate achieved nominally greater outcomes. Based upon the increased Harvest index and yield outcomes it can be perceived that the 125kgN/ha treatment achieved greater trial results.

Comparison of in-crop weather statistics received at both the Burdekin and Mackay sites provides a possible explanation as to why the 125kgN/ha resulted in greater yield for Mackay and the 75kgN/ha achieved greater yield for the Burdekin. As shown by Saboury et al., (2021), increasing both water and nitrogen inputs for sesame translate into increased yield. As seen in Table 3., Mackay received total in-crop rainfall of 760mm, and total evaporation of 1142.6mm, conversely the Burdekin received 375mm of rainfall and a total of 1236.2mm of evaporation. Although both crops received supplementary irrigation, it is possible that the greater availability of water and reduced evaporation for the Mackay site enabled the crop to effectively use the higher rate of 125kgN/ha which was translated into yield. Conversely the reduced amount of in-crop rainfall and increased evaporation received at the Burdekin meant that a maximum of 75kgN/ha was able to be effectively taken up by the crop and used for seed production.

Nominal comparison of trial results by site (Tables 1 and 2.) shows that the Mackay site achieved greater stem height at both 8WAS and 16WAS and yield (t/ha), and the Burdekin site recorded increased 16WAS stem girth and 8WAS and 16WAS number of branches; with variation noted between sites for 8WAS stem girth and dry biomass (t/ha). These outcomes may be due to varying factors such as time of sowing, soil type or condition, climate, farming system and water supplied via both irrigation and in-crop rainfall. In trial work conducted by El Mahdi et al., (2007) earlier sown sesame resulted in increased branching and reduced yield when compared to later sown sesame, and as identified by Bennett (2007), the optimum time of sowing in Qld for sesame is mid-December. Consequently, the increased no of branches observed in the Burdekin and the greater yield observed for Mackay may have been influenced by the time of sowing. The greater stem height for Mackay observed at both 8WAS and 16WAS may be a factor of water supplied via irrigation and in-crop rainfall. As identified by Sarkar et al., (2010), water inputs strongly influence sesame stem height. Over the Mackay trial period a total of 760mm was received in comparison to the Burdekin that received a total of 375.8mm, although irrigation was maintained at both sites the combination of reduced in-crop rainfall, and increased evaporation and solar radiation (Table 3.) achieved at the Burdekin site would have resulted greater crop water demand with an associated effect upon stem height. The observed total amount of rainfall and reduced evaporation received at Mackay may have been a further influencing factor upon the greater yield results obtained for this site.

Conclusion

Trial outcomes have demonstrated variation in optimal N application rate between Burdekin and Mackay black sesame trial sites with the potential for optimal N uptake possibly influenced by time of sowing and in-crop climatic conditions such as rainfall and evaporation. Where water was not a limiting factor the increased rate of N at 125kgN/ha was seen to translate to yield, however where water was a limiting factor a lower rate of 75kgN/ha was seen to achieve greater/statistically comparable yield outcomes when compared to N applied at the greater rate. Further trial work under controlled conditions would provide greater elucidation for these results.

Table 1. CRCNA developing an oilseeds industry for northern Australia. Burdekin black sesame nitrogen trial. 8 and 16 weeks after sowing (WAS) averaged: stem girth(mm), number of branches, primary stem height(mm) dry biomass (tonnes per ha) (t/ha) and seed yield at time of harvest (t/ha).

Treatment	8WAS stem girth (mm)	16WAS stem girth (mm)	8WAS no of branches	16WAS no of branches	8WAS primary stem height(mm)	16WAS primary stem height(mm)
0kgN/ha	13.56	16.92	8.31	5.78	559.44	945.39
50kgN/ha	13.22	16.33	8.92	5.56	572.78	963.61
75kgN/ha	14.18	18.15	8.50	6.42	554.31	1022.11
100kgN/ha	14.03	18.67	8.42	7.14	554.44	1014.11

Note: numbers followed by letters are significant at the 95% confidence limits ($P<0.05$)

Table 2. CRCNA developing an oilseeds industry for northern Australia. Mackay black sesame nitrogen trial. 8 and 16 weeks after sowing (WAS) averaged: stem girth(mm), number of branches, primary stem height(mm) dry biomass (tonnes per ha) (t/ha), harvest index, and seed yield at time of harvest (t/ha).

Treatment	8WAS stem girth (mm)	16WAS stem girth (mm)	8WAS no of branches	16WAS no of branches	8WAS primary stem height(mm)	16WAS primary stem height(mm)	Dry biomass (t/ha)	Harvest index	Yield (t/ha)
0kgN/ha	13.85	12.48	2.35	2.56	1173.35	1250.44	4.71	0.33	1.58
75kgN/ha	13.40	13.65	2.50	2.88	1201.98	1221.77	5.32	0.30	1.58
100kgN/ha	12.88	14.04	2.33	2.65	1171.10	1239.52	5.42	0.32	1.73
125kgN/ha	13.79	13.08	2.60	2.73	1218.00	1233.56	5.31	0.35	1.83

Table 3. CRCNA developing an oilseeds industry for northern Australia. Mackay and Burdekin black sesame nitrogen trial(s). Total: rainfall(mm), evaporation(mm), radiation (MJ/m^2) and averaged minimum and maximum temperature by month and total value.

Site	Month	Rainfall (mm)	Evaporation (mm)	Radiation (MJ/m^2)	Average minimum temperature (C^0)	Average maximum temperature (C^0)
Mackay	December	156.2	219.7	677	23	31
	January	51.2	206.4	628	23	32
	February	98.7	180.6	551	23	31

	March	92.3	199.4	592	23	31
	April	192.7	151	383	21	28
	May	167.1	113.4	331	19	26
	June	1.8	72.1	293	12	23
	Total	760	1142.6	3456	21	29
Burdekin	August	72.5	151	497	15	28
	September	0.3	194.9	580	17	29
	October	31.5	233.6	709	22	34
	November	81.5	219.6	607	23	32
	December	102.5	230.1	667	23	33
	January	87.5	207	642	24	34
	Total	375.8	1236.2	3702	21	32

An investigation into the suitability of 8 varieties of soybean (*Glycine max*) within 4 regions of Nth Qld, as determined by yield at time of harvest for the 2019-2020 summer cropping period.

Introduction

A series of trials were conducted over the 2019-2020 summer cropping season to assess the regional suitability of commercial lines of soybean (*Glycine max*) within individual regions of Nth Queensland. Soybean is grown globally for a multitude of purposes including green manure, forage, crop nitrogen inputs, protein, and oil, with the volume of oil obtained from soybean seed globally exceeding that of all other crops (Singh and Hymowitz, 1999). Within Australia, substantial work into breeding new varieties suited to Australian conditions has been conducted by the Commonwealth Scientific and Industrial Organisation (CSIRO) with the view to improving both yield and grain quality (James, 2017). As identified by Naeve and Huerd (2008) an individual regions climate has a strong affect upon soybean seed quality, with individual varieties better suited to specific regions (GRDC, 2016). To determine a regional best fit, eight varieties of soybean were trialed at four Nth Queensland localities with trial outcomes determined via yield: tonnes per hectare (t/ha) at time of harvest. Variety and location(s) are presented in Table 1.

Table 1. CRCNA developing an oilseeds industry for northern Australia. 2019_2020 Soybean variety by North Queensland trial location.

Location(s)	Variety(s)
Walkamin	A6785
Lakeland	Hayman
Cairns	Kuranda
Innisfail	Leichardt
	Mitchell
	Mossman
	O-1375
	Stuart

Methods

Trials were sown as per a replicated randomised trial design using cooperative grower commercial equipment with row spacing and number of rows per individual treatment, matched to the commercial situation. Each variety was replicated four times per individual location. Planting time by individual site varied between November 2019 and January 2020 subject to site availability, grower, and rainfall. Site specific information is provided in Table 2.

Table 2. CRCNA developing an oilseeds industry for northern Australia. 2019_2020 Soybean variety by North Queensland trial location. Site by planting date, treatment dimension(s) and irrigation management.

Site	Planting Date	Treatment by Row Spacing	Management
Walkamin	27th November	4 rows @ 25cm	Sprinkler Irrigation
Lakeland	21st December	2 rows @ 82cm	Centre Pivot
Cairns	31st December	2 rows @ 60cm	Rainfed
Innisfail	15th January	2 rows @ 60cm	Rainfed

Results and Discussion

Analysis results for all sites combined identified a significant effect of site, variety, and a significant interaction of site by variety upon yield at time of harvest (t/ha). Due to the noted interaction between site and variety a combined interpretation of outcomes is provided in Table 3. Variety by site interpretation demonstrates that at the Walkamin site significantly greater t/ha of grain was achieved for Mossman and Mitchell; Leichardt and Stuart grown at Walkamin, Cairns, and Lakeland achieved significantly more t/ha than Leichardt and Stuart grown at Innisfail; Kuranda and Hayman grown at Cairns and Walkamin achieved significantly more t/ha than Kuranda and Hayman grown at Innisfail; O-253-1 grown at Lakeland achieved significantly more t/ha than O-253-1 grown at Innisfail; and there was no significant differences in yields observed across sites for A6785. Viewing trial outcomes at the nominal level shows that Walkamin achieved the highest yield followed by Cairns then Lakeland and Innisfail which recorded lowest yield. By variety Mossman recorded highest yield, followed by Mitchell, Leichardt, Stuart, Kuranda, Hayman, O-253-1, and A6785 which recorded lowest yield.

Outcomes from the variety by combined site analysis indicate that trial outcomes were most likely impacted upon by time of sowing and an associated effect of water and solar radiation. In trials conducted by Ram et al., (2010) delayed sowing resulted in reduced yield considered to be due to the influence of solar radiation upon flowering and timing of maturity, and as shown by Karam et al., (2005) water supply at key growth stages significantly affects yield. The lower yields recorded at Innisfail may be considered to be due to the combination of the later sowing date, high levels of rainfall and reduced rates of evaporation and solar radiation. As shown by Eriksen, and Whitney, (1984) reduced sunlight (solar radiation) reduces soybean yield, and as shown by Linkemer et al, (1998) water logging in late planted soybean also reduces yield. Table 7., shows that Innisfail recorded lowest total amount of solar radiation, evaporation, and highest rainfall. By comparison Cairns recorded second highest yield and was planted 15 days prior to Innisfail, however this site had approximately: 180mm less rainfall, 100mm greater evaporation and 435ML/m^2 more sunlight. The outcomes for both Walkamin and Lakeland may be considered due to watering regimes combined with the climatic variables. Both these sites were irrigated and received less in-crop rainfall than both Cairns and Innisfail. Lakeland received 2nd lowest yields which may be due to the highest average maximum temperature and rate of evaporation, and second highest level of solar radiation (Table 7.) resulting in an increased crop water demand which may not have been supplied. By comparison Walkamin recorded highest yields, had 2nd highest average maximum temperature and rate of evaporation and highest rate of solar radiation, indicating that adequate irrigation was supplied enabling the crop to maximize the increased levels of solar radiation. Notably, without information regarding rates and timing of in-crop irrigation these explanations are tentative.

Analysis for variety by individual site shows for Walkamin (Table 4.) significant differences between varieties with Mitchell and Mossman recorded significantly higher yield(s) and A6785 and O-253-1 the lowest. For Cairns (Table 5.), Leichardt recorded significantly greater yield than Hayman, O-253-1, and A6785, there was no significant difference in yield between Leichardt, Mitchell, Mossman, and Stuart, and A6785 and O-253-1 recorded significantly lower yield when compared to the other varieties. Lakeland results (Table 6.), identify that Leichardt achieved significantly greater t/ha than all varieties excluding Mitchell, Mossman, and Stuart, and

A6785 recorded significantly lower yield. For Innisfail no significant differences between varieties were noted however nominally it can be seen that Mitchell recorded highest yield and O-253-1 the lowest. Across sites it can be perceived that outcomes are primarily demonstrating that the varieties with the larger biomass outperformed the smaller biomass plants. For example, across sites Mossman recorded higher yields than A6785. A6785 is a smaller plant that is known to provide reduced yield when compared to other soybean varieties but is grown due to high demand and premium price. In comparison Mossman provides high biomass and consequently the potential for increased yield.

Table 3. CRCNA developing an oilseeds industry for northern Australia. 2019_2020 Soybean variety by North Queensland trial location. Site by soybean variety and average yield, tonnes per ha (t/ha) at time of harvest.

Site	Variety	Average Yield (t/ha)
Innisfail	O-253-1	500 a
Lakeland	A6785	664 ab
Innisfail	Stuart	670 abc
Innisfail	Hayman	960 abcd
Innisfail	Leichardt	1180 abcde
Innisfail	Kuranda	1355 abcde
Cairns	A6785	1458 abcdef
Walkamin	A6785	1620 abcdefg
Walkamin	O-253-1	1727 abcdefgh
Innisfail	Mossman	1827 abcdefghi
Cairns	O-253-1	1847 abcdefghij
Innisfail	Mitchell	1933 abdefghijk
Lakeland	Hayman	2086 acdefghijkl
Lakeland	Kuranda	2306 efghijklm
Lakeland	O-253-1	2367 efghijklmn
Walkamin	Hayman	2493 fhijklmno
Cairns	Hayman	2803 hiklmnop
Walkamin	Kuranda	2918 jklmnop

Lakeland	Stuart	3152 ijklmnopq
Cairns	Mossman	3219 lmnopq
Cairns	Kuranda	3312 lmnopq
Lakeland	Mossman	3326 lmnopq
Lakeland	Mitchell	3334 lmnopq
Cairns	Stuart	3448 lmnopq
Walkamin	Stuart	3502 mnpq
Cairns	Mitchell	3513 lmnopq
Lakeland	Leichardt	3687 nopqr
Cairns	Leichardt	4228 qr
Walkamin	Leichardt	4687 r
Walkamin	Mitchell	5795 s
Walkamin	Mossman	6345 s

Note: numbers followed by different letters are significantly different at the 95% confidence limits (P=0.05).

Table 4. CRCNA developing an oilseeds industry for northern Australia. 2019_2020 Soybean variety by North Queensland regional assessment. Walkamin site by soybean variety and average yield, tonnes per ha (t/ha) at time of harvest.

Variety	Averaged yield (t/ha)
Mossman	6.34 a
Mitchell	5.8 a
Leichardt	4.8 b
Stuart	3.5 c
Kuranda	2.91 cd
Hayman	2.49 d
O-253-1	1.73 e
A6785	1.62 e

Note: numbers followed by different letters are significantly different at the 95% confidence limits (P=0.05).

Table 5. CRCNA developing an oilseeds industry for northern Australia. 2019_2020 Soybean variety by North Queensland regional assessment. Cairns site by soybean variety and average yield, tonnes per ha (t/ha) at time of harvest.

Variety	Averaged yield (t/ha)
A6785	1.46 c
Hayman	2.80 b
Kuranda	3.31 ab
Leichardt	4.23 a
Mitchell	3.51 ab
Mossman	3.22 ab
O-253-1	1.85 c
Stuart	3.45 ab

Note: numbers followed by different letters are significantly different at the 95% confidence limits (P=0.05).

Table 6. CRCNA developing an oilseeds industry for northern Australia. 2019_2020 Soybean variety by North Queensland regional assessment. Lakeland site by soybean variety and average yield, tonnes per ha (t/ha) at time of harvest.

Variety	Averaged yield (t/ha)
A6785	0.66 d
Hayman	2.09 c
Kuranda	2.31 bc
Leichardt	3.69 a
Mitchell	3.33 ab
Mossman	3.33 ab
O-253-1	2.37 bc
Stuart	3.15 abc

Note: numbers followed by different letters are significantly different at the 95% confidence limits (P=0.05).

Table 7. CRCNA developing an oilseeds industry for northern Australia. 2019_2020 Soybean variety by North Queensland regional assessment. Innisfail site by soybean variety and average yield, tonnes per ha (t/ha) at time of harvest.

Variety	Averaged yield (t/ha)
Hayman	0.96
Kuranda	1.36
Leichardt	1.18
Mitchell	1.93
Mossman	1.83
O-253-1	0.5
Stuart	0.67

Note: numbers followed by different letters are significantly different at the 95% confidence limits (P=0.05).

Table 8. CRCNA developing an oilseeds industry for northern Australia. 2019_2020 Soybean variety by North Queensland regional assessment. Site by average: maximum and minimum temperature (Degrees Celsius), and sum of: rainfall (mm), evaporation (mm) and solar radiation (MJ/m2). 5 months from date of sowing.

Site	Average maximum temperature (oC)	Average minimum temperature (oC)	Sum of rainfall (mm)	Sum of evaporation (mm)	Sum of solar radiation (MJ/m2)
Cairns	30.92	22.63	1167.80	857.10	2446.50
Innisfail	30.85	22.86	1350.40	657.30	2011.10
Lakeland	34.64	22.63	599.00	1031.50	2793.50
Walkamin	31.20	20.53	534.40	935.40	2927.30

Source: https://www.longpaddock.qld.gov.au/silo/point-data/

Conclusion

Trial results have demonstrated that across regions climatic factors and appropriate rates of in-crop water effected soybean yield and that a relative consistency of varietal performance was observed across sites, with the larger biomass cultivars achieving greater yield than the reduced biomass cultivars. Further investigation into the effect of time of sowing by variety by individual region would provide further understanding into the effect of climate upon yield by specific variety.

A comparison of 8 varieties of soybean (*Glycine max*), as determined by yield at time of harvest, within the Lakeland region of far Nth Qld. 2020-2021 summer cropping period.

Introduction

Over the 2020-2021 summer trial period, a soybean (*Glycine max*) trial was established in the far Nth Qld locality of Lakeland to determine the varietal regional suitability of different soybean varieties whilst further comparing two new varieties of soybean. The trial was a continuation of previous work conducted over the 2019-2020 summer trial period where the commercially available soybean varieties: A6785, Hayman, Kuranda, Leichardt, Mitchell, Mossman, Stuart, and a new variety O-253-1, were compared via yield (t/ha) at time of harvest, with outcomes identifying that Leichardt, Stuart, Mossman, and Mitchell achieved the greater yields. To provide a definitive conclusion upon varietal suitability for the Lakeland district, due to the effect of varying climatic conditions experienced between growing seasons impacting upon trial outcomes, the trial was sown again excluding varieties A6785 and O-253-1 due to reduced yield outcomes, which were replaced with new varieties SC10-179-2 and Wincup.

Methods

The trial was sown on the 25th of January 2020 using a commercial 8 row John Deere max-emerge precision planter into existing sunflower stubble and appropriate soil moisture. Surrounding the site was a commercial field of Hayman soybeans. Prior to planting, fertiliser was applied via 50l/ha of ClearStart20 + Zinc. Soybean seed was inoculated with group H inoculant and allowed to dry prior to planting. Over the duration of the trial irrigation was applied via a centre pivot. Trial design for each variety / treatment was 2 rows 82cm apart by 15mtrs long replicated four times in a north south direction. In-crop monitoring was conducted to record growth stage and incidence of weeds, pests, and disease. Where incidence was noted, a score was applied ranging from: 1 nil crop damage to 5 full crop damage. Biomass samples were taken at R2 growth stage via cutting to ground level 2 * 50cm long sections of row from each individual soybean treatment. Samples from each individual treatment were combined and total wet weight recorded. Individual samples were then dried until cessation of moisture loss and dry weight recorded for the purpose of determining tonnes per hectare of dry biomass. At the time of biomass sampling representative samples from each treatment were measured to obtain main stalk height. Crop desiccation occurred on the 29th of May (124 days after sowing) to achieve crop dry down with harvest occurring on the 4th of June via a Hege small plot harvester. Samples from each individual treatment were cleaned of extraneous matter and weighed to obtain yield. Samples were then subsampled with subsamples dispatched to PB Agrifood for oil and protein analysis.

Results and discussion

Trial results referred to are presented in Table 1. In-crop inspections identified incidence of stem fly (*Melanagromyza sojae)* damage initially noted via crop lodging and confirmed via visual inspection of individual plants. Applied lodging scores, show that Hayman, Mossman, and SC10-179-2 recorded no damage; Kuranda, Leichardt, Mitchell, and Stuart recorded mid-range damage and Wincup recorded high levels of damage. Grouped dry biomass results by low medium and high values show that Kuranda recorded low t/ha, Hayman, Mitchell, Mossman, and SC100-179-2 recorded mid-range t/ha and Leichardt, Stuart and Wincup recorded high t/ha. Statistical analysis upon grain yield at time of harvest demonstrates significant differences between varieties with Leichardt recording significantly greater yield than Hayman and SC10-179-2. No significant difference in yield was noted between Leichardt, Mitchell, Mossman, Stuart and Wincup; or Hayman, Kuranda, Mitchell, Mossman Stuart, and Wincup. Leichardt recorded highest yield and SC10-179-2 the lowest. Statistical analysis upon Protein (%) results show that Stuart recorded significantly greater Protein than all varieties excluding Hayman which was not significantly different to Leichardt; there was no significant difference between Mossman, SC10-179-2, Leichardt, and Wincup; and there was no significant difference between Kuranda and Wincup. Amongst all varieties Stuart recorded highest Protein and Mitchell the lowest. Oil (%) analysis results show that Mitchell recorded significantly more Oil than all other varieties; Kuranda recorded significantly more Oil than all varieties excluding Mitchell; there was no significant difference in Oil% between Hayman, SC10-179-2 and Wincup; and there was no significant difference in Oil% between Leichardt, Mossman, and Stuart which amongst all varieties recorded lowest Oil%. Correlation and Regression analysis to determine relationship between Oil% and Protein% identifies for varieties that as Protein % increased Oil% decreased, with increased incidence of occurrence identified for Hayman and Stuart, with Stuart not significantly different to Leichardt and Mitchell which were not significantly different to the remaining varieties.

For the 2020-2021 trial year, results have shown that although displaying mid-range infestation by stem fly and moderate levels of oil%, Leichardt and Stuart were well suited to the Lakeland region for production of oil. Leichardt is primarily grown for biomass and associated nitrogen inputs, with the seed suitable for oil but not flour due to a dark hilum (NQTS,2014). As observed in Table 1. Leichardt achieved greater tonnes per ha of both dry biomass and tonnes of grain per ha and although oil% was low the increased tonnages received at time of harvest would compensate, with the increased biomass further providing increased nitrogen inputs for successive crops. Stuart and Wincup demonstrated increased versatility of cropping with increased yield and dry biomass – second to Leichardt, and increased protein%. Wincup is a new American variety with limited information available aside from being suitable for human consumption. Conversely Stuart is an established variety bred for Nth Tropical conditions that displays resistance to nematodes and pathogenic fungi. Due to the light hilum, it is acceptable for nominated human consumption purposes and is well suited for the oil crushing market (CSIRO, n.d.). As per Leichardt the increased yield (t/ha) would compensate for the reduced oil% and the increased dry biomass (t/ha) would provide increased nitrogen inputs for successive crops.

A consideration when determining the most appropriate variety based upon trial results is the potential impact of stem fly upon soybean, as at the time of this report no current permits for chemical control exist, with previous outbreaks in soybean having a negative effect upon crop outcomes (The Beatsheet, 2018). Should a serious outbreak occur varietal control may provide the only viable option (i.e., Patil et al., 2014). In this instance Hayman and Mossman can be seen to have achieved resistance to infestation whilst maintaining significantly comparable yield (t/ha), whilst Hayman achieved both greater protein and oil.

Conclusion

Trial results have demonstrated that the soybean varieties Leichardt and Stuart were well suited to the Lakeland district of Nth Qld over the 2020-2021 summer cropping period due to increased yield(t/ha) and dry biomass with Stuart demonstrating increased market versatility via suitability for human consumption due to the high levels of protein. Although both demonstrated low levels of oil% when compared to other varieties included in the trial the reduced the increased tonnes of grain achieved at time of harvest would compensate, with the observed levels of dry biomass providing further benefit via increased nitrogen inputs for successive crops. Notably both Leichardt and Stuart were moderately susceptible to stem fly infestation. Where seasonal conditions indicate potential for stem fly outbreak Hayman and Mossman demonstrated resistance. Across both 2019_2020 and 2020_2021 summer trial periods both Leichardt and Stuart demonstrated increased yield outcomes indicating that these varieties were better suited to the conditions experienced in the Lakeland district over these defined periods.

Table 1. CRCNA developing an oilseed industry for northern Australia. 2019-2020 Lakeland soybean varietal trial outcomes. Average dry biomass, tonnes per ha (t/ha); Yield at time of harvest, tonnes per ha (t/ha); Protein percentage (%); Oil percentage (%); Lodging score by variety, combined recorded applied lodging score; and Average plant height (cm).

Variety	End use	Dry biomass (t/ha)	Yield (t/ha)	Protein (%)	Oil (%)	Lodging	Average plant height (cm)	Significance of relationship between protein (%) and Oil (%) LSD****: (P>0.05).
Hayman	HC*	2.24	2.59 b	44.38 ab	21.88 c	0	86.75	a
Kuranda	HC	2.04	2.53 bc	41.00 ef	22.60 b	2	78.25	c
Leichardt	HC /GM***	2.63	2.98 a	43.23 bc	21.13 de	3	103.75	bc
Mitchell	SF**/GM	2.21	2.73 ab	40.28 f	23.50 a	4	89.75	bc
Mossman	HC/GM	2.32	2.76 ab	43.00 cd	20.48 e	0	81.25	c
SC10-179-2	HC	2.28	2.30 c	42.30 cd	21.83 c	0	86.5	c
Stuart	HC	2.60	2.79 ab	44.90 a	20.58 e	5	98.75	ab
Wincup	HC	2.62	2.78 ab	41.88 de	21.58 cd	8	94.5	c

Note: numbers followed by different letters are significantly different at the 95% confidence limits ($P<0.05$).

*HC: Human consumption.

**SF: Stock feed.

***GM: Green manure.

****LSD: Least Significant Difference

The effect of 4 different rates of sowing upon 4 soybean varieties (*Glycine max*) as determined via biomass sampling at key growth stages and yield at time of harvest within the Mackay sugarcane growing region over the 2020-2021 summer cropping period.

Introduction

Over the 2020-2021 summer trial period a soybean (*Glycine max*) trial was established in the Nth Qld Central sugarcane growing locality of Mackay to investigate the effect of sowing rate upon 3 new varieties of soybean which were compared with one established reference variety. Within a sugarcane summer fallow period soybeans are often included to provide benefit for the following sugarcane crop via a reduction of soil pathogens and provision of nitrogen (N) (Park et al., 2010) and providing an alternative income stream. Prior to the 2020-2021 summer trial period, new varieties of Sempra® herbicide tolerant soybeans were released allowing for the in-crop control of nutgrass (*Cyperus rotundus*) (Walker et al., n.d.), a weed that negatively effects cropping outcomes due to competition for water and nutrients (University of New England, 2019). As demonstrated by Walker et al., (2010) different varieties of soybean have an optimal sowing density which can impact upon yield at time of harvest. To determine optimal sowing density of the new varieties of soybean: New Bunya, Kuranda, and Mossman a trial was established comparing sowing rates of: 200,000, 250,000, 300,000 and 350,000 seeds per hectare with outcomes compared with Leichardt used as reference sp., due to it being an established variety commonly grown in the Central sugarcane districts.

Methods

Prior to site establishment soils analysis was conducted to determine crop nutritional requirements and potential soil constraints. To address soil acidity (<5.5w) lime was applied at 2.5t/ha. To address nutritional requirements fertiliser was applied at the following rates: nitrogen 20kg/ha, potassium 40kg/ha, Sulphur (S) 20kg/ha and molybdenum (Mo) 100g/ha. Raised beds were then formed in preparation for planting as per standard regional practice. Planting occurred on the 17th of December 2020, into an established soil moisture profile using the cooperating grower's "Covington" seeder box, with group H soybean inoculant applied to the seed prior to sowing. Trial design was a replicated randomised Latin square(s) with each variety by treatment replicated 4 times. Individual treatment sizes were 20 x 3 metre beds at 1.6m spacings, with 2 rows per bed at 40cm row spacing, orientated north south. Emergence of all varieties was noted 9 days post sowing, with Kuranda observed to be maturing at a faster rate - 2nd true leaf stage. Plant counts 2 weeks post sowing identified successful emergence for the individual varieties and correct establishment of the different seed/ha treatments. R1 (commence flowering) and R5 (commence pod fill) biomass samples were taken at the individual variety stage of maturity. Individual biomass samples were weighed, mulched, sub-sampled, weighed, and then dried until sample weight was consistent. Samples were weighed again, and from the resulting t/ha measure, dry biomass (tonnes per ha) was determined for each variety/treatment. Crop maturity was identified at 80% dry seed pods per plant, with desiccant applied at this stage. Harvest was conducted via a KEW small plot harvester with timing based upon individual variety timing of maturity. Post-harvest samples from each individual treatment were cleaned of extraneous matter and weighed to obtain yield. Samples were then subsampled with subsamples dispatched to PB Agrifood for oil and protein analysis. Data obtained was entered into Microsoft Excel and provided to DAF biometric statisticians.

Results and discussion

Combined variety by seeding rate(s) results (Table 1.), identify the following. R1 averaged biomass statistical outcomes show that Leichhardt and Mossman achieved significantly higher dry biomass (t/ha) than Kuranda which achieved significantly higher dry biomass (t/ha) than New Bunya. R5 averaged biomass results demonstrate that Leichhardt achieved significantly higher dry biomass (t/ha) than Kuranda and Mossman which were not significantly different from each other, and New Bunya recorded significantly less dry biomass (t/ha). Variety by total average yield at time of harvest identifies that, excluding Mossman and Kuranda, all varieties achieved significantly different tons of grain per ha (Table 1.). Yield by variety in decreasing order of yield was: Kuranda/Mossman > Leichardt > New Bunya.

Averaged protein% by variety shows that all varieties achieved significantly different results with outcomes viewed in the following order: New Bunya> Leichhardt>Mossman>Kuranda. Averaged oil% by variety identifies that Kuranda recorded significantly highest results, Leichhardt and Mossman were not significantly different from each other and recorded 2nd highest oil%, New Bunya recorded lowest oil%.

Analysis by individual variety has shown that as an oil seed crop Kuranda was the higher producing variety achieving both significantly greater tonnes per ha of grain at time of harvest and significantly greater proportion of oil. As a variety, Kuranda soybean is broadly adapted to a range of Nth Qld environments, has a high disease profile, and is suitable for high end human consumption markets such as oil, tofu, and full fat processing (Australian Oilseeds, n.d.). Although protein % was significantly lower than the other varieties included in the trial, the greater yield would provide compensation should increased protein attract a price premium. The significantly greater biomass achieved for Leichardt at both R1 and R5 growth stages is as expected as this variety is primarily grown within a sugarcane summer fallow due to its increased biomass and associated N inputs, with seed achieved suitable for the oil crushing market if taken to harvest (NQTS, 2014). Leichardt oil % and yield (t/ha) results demonstrate that Leichardt provides a viable option as an oilseed crop for the Central region with the associated benefit of increased N inputs. New Bunya results are as expected as it is a short season variety primarily grown for its protein levels, making it suitable for flour and tofu manufacturing (AOF, n.d.). In this trial the reduced period of growth can be seen to have translated into significantly reduced biomass at both R1 and R5, and the significantly greater protein% was expression of its genetic traits. Mossman results have identified this variety as an all-round performer shown via its comparable biomass at R1 with Leichardt, comparable yield with Kuranda, and mid-range oil% and protein%. Closely related to Leichardt, Mossman has a large biomass, is suitable for green manuring and if taken to harvest the grain is suitable for both oil crushing and human consumption (AOF, n.d.).

Individual variety by seeding rate analysis results are presented in Table 1. and identify the following results. Kuranda 200,000 seeds per ha achieved non significantly greater t/ha dry biomass at both R1 and R5 biomass sampling events. At time of harvest Kuranda was the only cultivar that showed a significant difference between sowing rates with 200,000 and 350,000 seeds per ha achieving significantly more t/ha of grain than 250,000 seeds per ha. No significant effect of sowing rate can be observed upon either protein and oil% however it can be noted that 350,000 seeds per ha achieved increased protein and reduced oil, and conversely 200,000 seeds per ha achieved greater oil and reduced protein.

Leichhardt results identify no significant effect of sowing rate upon at R1 and R5 dry biomass (t/ha) assessment, yield (t/ha) at time of harvest or protein or oil %. At the nominal level of assessment, at R1 350,000 seeds per ha recorded greatest biomass, and for R5, yield (t/ha) at time of harvest and protein% 250,000 seeds per ha achieved nominally greater outcomes. Oil% results show minimal variation with 200,000 and 350,000 seeds per ha seen to achieve increased results.

Mossman results identify at the R1 sampling event that 300,000 and 350,000 seeds per ha recorded significantly greater t/ha of dry biomass than 200,000 seeds per ha, and 250,000 seeds per ha was not significantly different to all sowing rates. No significant difference was recorded between sowing rates for R5, yield at time of harvest, Protein and Oil%. However nominally it can be observed that at R5 300,000 seeds per ha recorded increased t/ha of dry biomass, and at time of harvest 200,000 seeds per ha recorded increased yield and oil, but lower protein.

Across individual monitoring events New Bunya displayed no significant effect of the different sowing rates. Nominally it can be seen that at the R1 growth stage 350,000 seeds per ha achieved greater dry biomass, and for both R5 and yield (t/ha) at time of harvest 250,000 seeds per ha achieved greater results. Protein % results show that both 200,000 and 350,000 seeds per ha achieved greater outcomes, and for Oil% 300,000 seeds per ha achieved greater results.

For the varieties included in this trial although a lack of significant effect was often not observed a nominal relationship between variety, sowing rate, yield (t/ha), oil and protein% can be perceived. For Kuranda the reduced sowing rate of 200,000 seeds per ha resulted in increased oil% and 350,000 seeds per ha resulted in increased protein with no statistically significant differences in yield observed between the two sowing rates. Mossman results display a similar result where it can be nominally observed that 200,000 seeds per ha resulted in increased yield and oil% and the 350,000 seeds per ha achieved greater protein% with increased yield that was minimally greater than 250,000 and 300,000 seeds per ha. These results indicate that manipulation of Kuranda and Mossman to either the higher or lower sowing rates could facilitate an increase in either oil% or protein% whilst maintaining yield outcomes. For Leichardt a potential relationship can be observed between sowing rate, yield, and oil and protein% with both the 200,000 and 350,000 sowing rates achieving lower yield and increased oil%. In comparison the 250,000 and 300,000 rates achieved increased yield and protein%. Identifying that manipulation of sowing density to increase oil% would come at a penalty of yield. As Leichardt grain is primarily used for crushing, manipulating sowing rates to achieve increased yield would come at a yield penalty. New Bunya results by comparison identify a somewhat relative consistency between sowing rate, yield, oil, and protein% with 250,000 seeds per ha achieving greater yield, protein%, and increased oil%.

Table 1. CRCNA developing an oilseed industry for northern Australia. 2020-2021 Mackay soybean varietal by sowing rate trial outcomes. Average dry biomass, tonnes per ha (t/ha) at soybean reproductive stages R1 and R5; Yield at time of harvest, tonnes per ha (t/ha); Protein percentage (%); Oil percentage (%).

Variety	Seeds per ha	R1 dry biomass (t/ha)	R5 dry biomass (t/ha)	Yield (t/ha)	Protein %	Oil %
Kuranda	200,000	1.84	5.36	5.03 a	42.85	23.95
	250,000	1.74	4.83	4.48 b	42.87	21.73
	300,000	1.73	4.93	4.83 ab	42.85	21.60

	350,000	1.68	4.68	5.26 a	43.45	21.33
Kuranda total		1.75 b	4.95 b	4.90 a	43.04 d	22.27 a
Leichhardt	200,000	2.03	5.68	4.10	44.94	20.28
	250,000	2.07	6.01	4.35	45.10	20.13
	300,000	1.95	5.86	4.21	45.03	20.16
	350,000	2.12	5.70	4.14	44.88	20.28
Leichhardt total		2.04 a	5.81 a	4.20 b	44.98 b	20.21 b
Mossman	200,000	1.71 b	4.53	4.65	43.73	19.73
	250,000	1.95 ab	4.95	4.52	44.60	19.40
	300,000	2.11 a	4.99	4.57	44.50	19.55
	350,000	2.09 a	4.28	4.58	44.67	19.60
Mossman total		1.97 a	4.69 b	4.58 a	44.31 c	19.61 b
New Bunya	200,000	0.85	2.39	2.79	46.05	16.43
	250,000	0.86	2.66	3.03	45.98	16.88
	300,000	0.93	2.32	2.74	45.88	16.90
	350,000	0.96	2.31	2.52	46.05	16.60
New Bunya total		0.90 c	2.42 c	2.77 c	45.99 a	16.70 c

Note: numbers followed by letters are significantly different at the 95% confidence limits (P<0.05)

Conclusion

Comparison of varietal performance identifies that for the 2020_2021 summer soybean season shows that Kuranda achieved significantly greater oil% than all varieties, and statistically comparable yields to Mossman, greater than both Leichardt and New Bunya. Trial results comparing the impact of sowing rate have indicated an effect of, and potential relationship between, sowing rate upon yield protein% and oil% content that may be considered to be variety specific. However, due to the lack of significant differences (P<0.05) these observations are tentative.

The effect of 4 different forms of fungicide upon Anthracnose spp., colonisation of 2 soybean varieties as determined by incidence of pod infection and yield at time of harvest within the Mackay sugarcane growing region of Nth Qld.

Introduction

To determine the effect of preventative application of fungicide upon the fungal pathogen Anthracnose (*Colletotrichum spp.*) and its effect upon soybean (*Glycine max*) yield, a trial was established within the Central sugarcane growing region of Nth Qld over the 2021-2022 summer cropping season. Anthracnose is a fungal disease that is known to cause soybean yield losses of up to 100% in some situations (Subedi *et al*., 2015). Within a sugarcane summer fallow soybean has been identified as a key component of breaking the disease cycle of soil borne pathogens and providing nitrogen (N) inputs for the successive sugarcane crop (Park et al., 2010). For the Qld central and north coastal sugar cane growing regions the recommended date for sowing soybean is mid to late December (GRDC, 2016), however anecdotal evidence suggests that individual varieties of soybean sown during this timeframe are more susceptible to Anthracnose colonisation due to high levels of humidity and moisture experienced during the tropical monsoon season (Shannon pers com, 2021). To identify the effect of preventative fungicide application applied at key soybean growth stages upon Anthracnose infection of two varieties of soybean four different commercially available fungicides, 2 contact and 2 systemic, and a 0 treatment (control) were applied to two soybean varieties: Hayman and A6785 at key reproductive growth stages. A6785 was selected as it is an established variety that is known to be susceptible to Anthracnose infection and Hayman was chosen as it is commonly grown variety that although suffering loss to Anthracnose, displays increased resistance to infection.

Methodology

The trial was established mid-December 2021 into a representative sugarcane farming system. A randomised split plot trial design by variety (main plots) and treatment (sub plots) was established with 8 replications to ensure appropriate degrees of freedom allowing for robust statistical analysis of trial results. Raised beds were established at 1.6m spacings, and fertiliser was side dressed to each bed. Soybean was sown into existing soil moisture using commercial equipment at 250,000 seeds per ha, 2 rows per bed at 40cm spacings. Variety treatment dimensions were 3 beds wide by 70m long. Fungicide treatment dimensions were 3 beds wide by 15m long, with fungicide only applied to the middle bed, allowing for the external beds to act as a source of fungal inoculum. Fungicides were applied off label under an APVMA research permit at R1: commence flowering and R3: commence podding, via a handheld spray boom with nozzles at 50cm spacing. At R7: beginning maturity, pods were randomly selected from each treatment for each soybean variety and dispatched to Queensland Department of Agriculture and Fisheries (QDAF) plant pathology department for Anthracnose assessment. Harvest occurred on the 9th of July via a KEW small plot harvester. Seed achieved via harvest was cleaned of extraneous matter, weighed and subsequent weights recorded. Data was entered into Microsoft Excel in preparation for statistical analysis via R Studio. Yield data was analysed via Lme4 linear model analysis; analysis of deviance (Type II Wald chi square test), and post hoc analysis via General Linear Model at the 95% confidence limits. Anthracnose infection was assessed via a Fisher's exact test at the 95% confidence limits.

Results and discussion

Analysis upon incidence of pod infection by fungicide treatment (Table 1.), identified significantly greater infection in A6785, however no significant difference was observed between individual fungicide treatments for either variety. Nominal assessment of the data shows that Treatment 4, recorded reduced incidence of infection in A6785 and in Hayman Treatment 2, recorded reduced incidence of infection.

Analysis upon yield at time of harvest (t/ha) shows a significant treatment effect upon both varieties (Table 2.). For A6785 Treatments 1 and 4 achieved significantly greater yield (t/ha) than the Control treatment. For Hayman, Treatment 1 achieved significantly greater yield (t/ha) than the Control treatment.

Table 1. CRCNA developing an oilseeds industry for northern Australia. Mackay soybean variety by fungicide trial. Incidence of pod infection by fungicide treatment.

Variety	Treatment number	Treatment active	Incidence of infection
A6785	1	Prothioconazole + bixafen	7
	2	Chlorothalonil	5

	3	Mancozeb	7	
	4	Tebuconazole + azoxystrobin	4	
	5	Control	6	
Total				29 a
Hayman	1	Prothioconazole + bixafen	5	
	2	Chlorothalonil	2	
	3	Mancozeb	4	
	4	Tebuconazole + azoxystrobin	3	
	5	Control	3	
Total				17 b

Note numbers followed by different letters are significantly different at the 95% confidence limits (P<0.05).

The significantly greater incidence of pod infection observed for A6785 confirms previous information regarding A6785 increased susceptibility to Anthracnose (i.e., GRDC, 2020). Viewing the effect of treatment active by incidence of infection demonstrates for A6785 nominally greater control was achieved by Treatment 4. This outcome potentially builds upon work conducted by Qld DAF, where Treatment 4, has been issued a permit for use in Soybeans to control Anthracnose in Qld regions upon display of symptoms (APVMA, n.d.). The reduced A6785 pod infection achieved by Treatment 4 was translated into increased yield for A6785. A6785 harvest results further identify Treatment 1 as achieving significantly greater yield outcomes when compared to the control. Both Treatment 1 and 4 are systemic fungicides combining two forms/groups of chemistry (Bayer, n.d.; ADAMA, n.d.). Treatment 1 combines group 3: demethylation inhibitors and group 11: quinone outside inhibitors. Treatment 4 combines group 3, and group 7: succinate dehydrogenase inhibitors (CropLife, 2022). It is possible that the group 3 component had a greater impact upon yield and the group 7 component a greater impact upon expression of fungal pod colonisation, with Treatment 4., group 7 viewed to achieve greater fungal suppression at R7. This theory may be confirmed by Hayman outcomes where Treatment 1., recorded an increased incidence of pod infection yet achieved significantly greater yields when compared to the control. Although not significantly different to either the control or Treatments 2 and 3, it can be noted nominally that within Hayman Treatment 4 recorded 2nd highest yield outcomes.

Table 2. CRCNA developing an oilseeds industry for northern Australia. Mackay soybean variety by fungicide trial. Variety by area harvested, fungicide treatment, and yield (tonnes per ha) (t/ha) at time of harvest.

Variety	Treatment number	Treatment active	Yield (t/ha)
A6785	1	Prothioconazole + bixafen	1.59 a
	2	Chlorothalonil	1.29 ab
	3	Mancozeb	1.18 ab
	4	Tebuconazole + azoxystrobin	1.58 a
	5	Control	1.06 b
Hayman	1	Prothioconazole + bixafen	1.29 a
	2	Chlorothalonil	1.14 ab
	3	Mancozeb	1.13 ab

4	Tebuconazole + azoxystrobin	1.22 ab
5	Control	0.96 b

Note numbers followed by different letters are significantly different at the 95% confidence limits (P<0.05).

Conclusion

Trial results have confirmed soybean variety A6785 as displaying increased susceptibility to Anthracnose when compared to Hayman as shown via significantly increased levels of infected pods at R7; and the ability for both forms of systemic fungicides used in this trial to outperform the contact fungicides as shown via significantly greater yields when compared to the control for A6785 and Treatment 1 for Hayman. Results also potentially indicate an effect of group 3 fungicides upon increasing yield via fungal suppression with a further effect of group 7 fungicide upon reducing Anthracnose display upon pods at R7. Overall results identifying a benefit of preventative application of the systemic fungicides used in this trial when applied at R1 and R3 soybean reproductive growth stages. It is recommended that further work is conducted to confirm this outcome.

A regional comparison of E40R Safflower (Carthamus tinctorius), Carinata (Brassica carinata), and Indian Mustard (Brassica juncea) across the Atherton Tablelands, Far Nth, Burdekin and Mackay sugarcane growing regions.

Introduction

Over the 2019 winter cropping period individual trials were established in the Atherton Tablelands locality of Walkamin to assess the regional suitability, and impact of specific agronomic factors upon Carinata (*Brassica carinata*) E40R Safflower (*Carthamus tinctorius*) and Indian Mustard (*Brassica juncea*). Trial outcomes demonstrated that these crops had potential for commercial realisation, however further work was required to fully determine suitability to other regions as defined by climate, soil type and farming system. To address this, over the 2021 winter cropping period trials were established within the Far North, and Burdekin and Mackay sugarcane farming regions directly comparing the yield outcomes of each crop. Trial site description by location is provided in Table 1.

Table 1. CRCNA developing an oilseed industry for northern Australia. E40R Safflower, Carinata and Indian Mustard winter trial crop comparison. Region by climate description by soil type and farming system / site description.

Region	Climate	Soil type	Farming system / site description.
Far North	Wet tropic*	Alluvial plain****	Rainfed. 5 rows per treatment @ 25cm spacing. No cane trash retention.
Burdekin	Dry tropic**	Vertisol grey****	Furrow irrigation. High profile raised beds at 1.6m spacing. 2 rows per bed at 25cm spacing. 3 beds per treatment. No cane trash retention.
Mackay	Tropical***	Silty Sandiford: silty loam A horizon and a clay B horizon****	Supplementary irrigation (based upon crop stress) via overhead sprinklers. Low profile raised beds at 1.6m spacing. 2 rows per bed at 25cm spacing. 3 beds per treatment. No cane trash retention.
Walkamin	Sub-tropical*****	Ferrosol*****	Irrigation via overhead sprinklers (fortnightly). 6 rows per treatment @ 25cm spacing. No cane trash retention.

*Source: https://sites.google.com/site/geo121wikispring2012/home/wet-tropics-of-queensland-australia

**Source: http://www.bom.gov.au/climate/climate-guides/guides/022-Burdekin-QLD-Climate-Guide.pdf

***Source: http://www.bom.gov.au/qld/mackay/climate.shtml

****Source: https://qldglobe.information.qld.gov.au/

*****Source: https://www.daf.qld.gov.au/contact/offices/stations-facilities/walkamin

Methods

Prior to sowing 2021 winter trials, nutrition was applied based upon soils analysis, and cultivation occurred to provide a fine tilth so as to facilitate seed soil contact and to reduce weed populations. Excluding the Far Nth, irrigation was further applied prior to sowing so as to provide the required moisture levels to facilitate germination. All sites were sown via Jang JPH-U precision tractor mounted units. Sowing date by site is as follows: Far Nth 22/07/2021; Burdekin 10/05/2021; Mackay 01/06/2021. At each site replicated and randomised trial designs were implemented to ensure that statistically robust outcomes were achieved at the 95% confidence limits. Over the course of the trial period sites were monitored on a bi weekly basis to determine irrigation requirement (Burdekin and Mackay), general crop observations, and weed and pest pressure. As required herbicide and pesticides were applied using on-label products via commercial application equipment. Harvest was conducted by small plot harvesters with timing of harvest based upon the individual crops natural dry-down period and the recommended grain moisture content for oilseed crops of 8%. Harvest date by crop and location is provided in Table 2.

Table 2. CRCNA developing an oilseed industry for northern Australia. 2021 winter crop comparison. Region by crop and date of harvest.

Region	Crop	Harvest date
Far North	Carinata	17/11/2021
	Indian Mustard	02/11/2021
	Safflower	17/11/2021
Burdekin	Carinata	4/11/2021
	Indian Mustard	14/10/2021
	Safflower	18/10/2021
Mackay	Carinata	10/12/2021
	Indian Mustard	30/10/2021
	Safflower	22/11/2021

Results and discussion

For the 2021 winter cropping trial period, trial results (Table 3.) have shown that across all sites Safflower achieved significantly greater yield than Indian Mustard which achieved significantly greater yield than Carinata. Nominal assessment of crop yield(s) by site shows that the Burdekin achieved greatest yield outcomes for Safflower and Carinata and the Far Nth recorded greatest yield for Indian Mustard.

Table 3. CRCNA developing an oilseed industry for northern Australia. 2021 winter crop comparison. Carinata, Indian Mustard and Safflower Harvest index and yield at time of harvest (tonner per ha) (t/ha).

Region	Crop	Harvest index	Yield (t/ha)
Far Nth	Carinata	0 c	0 c
	Indian mustard	0.46 a	1.3 b
	Safflower	0.36 b	1.66 a
Burdekin	Carinata	0.06 b	0.27 c
	Indian mustard	0.26 a	0.89 b
	Safflower	0.25 a	1.72 a

Mackay	Carinata	0 c	0.23 c
	Indian mustard	0.04 b	0.95 b
	Safflower	0.25 a	1.59 a

Note: numbers followed by letters are significant at the 95% confidence limits (P<0.05).

Nominal comparison of trial outcomes between trial years identifies that in 2021 Safflower achieved reduced yields with a maximum of 1.72t/ha achieved in the Burdekin (Table 3.), compared to a maximum yield 3.15t/ha achieved in 2019 (Walkamin) (Table 4.). Carinata results display a similar reduction in yield between trial years with 0.27t/ha achieved in the 2021 Burdekin trial (Table 3.) and a maximum of 1.54t/ha achieved in 2019 at the Walkamin site (Table 5.). Indian mustard results demonstrate an increase in yields between years with 1.3t/ha recorded in 2021 for the Far Nth site (Table 3.) compared to a maximum yield of 0.74t/ha in 2019 at Walkamin (Table 5.).

Table 4. CRCNA developing an oilseeds industry for northern Australia. 2019 Atherton Tablelands (Walkamin) E40R safflower row spacing by plant density trial. Row spacing by plant density per 1m of row by averaged yield, tonnes per ha (t/ha) at time of harvest. Significance of treatment effect.

Row spacing	Yield (t/ha)	Plant density per 1m of row	Yield (t/ha)
25	3.05a	5	2.98a
50	2.69b	10	3.15a
		20	2.49b

Note: numbers followed by different letters are significantly different at the 95% confidence limits (P<0.05).

Table 5. CRCNA developing an oilseeds industry for northern Australia. 2019 Atherton Tablelands (Walkamin) Carinata and Indian mustard variety comparison trial. Crop by variety and yield (tonnes per ha) at time of harvest. Significance of treatment effect.

Crop	Variety	Yield (t/ha)
Carinata	DH-129.B036	1.54 a
	DH-146.842	1.32 ab
	DH-157.509	1.54 a
	DH-168.321	0.58 bc
Indian mustard	PREMS-S	0.74 c
	RAPP	0.66 bc
	SBF-H	0.47 c

Note: numbers followed by different letters are significantly different at the 95% confidence limits (P<0.05).

Determination of the factors that influenced trial outcomes between sites and across years may be considered to be primarily due to Farming system and variety as climatic factors by site and trial location shows a relative consistency in averaged monthly minimum and maximum temperature(^{0}C) (Figure 1.), and a relatively comparable pattern of rainfall and evaporation (Figure 2.).

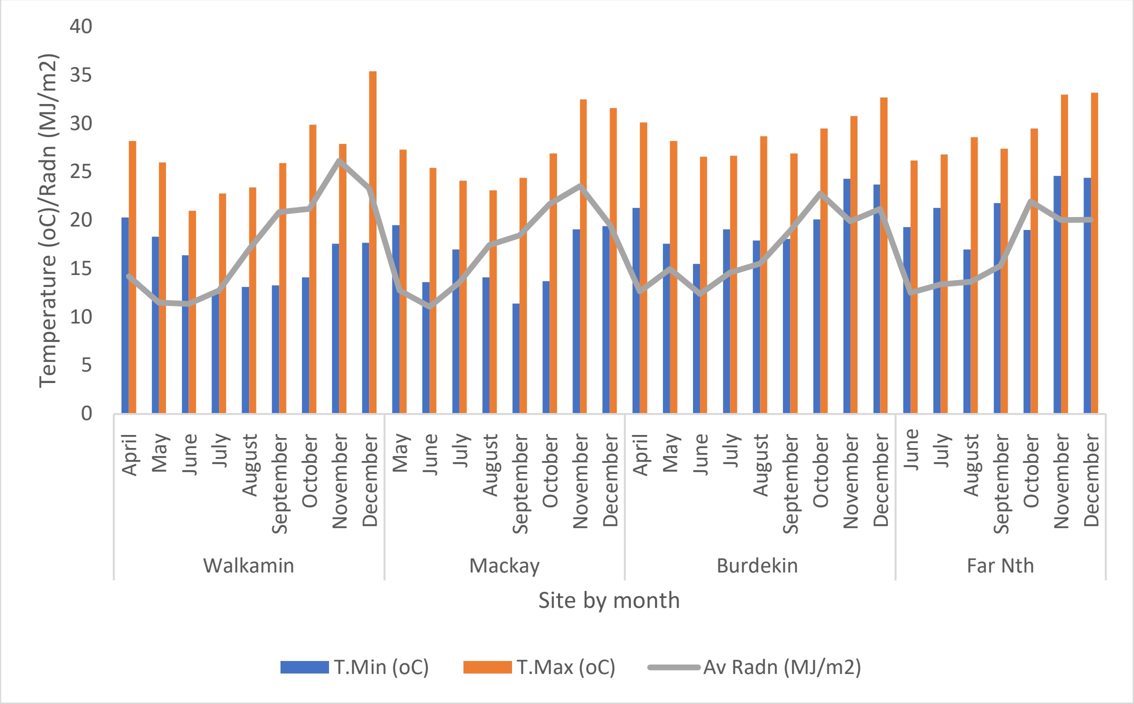

Figure 1. CRCNA developing an oilseeds industry for northern Australia. Averaged maximum and minimum temperature (0C) and solar radiation (MJ/m2) by month and site location.

Comparison of farming systems between sites (Table 1.) identifies that at both the Walkamin and Far Nth sites crops were sown at multiple rows at 25cm row spacing; i.e., Far Nth: 5 rows and Walkamin: 6 rows. In comparison both the Burdekin and Mackay were sown into a “traditional” sugarcane farming system: raised 60cm wide beds at 1.6m spacing with 2 rows applied at 25cm spacing per bed. As is demonstrated via the greater yields achieved for Safflower at the Walkamin site when compared to the other sites (Tables 3 and 4.) the increased number of rows per meter2 most likely resulted in the greater yield. This is further reflected in 2021 trial results (Table 3.) where Indian Mustard at the unirrigated Far Nth site achieved increased yield, and Safflower achieved comparable yield, when compared to both the Burdekin and Mackay irrigated sites.

Between 2019 and 2021 trial years different varieties of Carinata and Indian Mustard were trialled, confounding comparison of regional suitability. Notably across trial sites and years E40R Safflower was consistently used, providing the opportunity for direct comparison. Here it may be perceived that there was either an individual or combined effect of Time of Sowing (TOS), water availability, row spacing, and soil type upon trial results. As shown by Mohamadzadeh et al., (2007), early sown Safflower at multiple rows spaced at 30cm achieved greater yield than late sown Safflower at 60cm row spacing. Irrigation has a positive effect upon yield outcomes (i.e., Omidi et al 2012), and Ferrosol soil types are inherently fertile (Bell et al., 1999). In comparison coastal areas under sugarcane cultivation are characterised by weathered, and leached soils leading to low levels of plant available nutrients (i.e., Keeping, 2017). The Walkamin site although sown at the same row spacing as the Far North recorded an earlier TOS and received in-crop irrigation. Furthermore, the Ferrosol soil type at the Walkamin site may be considered to have greater inherent fertility than the coastal soils identified at the other sites.

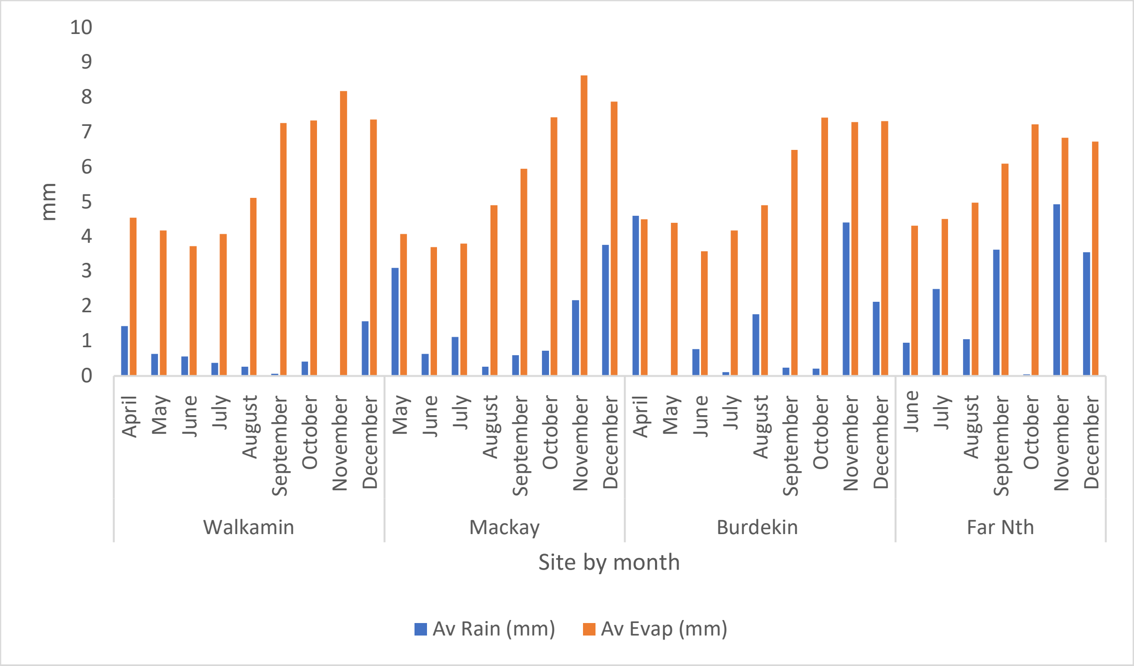

Figure 2. CRCNA developing an oilseeds industry for northern Australia. Averaged rainfall (mm) and evaporation (mm) by month and site location.

Conclusion

2021 winter trial results have identified that across regions and different crops compared Safflower can be seen to have achieved the greater yield (t/ha) at time of harvest. Comparison of 2019 with 2021 trial results further demonstrates that Safflower achieved the greater yield. Notably an effect of row spacing/number of rows was observed across trial years and sites with the 1.6m bed spacing and 2 rows per bed at 25cm row spacing achieving reduced results.

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