Canola growth and development in central western NSW

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Abstract
The aim of this study was to measure crop development and yield accumulation throughout a growing season to enhance the understanding of these processes and to link them to agronomic management decisions. Two canola crops trials located on the plains and on the slopes areas of central western New South Wales were monitored throughout the 2011 growing season to detail differences in crop growth and development. The influence of thermal time (TT) on the seed germination and emergence, vegetative growth phases and reproductive development, including seed development, were monitored.

Findings showed overall responses to TT to be closely aligned at the two sites, crop cycles completed by 2569°Cd at Wellington (W) and 2336°Cd at Gilgandra (G). Individual phase durations were consistent: sowing to emergence - 112°Cd (W), 105°Cd (G); emergence to stem elongation - 760°Cd (W), 747°Cd (G); stem elongation to start of flowering - 288°Cd (W), 364°Cd (G) and flowering period - 572°Cd (W), 616°Cd (G). Environmental conditions throughout much of the growing season were favourable, with mean temperatures close to optimums for canola and frequent rainfall events. Both decreasing PAW and maximum daily temperatures exceeding 30°C impacted on crop development during the final 2 weeks of the study. Differences in daily TT averaged 12.3°Cd at W and 18.4°Cd at G. The rate of rapid oil and yield accumulation under favourable seasonal conditions was found to be strongly correlated to TT. The end of these periods measured in TT was comparable at both sites. Rapid oil accumulation ceased at 2032°Cd at G and 1990°Cd at W; yield accumulation ceased at 2256°Cd at G and 2201°Cd at W.

Keywords: canola, day degrees, oil, yield, temperature

Introduction

Canola is the third largest crop by area produced in Australia (Edwards & Hertel 2011). Growing areas extend over a wide latitudinal range extending from Tasmania to southern Queensland, and subsequent large variations in photothermal regimes influence crop development rates (Robertson et al. 2002). Canola is widely perceived to be a high risk crop to grow, with seed yield and oil concentrations often below expectations.

Knowledge and understanding of canola physiology, particularly during pod and seed development is poorly understood (Hertel, unpublished data). This study is part of an agronomy extension project to improve the knowledge and understanding of canola growth and development amongst growers, agronomists and consultants and industry contractors. Through better understanding of the linkages of environmental factors with crop physiological responses and crop management operations, agronomic and economic performance can be maximised.

Methods

Site details

Field experiments were sown at Gilgandra and Wellington using the imidazolinone tolerant variety 45Y82 on 29 April and 3 May 2011 respectively. 45Y82 is an early to mid maturing variety (Mathews and McCaffery 2012). The vernalisation response of Australian spring type cultivars is generally regarded as absent or weak (Robertson et al. 2002). Granulock 15 fertiliser was applied at 100 kg/ha at sowing and sites treated to protect against mice with bromodiolinone-treated grain. Canola seed was sown at 2 kg/ha at G and 3 kg/ha at W using a cone plot seeder in 5 rows with 30 cm row spacing into standing wheat stubble.

Design

Designs at each site were in Randomised Complete Blocks with treatments within replicates spatially arranged using DiGGer (Coombes, 2002) to improve treatment neighbour balance. Ten plots (G) or twelve plots (W) were sown with 4 replications. Biomass sampling dates were randomly assigned to these plots.

Measurements
Hastings data loggers were placed at 1.2 m above ground level under shade in Plot 1 of each trial. Air temperatures were measured hourly and maximum and minimum recorded throughout the growing season. Measurements commenced the day after sowing and ceased when the crop was harvested at 8% seed moisture content. Thermal time (TT) time was calculated based on maximum and minimum using a base temperature of 0°C (Virgil et al. 1997, Gabrielle et al. 1998). Optimal temperatures were not used in the calculations. Growth stages (GS) were recorded throughout the season, with frequency increasing after the commencement of stem elongation.

Sampling commenced less than a week after the end of flowering (GS 69), 48 days (G) and 40 days (W) after the start of flowering. The number of sampling times totalled 9 at G and 12 at W. Sampling took place every 3 – 4 days initially with later times occurring every 5 – 7 days. At each date a representative area containing approximately 25 plants (G) and 35 plants (W) was taken from the middle 3 rows. The individual main stem raceme was removed from each plant and divided into basal, middle and upper thirds, placed immediately into an insulated box containing ice bricks before placement in a refrigerator until processing. Processing was completed within 8 hours of cutting. Pods were removed from each of the raceme sections and seeds were removed and weighed from a 50 pod sub-sample. From each sub-sample 300 seeds were counted and weighed (fresh weight) then dried for 3 days at 70°C before re-weighing. Seed colour at each date was recorded. The remaining plant material was cut 20 cm above ground level, placed in bags and air dried. It was then threshed and seed weight, seed size and seed quality including oil, protein, glucosinolates and moisture were determined. Seed quality data were determined using the standard methods described by Seberry et al. (2011). Total oil content of canola was calculated to 6% moisture.

Statistical analysis
Results were analysed using GenStat 5 using transformations when necessary.

Results

The duration of each phase of canola growth and development is determined by temperature, vernalisation and photoperiod. The time to complete phases is based on thermal time (TT) expressed as day degrees (°Cd). The duration of the growing season from sowing to seed maturity (8% moisture) was calculated to be 2567°Cd at W and 2336°Cd at G. This corresponds to 193 days (W) and 175 days (G) (Table 1).

Table 1: Canola phase lengths in time (days) and thermal time (°Cd) and rainfall at Wellington and Gilgandra

Crop stage	Wellington			Gilgandra		
	Time (days)	Degree Days (°Cd)	Rainfall (mm)	Time (days)	Degree Days (°Cd)	Rainfall (mm)
Sowing to emergence	11	112	2.5	8	105	4
Emergence to stem elongation	64	648	120.5	55	642	45
Sowing to stem elongation	75	760	129	62	747	49
Stem elongation to start of flowering (10%)	26	288	29	35	364	8
Start of flowering (10%)	103	1047		96	1112	
End of flowering (5%)	142	1619		139	1728	
Flowering period	39	572	70	43	616	60
Sowing to 40% seed moisture	181	2262	289	133	2115	105
Sowing to 8% seed moisture	193	2567	296	175	2336	191

NOTE: Seed moisture refers to the mean % moisture of seeds on the main raceme

Crop growth and development was closely aligned with TT at both locations. Figures reflect the differences between the geographical locations, W in the NSW central western slopes and G on the NSW central western plains.

Canola is a long day plant, where the duration to flowering is shortened under long days (Major, 1980; Mendham and Salisbury 1995). The period from the end of the juvenile phase to floral initiation is responsive to photoperiod (Nanda et al 1996), whereas other phases are unresponsive. Photoperiod differences between the two site locations were assumed to be minimal as they differed little in latitude. Temperature determines the duration between germination, emergence and the end of the juvenile period, from stem elongation to mid flowering (Nanda et al 1996).

The TT for seedling emergence was 112°Cd (W) and 105°Cd (G). This is comparable to 110°Cd TT measured by Gabrielle et al. (1998) and Nanda et al. (1995). The total TT was consistent between emergence and stem elongation; 648°Cd at W and 642°Cd G. The response of crop development after the end of flowering at W increased at a greater rate compared to G. Suggested main contributing reasons include the crop response to changes in plant available water (PAW) where rainfall during this period measured 131 mm at W and 64 mm G.

Crop water demand is the consequence of interactions involving the timing of rainfall events, stage of crop development, overall crop biomass and temperature regime effects. Crop moisture stress affected the duration of this period. The time taken for the average seed moisture content on the main raceme to reach 40% was 38 days at W and 24 days at G, reflecting changes in the daily rate of plant development.

The rate of development of each crop phase is generally hastened by increasing temperature in controlled environment conditions (Nanda et al. 1995, Morrison et al. 1989). In the field however, the rate of crop growth and development is impacted by a range of factors, including variations in soil moisture, nutrition, disease, pests, weeds and competition within crops for resources and their interactions.

Early crop growth during the first weeks after sowing were characterised by the absence of rainfall at G. The crop response to the main limiting factor - declining PAW, was to decrease the duration of the phases. Initial G daily TT decreased from 13.2°Cd /day between sowing and emergence to 10.4°Cd /day from stem elongation to the start of flowering. Small rainfall events were intermittent during the stem elongation phase at both sites. Effective rainfall did not fall until a few days after the commencement of flowering at G or just prior to at W. Throughout the period of flowering at both locations, 70 mm at W and 60 mm at G increased PAW. Mean daily TT during flowering increased to 14.3°Cd /day at G and 14.7°Cd /day at W.

The duration of the seed fill period - between the end of flowering to 40% seed moisture, was distinct in its apparent differences - at W this phase extended to 38 days in contrast to 24 days at G. Based on TT however, they were very consistent. Mean TT was 16.9°Cd /day/day at W and 16.1°Cd /day at G. Environmental conditions during the final crop phase as seed dried down was characterised by large differences in site rainfall, 123.5 mm at W and 64 mm at G and successive days of maximum temperatures exceeding 30°C. This impacted on the rate of seed desiccation causing a divergence in calculated daily TT, 12.3°Cd /day at W and 18.4°Cd /day at G. Daily seed moisture losses averaged 2.3% at W and 2.7% at G.

Crop performance

Changes in crop yield and oil content as seed development progressed reflected similar patterns at both sites (Figure 1). Highest rate of yield accumulation occurred over 10 (G) to 16 (W) day periods. This rapid increase, measured in TT from sowing commenced at 2081°C (G) and 1885°Cd (W) and continued before plateauing. Comparing the sites, the length of the rapid yield accumulation stage was quite different, 175°Cd at G and 518°Cd at W. At both sites yields plateaued at similar TTs, 2256°Cd at G and 2201°Cd at W, a difference of 55°Cd.

Highest rate of oil accumulation occurred over 14 day (G) and 21 day period (W), commencing at 1805°C at G and 1685°Cd at W (Figure 1). The duration of the period of rapid oil accumulation was 227°Cd at G and 305°Cd at W, a difference of 78°Cd between each site. Frequent rainfall events throughout this period at both sites, combined with average daily temperatures of 13.7°C (W) and 15.2°C (G) were favourable environmental conditions for high oil concentrations to be realised.

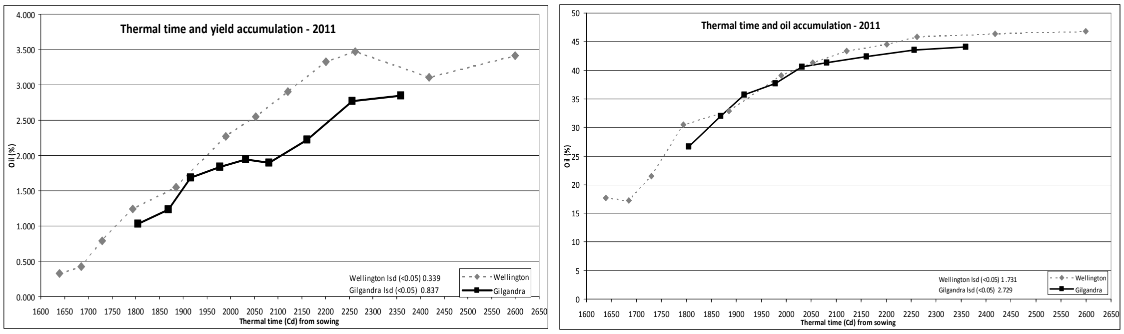

Figure 1. Thermal time effects on yield and oil accumulation in canola at Wellington and Gilgandra – 2011

Conclusion

This paper presents the results of canola crops grown under field conditions and their responses to environmental influences. It provides a snapshot of some baseline figures that demonstrate acknowledged scientific understanding of canola growth and development. The seasonal conditions that prevailed during this study, particularly during the reproductive phases enabled natural physiological development to progress relatively unhindered by adverse environmental conditions, a contrast to frequent typical field situations. It provides a reference to compare field crops responses to unfavourable climatic conditions. Better understanding of the production outcomes of these responses will lead to making more informed and practical crop decisions. The large range of locations and the subsequent climate variations where canola is grown in Australia challenges crop production. Improved knowledge across industry participants will assist confidence and reliability of canola production.

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