THE EFFECT OF PLANT POPULATION AND GROWTH REGULATORS ON GROWTH AND YIELD OF LENTIL (*Lens culinaris* Medik.) cv. Olympic

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ABSTRACT

Two field experiments were conducted in spring 1987-88 and in autumn 1988-89 to investigate the effects of plant population and growth regulators on lentil (*Lens culinaris* Medik.) cv. Olympic growth and yield. In 1987-88 a plant population of 300 plants/m^2 significantly increased dry matter production to 515 g/m^2 compared to 459 g/m^2 at 100 plants/m^2. Seed yield was increased from 225 to 239 g/m^2, plant height and mean internode length also increased. Pod number, branch number and HI were reduced. Both Paclobutrazol and Triapenthenol at 0.6 kg a.i./ha increased seed yield, harvest index and mean seed weight, but reduced plant height and mean internode length. In 1988-89, a dry season, at 300 plants/m^2 dry matter production was increased from 396 to 468 g/m^2 ($P < 0.001$). Branch and pod number per plant were reduced. Paclobutrazol tended (not significant) to increase seed yield from 164 to 177 g/m^2, HI from 36.4 to 38.5 %, pods per plant from 18.9 to 19.7 and branches per plant from 10.6 to 12.6. The effect of Triapenthenol was not clear. Both Paclobutrazol and Triapenthenol reduced plant height and mean internode length.

*Additional Keywords: Lentil (*Lens culinaris* Medik). population, growth regulators.*

INTRODUCTION

Lentils (*Lens culinaris* Medik.) are an important food crop in many countries, particularly in India, Pakistan, Turkey, and the Middle-East. Annual world production is about 2.5 million t (FAO, 1985). Major producers are India, Turkey, Syria, Canada, and the United States of America.

Because of the high protein content of their seed, lentils have become the world's fifth most important grain legume for human food. Lentils contain approximately 19.5 - 35.5 % protein (Savage, 1988) and the protein has a high apparent digestibility (Williams & Nakkoul, 1985).

Lentils are a relatively new crop in New Zealand. However, some basic agronomic research has been conducted (Jermyn *et al.*, 1981; Butler & Jermyn, 1981; Jermyn, 1983). In New Zealand farm lentil yields have been as high as 2.5 t/ha. If autumn sown, they can produce nearly 4.0 t/ha (McKenzie, *et al.*,1985). Generally autumn sown lentils have out yielded spring sowings.

There are a number of agronomic methods which can be used to increase crop production, two of these are altering plant population and the use of plant growth regulators.

Plant population: Increasing plant population has given variable results on lentil seed yield. High plant population have given large yield increase (Wilson & Teare, 1972; El-Saraq & Nourai, 1983); but some authors have reported no increase or only a small increase (Jermyn, *et al.*, 1981; Krarup, 1984). Todorov (1970) and Wilson & Teare (1972) suggested that to obtain high lentil yields they should be sown at 300 to 400 plants/m^2. The most common population used was 372 plants/m^2. Futhermore, at row spacing of 15 and 30 cm, with 1.5, 3.0 and 12.0 cm between plants within the row, lentil yield was greatest at 15 cm between rows and 1.5 cm between plants within the row.

In New Zealand, McKenzie, *et al.* (1986) found no seed yield response to plant population at populations of 100, 200, 300 and 400 plants/m^2. Seed yield per plant was strongly affected by both population and sowing date and ranged from 99.5 seeds per plant in May to 16.2 seeds per plant in August. However, total dry matter production increased linearly as population increased.

The use of plant growth regulators: Plant growth regulators are substances which when applied in small quantities change the form of plants by altering the relative proportion of their components parts (Humpries, 1967). They have been recognised for nearly 50 years (Wareing, 1981).

Paclobutrazol (PP-333) and Triapenthenol (RSW-0411) are two growth regulators which belong to the Triazole group of growth retardants. There are some reports of the use of Paclobutrazol on legumes. In soybean *Glycine max* L. Merr.), application of 250 μg/plant of soil applied Paclobutrazol reduced plant height (Davis & Sankhla, 1987). In field bean *Vicia faba* L.) Paclobutrazol at 1.0 kg a.i./ha applied to field beans at 40 cm crop height significantly increased yield (Hack, *et al.*, 1985).

To date there are no reports of increasing lentil yield by use of plant growth regulators (Saxena, 1981).

The experiments reported here aimed at investigating the effects of altering plant population and the use of plant growth regulators on the growth and yield of lentils.

MATERIALS AND METHODS

Two field experiments were conducted in spring 1987-88 at Henley Block-4, and in autumn of 1988-89 at Henley Block-6, Lincoln College Research Farm, Canterbury. Soil type at both sites is a Templeton Silt Loam (New Zealand Soil Bureau, 1954), with pH about 5.7 with the two prior years in red clover on Henley Block-4. The sites were cultivated by rotary hoeing, ploughing, rolling and grubbing. Soil nutrient analysis showed acceptable values for all major nutrients, however, 250 kg/ha of flowmaster superphosphate was applied to both sites prior to sowing.

Experiment 1: In 1987-88 a 2 x 2 x 4 factorial Randomised Block Design with four replicates was used. The treatments were: plant population of 100 and 300 plants/m^2, growth regulators Paclobutrazol and Triapenthenol applied at 0.0, 0.3, 0.6, and 0.9 kg a.i./ha. Lentil cv. Olympic was sown into plots of 2.1 x 5.0 m with 14 rows per plot 15 cm apart on 18 September 1987.

Paclobutrazol was in a solution at 250 g a.i./l, and Triapenthenol was in granule form of 70 WG. Prior to spraying each plant growth regulator was mixed with water to provide 250 l of solution per ha and applied when plants were at the 11-12 leaf stage on 11 November 1987 using a knapsack sprayer fitted with LP-80015 T-Jet Nozzles, at 150 KPa pressure held at about 40 cm above the crop canopy.

At 82 days after sowing (DAS) 2 x 0.1 m^2 quadrats from the eight middle rows of each plot were taken for dry matter determination. Five plants was taken as sub-sample for determination of yield components. Further samples were taken one month later (109 DAS). At final harvest (136 DAS) 6 x 0.25 m^2 quadrats were taken from the eight middle rows for dry matter and yield determination. Ten plants from each sample were taken as a sub-sample for growth analysis.

Experiment 2: In 1988-89 a 3 x 3 x 2 factorial Randomised Block Design with four replicates was used. Treatments were: Plant populations of 100, 200 and 300 plants/m^2 the growth regulators Paclobutrazol and Triapenthenol at 0.0 and 0.6 kg a.i./ha, and application at the 6-7 or at the 11-12 leaf stage.

Lentil cv. Olympic was again used and sown on 31 May 1988 in plots 2.1 x 12 m with 14 rows per plot, 15 cm apart. The sprayer used was similar to that used in the 1987-88 experiment. Regular hand weeding was carried out following a pre-emergence application of Cyanazine at 1.5 kg a.i./ha. In 1988-89, first samples were taken at 126 DAS and repeated monthly. The sample size was the same as in the previous experiment but 10 plants were taken as a sub-sample instead of five. The final samples were taken at harvest (198 DAS).

RESULTS

Climate: In the spring 1987-88 trial maximum and mean temperatures (except at final harvest) were higher than in 1988-89 and than the long-term average. Minimum temperatures in 1987-88 were lower than the long-term average but were higher than in 1988-89. Mean air temperatures in 1987-88 (except at final harvest) were also higher than in 1988-89 and the long-term average (Table 1).

Rainfall in 1987-88 (except at the time of sowing) was higher than in 1988-89 and so was total rainfall for the entire season in 1987-88 at 227 mm compared with 157 mm in 1988-89. In 1987-88 solar radiation during September to December was similar to long-term values. During January and February 1988 during which plant maturity commenced, solar radiation was only half the long-term average. In 1987-89 while

Table 1: **Climate data for Lincoln University during the spring 1987-88 trial and the autumn 1988-89 trial compared with the long-term average in parenthesis.**

Month	Temp. max. °C	Temp. min. °C	Mean air temp.°C	Rainfall mm	Solrad MJ/m²/d	RH %	Wind run km/d
June							
1988	12.1	1.2	6.6	30.8	3.3	87	290
Mean	(10.7)	(1.5)	(6.2)	(61.0)	(5.5)		
July							
1988	12.6	2.6	7.6	24.9	3.7	80	313
Mean	(10.1)	(1.4)	(5.7)	(68.0)	(9.4)		
August							
1988	13,8	2.4	8.1	34.9	5.4	76	359
Mean	(11.4)	(2.7)	(6.7)	(62.0)	(9.4)		
September							
1987	14.7	4.9	9.8	17.9	13.3	77	316
1988	16.8	5.5	11.2	7.0	7.6	75	354
Mean	(11.4)	(2.7)	(9.4)	(47.0)	(13.4)		
October							
1987	16.9	7.0	11.9	65.3	17.6	72	321
1988	20.7	7.3	14.0	6.7	9.8	54	505
Mean	(14.2)	(4.6)	(11.7)	(49.0)	(17.9)		
November							
1987	18.8	8.4	13.6	48.7	19.6	79	310
1988	20.7	9.5	15.1	30,0	11.3	72	437
Mean	(16.8)	(6.7)	(9.4)	(53.0)	(20.8)		
December							
1987	20.3	10.5	15.4	33.7	19.9	70	345
1988	24.0	12.1	18.0	22.6	11.9	63	477
Mean	(18.8)	(8.1)	(15.4)	(57.0)	(21.2)		
January							
1988	23.5	10.5	17.1	27.8	11.5	72	411
Mean	(20.4)	(10.4)	(16.4)	(60.8)	(21.3)		
February							
1988	22.4	12.3	17.2	33.6	10.2	78	443
Mean	(21.3)	(11.5)	(16.2)	(54.0)	(19.5)		
Total							
1987-88				227			
1988-89				156			

All long-term means except rainfall are for the period 1975-1983. Long-term rainfall from 1930-1981.
Total rainfall is for the period from sowing to harvest of each trial.

relative humidity during peak vegetative growth in 1988-89 was lower than in 1987-88. For the entire season in 1987-88 relative humidity was above 70 %, while in 1988-89 it ranged from 54 to 87 %. Wind run was similar in both experiments (Table 1).

Plant height and mean internode length:

1987-88

At 82 DAS, plants at 300 plants/m² were significantly ($P < 0.001$) taller at 307 mm compared with 276 mm for plants at 100 plants/m². By 109 DAS, the higher population still had significantly ($P < 0.05$) taller plants at 370 mm compared with 347 mm. At the high plant population plants also had longer internodes, at 16 mm compared with 14 mm ($P < 0.001$). Paclobutrazol decreased plant height and mean internode length at 82 and 109 DAS (Table 2). Triapenthenol decreased plant height and mean internode length at 82 DAS ($P < 0.001$) but by 109 DAS only mean internode length was reduced ($P < 0.05$) (Table 2).

1988-89.

Increased population increased ($P < 0.05$) plant height and mean internode length at 126 DAS from 115 to 123 mm and from 10.0 to 10.6 mm, respectively. But by 154 DAS population had no effect on these parameters (Table 3). Neither growth regulators had any effect on plant height or mean internode length at 126 DAS, but they significantly ($P < 0.05$) reduced plant height from 196 to 187 mm by 154 DAS but had no effect on mean internode length (Table 3). At 126 DAS, time of PGRs application did not affect plant height or mean internode length. By 154 DAS late application reduced mean internode length to 11.1 mm ($P < 0.01$) compared to 11.8 mm when applied at the 6-7 leaf stage (Table 3).

Dry matter production, seed yield, harvest index and yield components:

1987-88.

Compared with plants sown at 100 plants/m², plants sown at 300 plants/m² significantly ($P < 0.001$) increased dry matter production from 459 to 515 g/m², seed yield ($P < 0.05$) from 225 to 239 g/m²; but reduced ($P < 0.05$) harvest index from 48.7 to 47.2 % (Table 4). Branch number was reduced from 20.7 to 9.6 ($P < 0.001$), and pods per plant from 46.4 to 17.1 ($P < 0.001$). Plant population had no effect on seeds per pod or mean seed weight (Table 5).

There was no effect of growth regulators on total dry matter production, pod number, and seeds per pod. However, both Paclobutrazol and Triapenthenol affected ($P < 0.05$) seed yield with a maximum of 253 g/m², and of 240 g/m² respectively ($P < 0.05$). Increasing the rate of Paclobutrazol from 0.0 to 0.9 kg a.i./ha had no effect on branch number (Table 5). Branch number was increased with Tripenthenol with a maximum of 17.1 branches per plant ($P < 0.05$). There was no effect of Triapenthenol on mean seed weight (Table 5). There was a significant interaction between growth regulators and plant population ($P < 0.05$) on seeds per pod with increased plant population. Paclobutrazol increased the number of seeds per pod from 1.10 to 1.16, while increasing plant population with Triapenthenol reduced seeds per pod from 1.12 to 1.10.

1988-89

Increased plant population significantly increased dry matter production from 396 to 468 g/m² ($P < 0.001$), seed yield from 146 to 188 g/m² ($P < 0.001$), HI from 34.9 to 39.0 % ($P < 0.001$), and mean seed weight from 56.4 to 63.3 mg (Table 6). Population reduced branch number from 14.8 to 8.0, pods per plant from 1.11 to 1.07 ($P < 0.05$) (Table 7). Neither growth regulators nor time of application significantly affected any parameter, and there were no significant interactions (Table 6, 7).

DISCUSSION

Compared with the spring of 1987-88, autumn 1988-89 was considerably drier (Table 1). In 1987-88 the moisture conditions gave taller plants with longer mean internode lengths regardless of plant population (Table 2, 3). In both seasons, higher plant populations gave taller plants. The effect of the growth regulators were not consistent between the 1987-88 and 1988-89 sowings. The use of growth regulators to reduce plant height and mean internode length seems to be more effective in favourable conditions than in unfavourable conditions.

In favourable conditions plants grow normally and the efficacy of using growth regulators to dwarf plants was more clear. On the other hand, in 1988-89 with less available water, the plants did not grow well and there was less response to the growth regulators. This was primarily due to inhibition of cell division and enlargement (Hsiao, 1973), and plant growth, therefore, was limited.

The yield components most affected by plant population were the number of pods per plant, number of branches per plant, harvest index, and dry matter production. The number of seeds per pod was less affected (Table 5, 7). At low populations the number of

Table 2: The effects of treatment on plant height and mean internode length in 1987-88

	82 DAS		109 DAS	
Treatments	Plant Height (mm)	Mean internode length (mm)	Plant height (mm)	Mean internode length (mm)
Population (plants/m²)				
100	276	14.0	347	14.2
300	307	16.4	370	16.7
Significance	***	***	*	***
S.E.M.	6.49	0.321	9.57	0.341
Growth regulators				
Paclobutrazol 0.0	331	17.1	381	16.4
Paclobutrazol 0.3	282	15.0	351	15.0
Paclobutrazol 0.6	284	14.7	355	15.4
Paclobutrazol 0.9	249	13.2	319	13.9
Sig.trend				
Linear	***	***	**	***
Quadratic	ns	ns	ns	ns
Triapenthenol 0.0	317	16.5	375.2	16.5
Triapenthenol 0.3	307	16.0	389.3	16.2
Triapenthenol 0.6	286	15.0	346.8	15.1
Triapenthenol 0.9	276	14.3	350.6	15.2
Sig.trend				
Linear	***	***	ns	*
Quadratic	ns	ns	ns	ns
Sig. contrast				
Paclo vs Tria	ns	ns	ns	ns
S.E.M.	12.98	0.641	19.14	0.683
Sign.interaction	None	None	None	None
cv (%)	8.9	8.4	10.7	8.8

ns = non significant, * significant at $P < 0.05$, ** significant at $P < 0.01$, *** significant at $P < 0.001$. S.E.M. = Standard error of mean. Paclo = Paclobutrazol Tria = Triapenthenol

pods per plant was high in line with the increased number of branches. More branches provided more sites for pod formation. However, higher pods per plant did not necessarily increase seed yield/ha due to the lower number of plants per unit area. In contrast, the lower number of branches and pods per plant at high populations in both seasons produced higher total numbers of pods and consequently a higher seed yield.

The number of seeds per pod was only slightly affected by population in 1988-89 season, and was not affected by population in 1987-88. This suggests that in lentils the number of seeds per pod is very stable.

Plant population increased yield components in 1988-89 ($P < 0.05$ and $P < 0.001$). Thus increasing plant population under dry condition in autumn in

Table 3: The effects of treatments on plant height and mean internode length in 1988-89

	126 DAS		154 DAS	
Treatments	Plant Height (mm)	Mean internode length (mm)	Plant height (mm)	Mean internode length (mm)
Population (plants/m²)				
100	115	10.0	184	11.3
200	122	10.2	190	11.5
300	123	10.6	190	11.6
Sig. trend				
Linear	*	*	ns	ns
Quadratic	ns	ns	ns	ns
S.E.M.	2.48	0.189	3.18	0.19
Growth regulators				
Control	123	10.3	196	11.7
Paclobutrazol	117	10.1	182	11.0
Triapenthenol	120	10.4	187	11.6
Sig. Contrast				
GR vs control	ns	ns	**	ns
Paclo vs control	ns	ns	**	ns
Tria vs control	ns	ns	ns	ns
Paclo vs Tria	ns	ns	ns	ns
Time of application				
6-7 leaf stage	120	10.2	192	11.8
11-12 leaf stage	120	10.3	184	11.1
Significance	ns	ns	*	ns
S.E.M.	2.03	0.154	2.6	0.16
Sig. interaction	None	None	None	None
CV %	10.1	9.0	8.3	8.4

ns = non significant, * significant at $P < 0.05$, ** significant at $P < 0.01$, *** significant at $P < 0.001$, S.E.M. = Standard error of mean, Paclo = Paclobutrazol Tria = Triapenthenol

Canterbury increased the number of branches per plant, pods per plant and finally increased seed dry matter production, yield, and HI. These results are contrary to those of McKenzie, *et al.* (1986) who in a wetter season obtained a maximum yield of autumn sown lentils at 200 plants/m². Their results may be valid under favourable moisture conditions, but not under dry condition. These inconsistent results on the effect of plant population on lentil seed yield agree with previous reports that the sowing date and sowing rate can significantly affect yield components and seed yield of lentils (Krarup, 1984).

Under favourable moisture condition such as in 1987-88, Paclobutrazol and Triapenthenol increased ($P < 0.05$) seed yield/ha (Table 4). This was mainly due to a higher number of pods per plant, total dry matter production, and HI. This was related to lower plant height and shorter mean internode length following

Table 4: The effect of treatment on dry matter production, seed yield and harvest index of lentil cv. Olympic in 1987-88.

Treatment	Dry matter g/m²	Seed yield g/m²	Harvest index %
Population (plants/m²)			
100	459	225	48.7
300	515	239	47.2
Significance	***	*	*
S.E.M.	11.8	7.2	0.58
Growth regulators (kg a.i./ha)			
Paclobutrazol			
0.0	480	215	44.8
0.3	505	243	47.5
0.6	507	253	49.8
0.9	480	236	49.2
Significant trends			
Linear	ns	ns	***
Quadratic	ns	*	*
Triapenthenol			
0.0	457	214	46.7
0.3	488	237	48.5
0.6	501	241	48.1
0.9	475	218	48.6
Significant trend			
Linear	ns	ns	ns
Quadratic	ns	*	ns
Significant contrast			
Paclo vs Tria	ns	ns	ns
Significant interaction	None	None	None
CV (%)	9.7	12.4	4.8

ns = non significant, * P < 0.05, *** P < 0.001, S.E.M. = Standard error of mean, P = Plant population, GR = Growth regulators, P = Paclobutrazol, T = Triapenthenol.

growth regulator application (Table 2). Paclobutrazol reduced endogenous gibberellin levels, and thus inhibits cell division and elongation (Jones & McMillan, 1984).

Table 5: The effect of treatment on yield components of lentil cv. Olympic in 1987-88.

Treatment	Branches /plant	Pods /plant	Seeds /pod	Mean seed weight mg
Population (plants/m²)				
100	20.7	46.4	1.11	67.4
300	9.6	17.1	1.13	69.0
Significance	***	***	ns	ns
S.E.M.	0.788	2.11	0.034	9.4
4				
Growth regulators (kg a.i./ha)				
0.0	13.6	30.3	1.17	65.4
0.3	16.1	28.5	1.08	70.1
0.6	15.3	33.5	1.12	70.6
0.9	16.8	32.1	1.14	67.9
Significant trends				
Linear	ns	ns	ns	ns
Quadratic	ns	ns	ns	*
Triapenthenol				
0.0	12.3	32.6	1.14	68.0
0.3	15.4	34.5	1.10	68.3
0.6	17.1	29.2	1.07	69.5
0.9	14.6	33.6	1.12	65.9
Significant trends				
Linear	ns	ns	ns	ns
Quadratic	*	ns	ns	ns
Significant contrast				
Paclo vs Tria	ns	ns	ns	ns
Significant interaction	None	None	PxGR*	None
CV (%)	9.9	12.7	12.0	11.3

ns = non significant, * P < 0.05, *** P < 0.001, S.E.M. = Standard error of mean, P = Plant population, GR = Growth regulators, P = Paclobutrazol, T = Triapenthenol.

Reduced vegetative growth induced by growth regulators tended to increase assimilate partitioning to organs like pods, or supporting organs such as branches. Similar effects were found in

Table 6: The effect of treatment on dry matter production, seed yield and harvest index of lentil cv. Olympic in 1988-89.

Treatment	Dry matter g/m²	Seed yield g/m²	Harvest index %
Population (plants/m²)			
100	396	146	34.9
200	445	172	37.7
300	468	188	39.0
Significant trends			
Linear	***	***	***
Quadratic	ns	ns	ns
S.E.M.	13.1	5.8	0.77
Growth regulators			
Control	434	164	36.4
Paclobutrazol	435	177	38.5
Triapenthenol	440	166	36.7
Significant contrast			
GR vs Control	ns	ns	ns
Paclo vs control	ns	ns	ns
Tria vs control	ns	ns	ns
Paclo vs Tria	ns	ns	ns
Time of application			
6-7 leaf stage	432	163	36.4
11-12 leaf stage	441	175	38.0
Significance	ns	ns	ns
S.E.M.	10.7	4.7	0.63
Significant interactions			
	None	None	None
CV (%)	14.7	16.7	10.1

ns = non significant, * P < 0.05, *** P < 0.001, S.E.M. = Standard error of mean, P = Plant population, GR = Growth regulators, P = Paclobutrazol, T = Triapenthenol.

Table 7: The effect of treatment on yield components of lentil cv. Olympic in 1988-89.

Treatment	Branches /plant	Pods /plant	Seeds /pod	Mean seed weight mg
Population (plants/m²)				
100	14.8	27.9	1.11	56.4
200	11.5	16.6	1.12	61.0
300	8.0	12.2	1.07	63.3
Significant trends				
Linear	***	***	*	***
Quadratic	***	ns	ns	ns
S.E.M.	0.58	0.97	0.016	0.77
Growth regulators				
Control	10.6	18.9	1.11	59.5
Paclobutrazol	12.6	19.7	1.08	61.1
Triapenthenol	11.1	18.0	1.10	60.1
Significant contrasts				
GR vs cont.	ns	ns	ns	ns
Paclo vs cont.	ns	ns	ns	ns
Tria vs cont.	ns	ns	ns	ns
Paclo vs Tria	ns	ns	ns	ns
Time of application				
6-7 leaf stage	11.4	18.6	1.10	60.4
11-12 leaf stage	11.4	19.2	1.10	60.0
Significance	ns	ns	ns	ns
S.E.M.	0.47	0.79	0.013	0.63
Significant interactions				
	None	None	None	None
CV (%)	4.2	10.5	6.9	10.1

ns = non significant, * P < 0.05, *** P < 0.001, S.E.M. = Standard error of mean, P = Plant population, GR = Growth regulators, P = Paclobutrazol, T = Triapenthenol.

Triapenthenol treated plants where increasing concentration tended to increase seed yield, HI and dry matter production (Table 4). In contrast, Triapenthenol also tended to decrease plant height and mean internode length. It is possible that in 1987-88 the reduction in plant height and mean internode length increased the competitive ability of pods for assimilate supply and aided seed formation.

The effects of the growth regulators in 1988-89 was not as clear cut as in 1987-88. However, the growth regulators, particularly Paclobutrazol, tended to increase (non significant) the number of branches, the number of pods per plant, seed yield/ha, and harvest index (Table

4, 5, 6, 7). These changes were associated with reduced plant height and mean internode length induced by Paclobutrazol (Table 3).

Although the effect of Paclobutrazol on the previous parameters was not significant (Table 4, 5, 6, 7), it indicated that by reducing plant height and mean internode length, Paclobutrazol provided greater chances for branches, and pods to compete for assimilate supply. Similar effects were found with Triapenthenol treated plants. Higher dry matter production in plants treated with both Paclobutrazol and Triapenthenol was due to a higher number of branches and pods even though plants were shorter and the population was lower.

Time of application of the growth regulators did not significantly affect any parameter in 1988-89 (Table 6.7), but late application (11-12 leaf stage) did tend to increase seed yield as a result of increasing the number of branches, number of pods, number of seeds, and dry matter production.

Many of the Triazole-group of retardants such as Paclobutrazol and Triapenthenol are rate and time dependant and their effect differs in different seasons and at different crop growth stages (Dawkins, 1986). In lentils, there are no previous reports of the effects of growth regulators and time of their application on seed yield. It appears that under favourable condition particularly where plant available water is sufficient, the effects of growth regulators will be more clear.

In contrast to what has been found in favourable seasons in Canterbury in the autumn sowing, the results showed that lentils can be sown at up to 300 plants/m^2. Further seed yield in spring sown lentils was higher than in the autumn sowing.

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