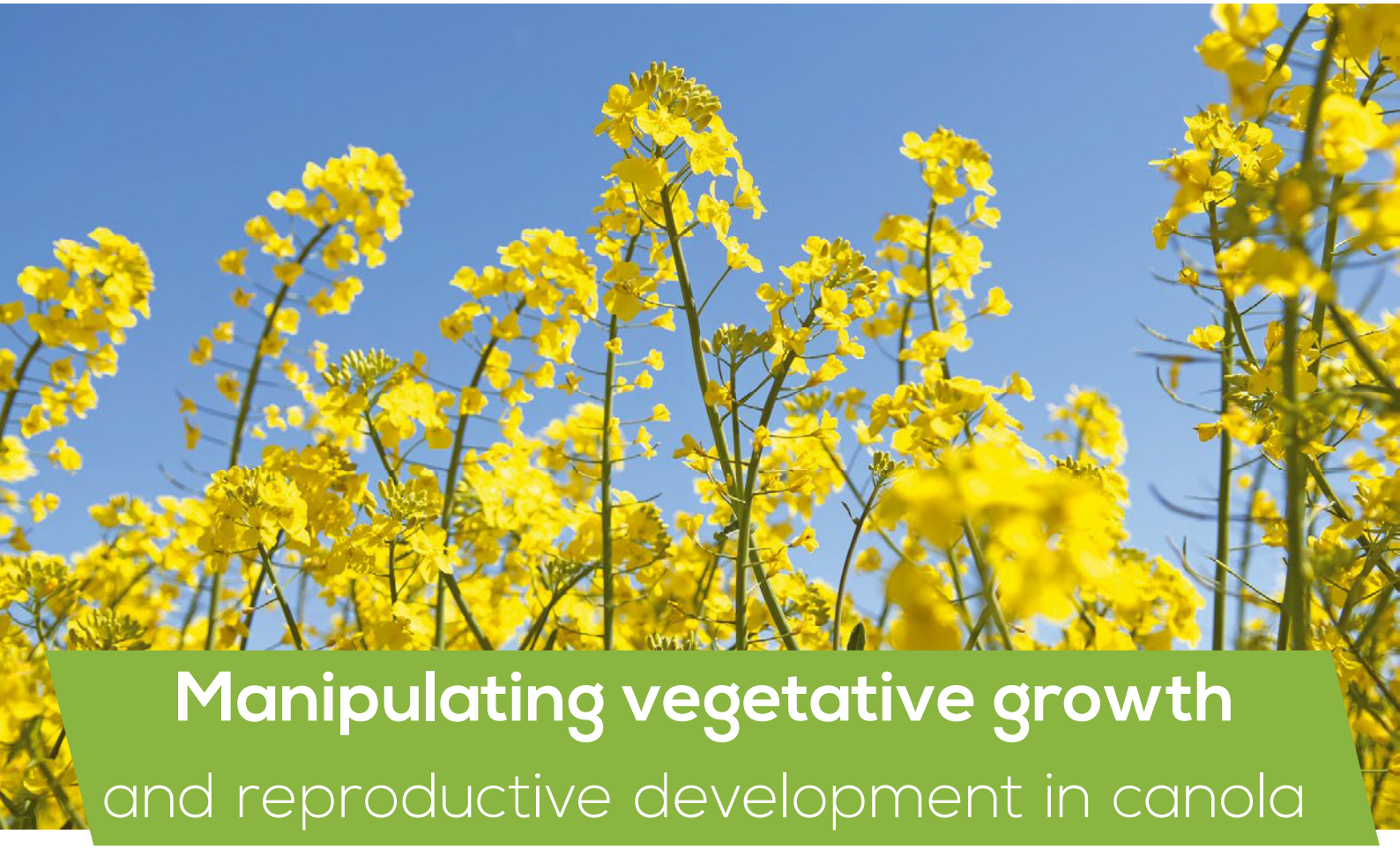


Manipulating vegetative growth and reproductive development in canola

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Expansion of canola (*Brassica napus L.*) as a crop in South Africa is still hampered by generally low grain yields, with resultant profit margins that are less than that obtained with grain crops such as wheat and barley.

Lower than expected yields may be the result of several factors, such as low and uneven plant populations when compared to Canadian crops, insect pests, poor plant nutrition management and weed control, as well as harvesting losses.

The highest yields are achieved with early plantings on high fertility sites, although this practice can produce bulky crops that, in combination with high plant populations, may result in lodging during pod development. Similar to Australia where canola is grown as a winter crop, plants in South Africa grow much taller compared to Canada and lodging may become a serious problem if canola is planted early at high planting densities.

Although bulky crops may show high yield potential at flowering, this potential often does not materialise due to poor light penetration and inefficiency in assimilate remobilisation, which result in fewer seeds per pod and a greater portion of immature pods (Armstrong and Nicol, 1991).

Plant growth regulators

Research done in Australia with plant growth regulators (PGRs) (Armstrong and Nicol, 1991) showed that:

- PGRs can reduce plant height.
- Shorter canola plants are less prone to lodging.
- PGRs can change the canopy structure of canola to produce a more compact, evenly developed plant canopy, which improves the penetration of sunlight and reduces competition for assimilates.
- Evenly developing plants will have more uniform ripening, which will reduce pod shattering and harvesting losses.

No PGRs are at present registered for use in canola in South Africa, but preliminary studies showed that PGRs with trinexapac-ethyl as active ingredient (Primo Maxx® and Moddus®) as well as liquid seaweed extract (Kelpak®) showed promising results in both pot and field trials.

Although Kelpak® is not a PGR in the sense that plant growth (height) is reduced, it may help to reduce lodging and increase canola yields due to improved rooting systems and an increase in stem diameter (Ferreira and Lourens, 2002); the product is registered for use in canola in South Africa. Both products are used in grain crops, though optimum application rates and time of application for canola are not yet determined.

Trials with Kelpak® and Moddus®

Field trials were conducted during the 2015-2017 growth seasons at high rainfall (Altona: 645mm annually) and medium rainfall (Langgewens: 473mm annually) localities in the Swartland and

a high rainfall (Roodebloem: 563mm annually) locality in the Southern Cape.

Five spraying treatments – an unsprayed control compared to Kelpak® (liquid seaweed extract) at 2 and 4ℓ/ha and Moddus® (trinexapac-ethyl) at 0,4 and 0,8ℓ/ha – were tested with the spraying treatments done at budding stage (start of stem elongation) or at budding and start of flowering. These spraying treatments were also tested in a low density (30-40 plants/m^2) and a high density (> 70 plants/m^2) crop with spraying done at budding stage.

Large differences in climatic (rainfall) conditions were experienced during the experimental period (2015-2017). In the Swartland, very dry conditions (the driest since 1978) prevailed during the period with growth season (April to September) rainfall of only 193mm (2015) and 194mm (2017), compared to a long-term average of 334mm measured at the Langgewens locality.

During 2016, the growth season rainfall in the Swartland was almost the same as the long-term average at Langgewens and cool and above average rainfall in September ensured high yielding crops. Although above average rainfall conditions were experienced in the Southern Cape (Roodebloem locality) during 2015, crop yields were hampered due to a very dry planting season (April to May) followed by very cold and wet conditions in June.

Table 1: Plant heights (cm) of canola in 2015 at different localities in response to chemical treatments at budding (start of stem elongation) compared to treatments at budding and start of flowering.

		Altona	Langgewens	Roodebloem
Spray at budding	Control	127,1a	104,5a	98,0ab
	Kelpak 1	126,4a	104,8a	99,1ab
	Kelpak 2	126,8a	105,7a	100,2a
	Moddus 1	123,1a	103,1a	96,4ab
	Moddus 2	122,0a	102,7a	95,2b
Spray at budding + flowering	Control	128,2a	105,4a	100,0a
	Kelpak 1	127,4a	106,6a	102,0a
	Kelpak 2	128,5a	105,7a	103,4a
	Moddus 1	122,1a	101,4a	94,0b
	Moddus 2	121,0a	100,5a	94,6b

Kelpak 1 = 2ℓ/ha; Kelpak 2 = 4ℓ/ha; Moddus 1 = 0,4ℓ/ha; Moddus 2 = 0,8ℓ/ha
Means in the same row for each treatment with at least a common letter are not significantly different, LSD$_{0,05}$

Total growth season rainfall in the Southern Cape during 2016 was also close to the long-term average, but the rainy season started late, which shortened the growth season and reduced yield potential. Although growth season rainfall in 2017 was nearly 20% less than the long-term average at the Roodebloem locality, the rainfall was well distributed to ensure high yielding crops.

Plant heights

As expected, the plant growth inhibitor Moddus® reduced plant heights in 2015, but differences were not consistent and varied between localities. In contrast, Kelpak® treatments had no or very little effect on plant height (*Table 1*). Application rates (recommended or double), time of application (budding or budding plus flowering), and plant density did not have an effect on the response to chemical treatments at any locality in 2015. No treatment effects were shown in 2016 or 2017.

Table 2: Number of flowering stems per plant of canola during 2015 at different localities in response to chemical treatments on low- and high-density crops.

		Altona	Langgewens	Roodebloem
Low plant density	Control	2,59cd	3,30cd	4,25c
	Kelpak 1	3,13a	3,63bc	5,65ab
	Kelpak 2	2,68cd	3,54bcd	5,30b
	Moddus 1	2,83bc	3,60bc	6,35a
	Moddus 2	2,83bc	3,82ab	5,98ab
High plant density	Control	2,10e	3,20d	3,63cd
	Kelpak 1	2,48d	4,03a	3,25d
	Kelpak 2	3,08ab	3,81ab	3,75cd
	Moddus 1	2,60cd	3,42cd	4,10cd
	Moddus 2	2,60cd	3,45bcd	4,00cd

Kelpak 1 = 2ℓ/ha; Kelpak 2 = 4ℓ/ha; Moddus 1 = 0,4ℓ/ha; Moddus 2 = 0,8ℓ/ha
Means in the same row for each treatment with at least a common letter are not significantly different, LSD$_{0,05}$

Number of flowering stems

Due to the generally poor growing conditions in 2015, the number of flowering stems at especially Altona and Langgewens were low and varied between two and five stems per plant. Application time of chemical treatments had no effect on the number of flowering stems per plant at Langgewens, but at Altona and Roodebloem treatments with especially Moddus® resulted in a higher number of flowering stems produced.

Although significant increases in the number of flowering stems per plant due to the application of Moddus® and Kelpak® were recorded where the effect of plant density was studied, responses were inconsistent (*Table 2*). This was most probably due to the non-uniformity of plant density. However, these effects were not repeated in either 2016 or 2017.

Table 3: Number of pods per plant of canola during 2015 at different localities in response to chemical treatments at budding (start of stem elongation) compared to treatments at budding and start of flowering.

		Altona	Langgewens	Roodebloem
Spray at budding	Control	104d	86d	74cd
	Kelpak 1	118c	108ab	83abc
	Kelpak 2	128ac	106b	80bc
	Moddus 1	119c	118a	83abc
	Moddus 2	130a	106bc	81bc
Spray at budding + flowering	Control	100d	86d	68d
	Kelpak 1	133a	113ab	86ab
	Kelpak 2	127abc	106bc	82bc
	Moddus 1	120bc	103c	92a
	Moddus 2	121abc	104bc	90ab

Kelpak 1 = 2ℓ/ha; Kelpak 2 = 4ℓ/ha; Moddus 1 = 0,4ℓ/ha; Moddus 2 = 0,8ℓ/ha
Means in the same row for each treatment with at least a common letter are not significantly different, $LSD_{0,05}$

Number of pods per plant

When sprayed at budding stage, the application of Moddus® and Kelpak® resulted in a significantly higher number of pods per plant at Altona and Langgewens, but not at Roodebloem during 2015 (*Table 3*). When sprayed at both budding and flowering stage, Moddus® and Kelpak® applications increased the number of pods per plant at all localities; in contrast to spraying at budding stage only, dosage rate did not have an effect.

When applied to plots with less than 40 plants/m² (low plant density), the application of Moddus® and Kelpak® at all dosage rates resulted in a significantly higher number of pods per plant at Altona and Roodebloem, but only at high dosage rates of Kelpak® at Langgewens.

In plots with more than 70 plants/m² (high plant density), applications of Moddus® and Kelpak® did not have any effect on the pod numbers at Langgewens, while at Altona higher pod numbers were only recorded at high dosage rates of Moddus®. At Roodebloem all rates of Moddus® and high dosage rates of Kelpak® showed a higher number of pods per plant. These positive responses were unfortunately not repeated in 2016 or 2017.

Grain yield

Due to the low rainfall during the growth season, grain yields of less than 2 000kg/ha canola were recorded at especially the lower rainfall localities of Langgewens and Roodebloem during 2015.

At Langgewens increases in grain yield due to the application of Moddus® and Kelpak® were only recorded when double the recommended rates were applied at budding and start of flowering during 2015. At Altona all Moddus® and Kelpak® applications, apart from Kelpak® at high application rates and Moddus® at low application rates in plots with less than 40 plants/m², resulted in significant increases in grain yield during 2015 (*Table 4*).

At Roodebloem all Moddus® and Kelpak® applications, except for Kelpak® at a low dosage rate in high plant density plots, resulted in significantly higher grain yields when compared to the unsprayed control plots.

Although rainfall during 2016 was very close to long-term averages, these

Table 4: Grain yield (kg/ha) of canola during 2015 at different localities in response to chemical treatments at budding (start of stem elongation) compared to treatments at budding and start of flowering.

		Altona			Langgewens			Roodebloem		
		2015	2016	2017	2015	2016	2017	2015	2016	2017
Spray at budding	Control	1941c	1242bc	937a	1233abc	1414bcd	774a	1205cd	1180a	2035a
	Kelpak 1	2431a	1231bc	933a	1302ab	1586abc	940a	1560a	1142a	2195a
	Kelpak 2	2406b	1209bc	963a	1273ab	1539abc	845a	1549a	1120a	2226a
	Moddus 1	2135b	1132bc	899a	1248abc	1659ab	945a	1515ab	1232a	2224a
	Moddus 2	2121b	1205bc	880a	1245abc	1603ab	949a	1495ab	1247a	2106a
Spray at budding + flowering	Control	1936c	1331abc	956a	1172bc	1273d	733a	1196d	1035a	2065a
	Kelpak1	2403a	1270bc	912a	1254abc	1361cd	776a	1371b	1070a	2048a
	Kelpak 2	2447a	1544a	902a	1355a	1761a	729a	1431ab	1066a	2171a
	Moddus 1	2143b	1388ab	960a	1110c	1653ab	851a	1386b	1046a	2128a
	Moddus 2	2134b	1345abc	822a	1375a	1462bcd	783a	1519ab	1216a	2041a

Kelpak 1 = 2,0ℓ/ha; Kelpak 2 = 4,0ℓ/ha; Moddus 1 = 0,4ℓ/ha; Moddus 2 = 0,8ℓ/ha
Means in the same row for each one treatment with at least a common letter are not significantly different, $LSD_{0,05}$

Table 5: Grain yield (kg/ha) of canola during 2015 at different localities in response to chemical treatments on low- and high-density crops.

		Altona			Langgewens			Roodebloem		
		2015	2016	2017	2015	2016	2017	2015	2016	2017
Low plant density	Control	1988c	870bc	808a	1220a	1290bc	927a	1190f	947b	1940a
	Kelpak 1	2404ab	722c	909a	1239a	1233c	783a	1627a	1195ab	2088a
	Kelpak 2	2244bcd	797c	768a	1202a	1332abc	937a	1714a	1195ab	2033a
	Moddus 1	2138cde	855bc	819a	1225a	1425abc	990a	1418cd	1160ab	2077a
	Moddus 2	2074de	787c	865a	1197a	1310abc	898a	1530abc	1064ab	1934a
High plant density	Control	2083de	1088ab	908a	1269a	1556a	834a	1248ef	1105ab	1893a
	Kelpak1	2371ab	1284a	976a	1339a	1518ab	882a	1357de	1081ab	1992a
	Kelpak 2	2439a	923bc	880a	1358a	1486abc	875a	1615ab	1221a	2138a
	Moddus 1	2382ab	1075ab	998a	1245a	1469abc	866a	1638ab	1052ab	2095a
	Moddus 2	2264abc	1052ab	862a	1252a	1427abc	896a	1663ab	1074ab	2002a

Kelpak 1 = 2,0ℓ/ha; Kelpak 2 = 4,0ℓ/ha; Moddus 1 = 0,4ℓ/ha; Moddus 2 = 0,8ℓ/ha
Means in the same row for each one treatment with at least a common letter are not significantly different, LSD $_{0,05}$

more favourable climatic conditions were not reflected in higher grain yields as opposed to that measured in 2015, except for the Langgewens locality (*Table 4*), which was most probably due to the late start of the rainy season.



Chemical treatments with Moddus® and Kelpak® at budding or budding and flowering had very little effect on grain yield at Altona and Roodebloem, but both Moddus® at the recommended rate and Kelpak® at double the recommended rate increased grain yields when applied at budding and the start of flowering at Langgewens during 2016.

When applied to canola plants at either low planting densities (< 40 plants/m^2) or high planting densities (> 70 plants/m^2), chemical treatments had no effect (*Table 5*).

Due to very dry conditions grain yields of less than 1 000kg/ha were recorded at Altona and Langgewens during 2017. Chemical treatments with Moddus® and Kelpak® had no significant effect on grain yield, regardless of dosage rate or time of application and planting densities (*Table 5*).

Although yields at the Southern Cape locality of Roodebloem were higher than 2 000kg/ha due to more favourable growth conditions – in contrast to especially 2015 when grain yields of more than 1 500kg/ha were attained – no significant differences due to chemical applications of Kelpak® and Moddus® were recorded.

Conclusions

- Moddus® as a plant growth regulator reduces plant height.
- Both Moddus® and Kelpak® stimulated the production of flower heads and pods per plant, resulting in higher grain yields per hectare.
- Plant responses to treatments with these chemicals were, however, not consistent and differed between localities and even between years on the same locality.
- The lack of more conclusive results may be due to poor growing conditions experienced in most trials of this study, which prevent the production of tall bulky crops prone to lodging.
- More consistent results may be expected when applied to canola grown under irrigation, where tall growing plants and high biomass are produced.

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